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SUNFISH QUEENSLAND INC.

Sunfish Queensland Inc

Freshwater Wetlands and Fish

Importance of Freshwater Wetlands to Marine Fisheries Resources in the Great Barrier Reef

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Cover photographs: Two views of the same Gavial Creek lagoon at Rockhampton showing the extreme natural variability in wetlands depending on the weather.

Information in this publication is provided as general advice only. For application to specific circumstances, professional advice should be sought.

Sunfish Queensland Inc has taken all steps to ensure the information contained in this publication is accurate at the time of publication. Readers should ensure that they make the appropriate enquiries to determine whether new information is available on a particular subject matter.

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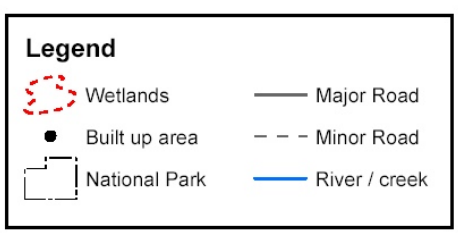
This legend applies to all maps of wetlands in this report.



Terminology in the Report

1. Acronyms Used in the Report

ACTFR: Australian Centre for Tropical Freshwater Research

AIMS: Australian Institute of Marine Science

ANSA Qld: Australian National Sportfishing Association Queensland Branch

ASS: Acid Sulfate Soils

Coastal CRC: Cooperative Research Centre for Coastal Zone, Estuaries and Waterway Management

DNRM&E: Department of Natural Resources, Mines and Energy

DPI&F: Queensland Department of Primary Industries and Fisheries

DSD: Queensland Department of State Development

EPA: Queensland Environment Protection Agency

GBR: Great Barrier Reef

GBRMPA: Great Barrier Reef Marine Park Authority

GBRWHA: Great Barrier Reef World Heritage Area

JCU: James Cook University

NHT: National Heritage Trust

PASS: Potential Acid Sulfate Soils

QPWS: Queensland Parks and Wildlife Service

RWQPP: Reef Water Quality Protection Plan

SIIP: Sugar Industry Infrastructure Package

SWBTA: Shoalwater Bay (Defence) Training Area

WCA: Wetland Care Australia

WTWHA: Wet Tropics World Heritage Area

2. Definition of Terms Used in the Report

Acid Sulfate Soils: The common name given to naturally occurring sediments and soils containing iron sulfides (principally iron sulfide or iron disulfide or their precursors). The exposure of the sulfide in these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid. Note: ASS generally includes both actual and potential acid sulfate soils. These soils pose a considerable environmental risk when disturbed, as they will become very acidic when exposed to air and oxidised.

Connectivity: Connectivity is the extent to which fish can move between different habitat types. The period of time water flows between wetlands, in-stream pools and estuaries and the extent and effectiveness of barriers determines the level of connectivity.

Drainage works: Man-made alterations to waterways and overland water flows that modify the natural hydrology of an area.

Fisheries values: The extent to which a particular waterway or wetland is important based on its use by fish.

Freshwater wetlands: These include off-stream freshwater bodies outside the banks of a waterway, in-stream freshwater bodies that are within the banks of a waterway but disconnected from adjoining parts of the waterway except during flow periods following rain, and sometimes fresh/sometimes brackish wetlands close to the intertidal zone that are occasionally inundated by tidal influence or flooding.

GBR catchment: The GBR Catchment includes all land areas and streams that drain into the GBR Lagoon.

GBR Lagoon: The lagoon is the relatively open area of the continental sea between the mainland and the part of the seabed where the Great Barrier Reef starts.

Riparian Zone: The land and vegetation immediately adjacent to a waterway including all “bankside and closely surrounding vegetation” (Giller and Malmqvist, 1998, pp 5).

Snags: Trees and other solid vegetation that have fallen into a waterway and provides cover for fish and other aquatic animals.

Water Quality: The quality of the water as measured by parameters such as pH, conductivity, turbidity, dissolved oxygen, temperature and salinity.

Freshwater Wetlands and Fish

3. Executive Summary

Various estimates of loss of freshwater wetlands in developed catchments along the GBR coast range between 70-90% (EPA, 1999) while the condition of the remaining 10-30% range from moderate to no value as fisheries resources. The most significant reason for the reduction in the value of remaining wetlands to fisheries is changed catchment hydrology resulting in loss of connectivity, habitat modification, poor water quality and poor habitat quality. High correlations have been identified between populations of coastal fisheries resources and adverse water quality combined with habitat destruction from modified floodplain hydrology (NSW Fisheries & Agriculture, 1989). Although similar studies have not been done in Central or North Queensland, the impact is likely to be similar for fish species that are dependent on access to fresh water.

Our knowledge of the value of freshwater wetlands to fishery resources has improved rapidly in the past decade and a series of related initiatives are identified in the report that will further improve this knowledge in the next few years, especially in relation to the use of freshwater wetlands by fish.

It is estimated that over 70 species of fish have been identified as spending part of their life cycle in both freshwater and marine habitats of the GBR Lagoon (Russell and Hales, 1993, 1997; Russell *et al*, 1996a, 1996b, 1998, 2000). These species require connectivity to allow movement between marine and freshwater habitats. The species include recreationally and commercially important species such as barramundi, eels, mullet and mangrove jack in addition to numerous smaller species that are an important part of the food chain (Bunn *et al*, 1997). It is likely that more species will be identified in future monitoring and research programs.

A larger number of species that use estuarine and marine habitats, including coral reefs, have been identified in previous studies over the last two decades. Many fish species use a chain of habitats (Cappo *et al*, 1998) from freshwater to the reef with interrelationships between all habitats.

The report provides an overview of freshwater wetlands of importance to fishery productivity from Daintree River to Bundaberg. This includes identification of wetlands and a brief description of their present status for fisheries with particular reference to connectivity, water quality and habitat quality. Reference has been made to invasive weed species where these are considered to impact

on wetland values. Available data on fish habitation is included. This report includes data from published reports, the Suntag tagged fish database and anecdotal information from local anglers and landholders.

Where possible, specific risks and threats to remaining wetlands have been identified. These risks and threats primarily result from continued urban, industrial and rural development and a lack of understanding of the importance of wetlands for the productivity of the fishery (Garrett, 1991) and the management of water quality for water entering the GBR Lagoon by both the general community and decision makers. A summary table of impacts on wetlands identified as important to marine fishery resources is at Table 2.

Whilst all wetlands are important for their hydrological and biological functions and therefore warrant protection, wetlands that are considered to be of high value from a fishery perspective have been identified below. Some wetlands have also been identified as likely to be of high value but their use by fish is unknown. It is considered that these wetlands should be given priority in future research of fish use of wetlands. Wetlands that are considered to have importance to fish but require some remedial action to improve their value to fish have also been identified. The listings are in order from north to south.

Wetlands and waterways considered to be high value:

1. Daintree River
2. Ella Bay Swamp
3. Wetlands of the Tully-Murray floodplain
4. Edmund Kennedy National Park wetlands
5. Barratta Creek wetlands
6. Gorganga Plains wetlands
7. Herbert Creek in Broad Sound
8. Gavial Creek lagoons at Rockhampton
9. Raglan Creek
10. Baffle Creek

Wetlands that could be important, but there is insufficient information on their use by fish:

1. Eubenangee Swamp
2. Hull River/Mt Coom wetlands
3. Barramundi Creek and Red Hill coastal wetlands

Important wetlands, but action is required to restore their fishery values:

1. Cattle Creek wetlands
2. Rocky Dam Creek wetlands at Koumala
3. 12 Mile Creek at Marmor

A number of recommendations are included for future action. Protection of remaining wetlands should be the first priority. There is a need to bring together catchment management groups, community leaders with a focus on changes to land management practices, government decision makers and those with knowledge and expertise of wetlands. At present most of these stakeholders are working in isolation and the benefit of their combined knowledge is compromised.

A more strategic targeted approach is required that includes priority setting based on wetland values, a thematic focus on specific threat types, protection ahead of restoration and specific restoration initiatives if there is to be a shift towards improvement in wetland management and protection. A Wetland Working Group comprising members of these groups should be established to provide guidance for future investment in wetlands.

It is considered that there is a sufficient knowledge base for investment in wetlands to shift from research to on-ground action aimed at protecting and improving high value wetlands. It is suggested that an investment ratio of 80% for on-ground action and 20% for further research and monitoring should be a target used in catchment management investment plans or when funding works on wetlands.

Monitoring needs to go beyond water quality parameters and address the food chain issues that are critical to fishery productivity. Use of biological monitoring will address both habitat issues and provide a better understanding of links to productivity. Regular population surveys should be introduced in all coastal waterways and used as an indicator for the health of wetlands.

Future research needs to focus on filling in the gaps in areas such as the relationship between habitat type and extent and the productivity of the fishery as identified in NSW in 1989. Other shortfalls include the impacts of sub-lethal effects of poor water quality in tropical wetlands and food chain relationships between freshwater and marine environments. Lack of research however, should not stop the restoration catchments to start addressing obvious water quality and connectivity issues.

There is a need to establish an agreed list of assessment criteria of wetland values for fishery resources with an agreed rapid assessment procedure. Factors should include biological diversity of fish populations, adult/juvenile habitat, food chain/productivity contributions, water quality issues and hydrological functions as a minimum. An inventory of wetland resources needs to be established and maintained.

The high value wetlands identified in this report should be targeted and management strategies developed to maintain their values as a priority for future investment in wetlands. Future strategies should include maintenance and improvements to connectivity, water quality and habitat quality. These strategies should also include the use of these wetlands as demonstration and education sites and for communication of wetland values to the wider community. The strategy needs to be community driven rather than government or science driven.

Investment in the improvement of wetlands is a key priority of the Reef Water Quality Protection Plan in terms of the future water quality of the water entering the GBR lagoon. However, further encouragement is required to target wetlands protection to enhance maintenance of fish stocks that use the GBR. It is recommended that priority investment for the GBR catchment area is targeted at wetlands assessed as having a high value from a fishery perspective.

Freshwater Wetlands and Fish

The Importance of Freshwater Wetlands to Marine Fishery Resources in the Great Barrier Reef

4. Introduction

Freshwater wetlands are perhaps the most maligned habitats on earth. To many, they are only swamps inhabitable by less desirable wildlife such as crocodiles, snakes and biting insects. Past and, in some cases, current attitudes towards wetlands can be judged from names such as Dismal Swamp and Bannister's Bog. While some research has been undertaken to establish the dependent linkages between freshwater wetlands and marine fishery resources, most research has focussed on in-stream reaches and off-stream deepwater permanent wetlands. It is likely that fish make use of a much wider range of habitats when they can be accessed.

The fish resources of the GBRWHA are an important part of the values of this world-renowned ecosystem. This is clearly demonstrated by the recent rezoning of the reef to protect over 30% of the GBRWHA from fishing. The protection of fish within the boundaries of the GBRWHA will not necessarily secure future fish stocks. A significant number of fish species found in the waters of the GBRWHA interact with adjacent coastal estuaries and some utilise associated wetlands.

Approximately 70% of marine fishery resources are dependent on estuaries for a part of their life cycle (Halliday and Young, 1996). Therefore the extent and habitat qualities of freshwater wetlands are important, as they contribute to the health of estuaries, adjacent coastal reefs and ultimately to the coral reefs of the Great Barrier Reef (GBR) as well as providing an important part of many species' lifecycles and important food resources at the bottom of the food chain. The concept of a "chain of habitats" (Cappo *et al*, 1998) is particularly appropriate for fish species.

Wetlands that are linked to rivers and estuaries flowing into the GBRWHA are mostly on the coastal plains. This is the area where much of the population resides and is also the area used for manufacturing industries and rural production including intensive agriculture, particularly sugar cane. As a result of agricultural, grazing, residential, and industrial land development, wetlands have been removed, altered, reclaimed or degraded through neglect or through changes to hydrological flows as a result of changed land use in the catchment (GBRMPA, 2001).

There is no reliable estimate available of the loss of wetlands in the GBR catchment; however, various guesstimates of loss range from 70–90% for individual catchments (EPA, 1999). Fisheries values of the remaining 10–30% of wetlands range from moderate to no value. One significant reason for change in value to fisheries is the loss of connectivity from changed catchment hydrology as this prohibits fish movement to and from wetlands. Even degraded wetlands that have some connectivity still show some use by fish.

Part of the reason for the loss of wetlands is the poor understanding of their significance in terms of their role in influencing water quality, the importance of their linkages with adjacent parts of the ecosystem and especially their value to fisheries. In the past decade, understanding and knowledge of water quality issues has significantly improved but there is still appears to be a lack of understanding by decision makers about the importance of freshwater wetlands to fishery resources.

The most noticeable evidence of a wetland becoming unsuitable as fish habitat is when the fish die. Often however, the visible evidence is only a part of the problem and some fish species have been shown to avoid poor water quality whilst migrating at some stages of their development (Kroon *et al*, 2003).

The challenge is to continue to improve the community's understanding of the value of wetlands and to improve land management practices to restore and enhance wetlands. The current knowledge base is sufficient to take action now to improve the connectivity and value of remaining wetlands to fisheries as the next step in ensuring the viability of fish stocks in and adjacent to the GBRWHA.

5. Terms of Reference

The terms of reference for this report are:

1. Document connectivity between freshwater wetlands and the marine environment for fish species.
2. Identify the risks to remaining important wetlands in the Great Barrier Reef catchment with respect to existing or changed connectivity to marine environments and regarding potential water quality and connectivity impacts from surrounding activities.
3. Identify threats to fish species and wetland health with respect to invasive weed species.
4. Identify water quality benefits accruing from healthy wetlands.
5. Identify high value wetlands within the Great Barrier Reef catchment.

6. Scope of the Report

"Freshwater Wetlands and Fish" provides an overview of wetlands on the coastal plains from the Daintree River in the north to Bundaberg in the south (*figure 1*). The report provides a brief description of the status of important or representative wetlands from a fishery perspective with reference to connectivity, water quality and habitat quality. Information provided includes barriers to fish movement, the status of the riparian zone and adjoining landscape, and the extent of terrestrial and aquatic weeds where available. Where possible, risks and threats to these wetlands have been identified.

Not all wetlands were able to be included in the report due to limitations with data, time and resources. Wetlands considered to be high fisheries value have been reported on; however, in some areas a wetland has been included that is representative of other nearby wetlands.

For the purpose of this report wetlands that have been included are off-stream freshwater wetlands that are outside the banks of a waterway, in-stream freshwater wetlands that are within the banks of a waterway but disconnected from adjoining parts of the waterway except during flow periods following rain, and sometimes fresh/sometimes brackish wetlands close to the intertidal zone that are occasionally inundated by tidal influence or flooding. All these types of wetlands are part of the "chain of habitats" used by fish and rely on connectivity to the estuarine parts of the system to allow access by marine fish. All three types of wetlands are often found within the same catchment.

The study was limited by the lack of current survey data. Some of the data such as that for the Johnstone River (Russell and Hales, 1993) was eleven years old when reviewed whilst other survey reports such as Perna (2003) were recent. Additionally, work on sub-lethal effects including habitat denial such as that done by Kroon *et al* (2004), has not been attempted for tropical native fish species whilst other work on the tolerance of fish to poor water quality and the sub-lethal effects on breeding capacity has not been published.

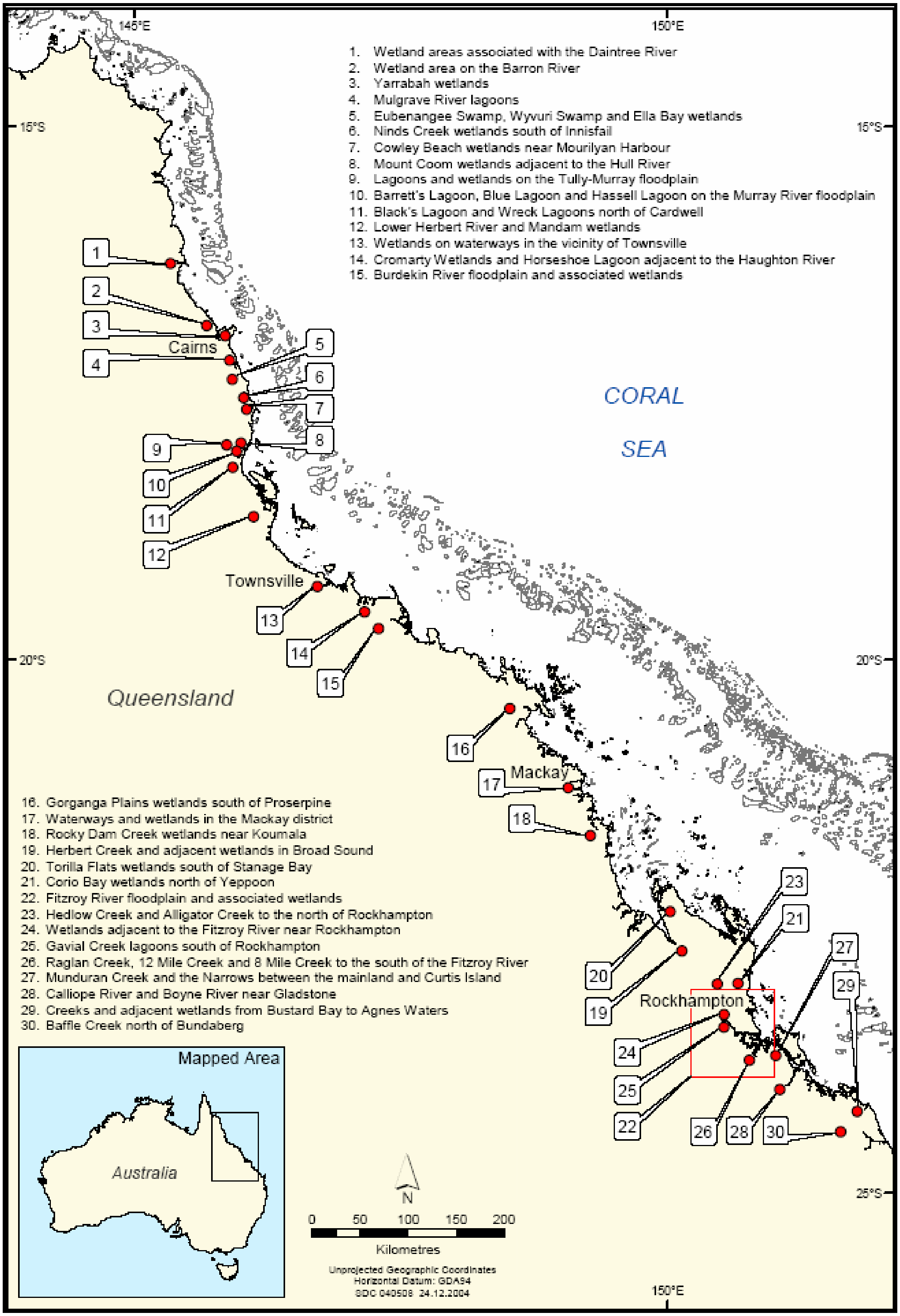


Figure 1: Map showing wetlands covered by this report

7. Methods

Wetlands that are included in the report were identified from maps, aerial photographs and from anecdotal evidence from people in the study area, including government and local council officers and long-term local residents who had extensive knowledge of their local wetlands. Researchers who have worked on wetlands were also consulted.

Existing documents on wetlands were reviewed. These included research papers, catchment management reports and other reports on wetlands. Relevant research papers and technical reports on marine fish species' use of estuaries and wetlands were also reviewed and historic records of early explorer Robert Arthur Johnstone were reviewed for descriptions of wetlands as he found them in the 19th century.

Data on fish movement to and from wetlands was obtained from the ANSA Qld Suntag database and from published reports. Details of fish tagged in wetlands and movements to and from wetlands are contained in the Appendices of this report.

Field inspections of wetlands were undertaken during December 2003 and January 2004. Wetlands from Mossman in the north to Turkey Beach in the south were visited. These visits were mostly conducted in the company of local experts. Information provided by local experts has been invaluable in the compilation of this report. It should be noted that the inspections followed the driest two years on record for most of the Wet Tropics and some of the Dry Tropics while other areas had average or above average rainfall, particularly south of Mackay.

In order for this report to be viewed in the context of wider activities in relation to wetlands, other initiatives that are currently in progress, commencing or planned for the near future have been identified in Section 8.

8. Related Initiatives on Fisheries Values of Wetlands in the Study Area

During the course of the research undertaken for this report a number of related initiatives on the fishery and broader values of wetlands have been identified. These initiatives are currently in progress, commencing shortly or being planned. This report needs to be viewed in the context of these initiatives that are summarised below. This summary is based on the information that was available at the time of preparation of this report and is not considered to be an exhaustive record.

- This report should be read in conjunction with the Reef Water Quality Protection Plan (RWQPP). The goal of the RWQPP is "Halting and reversing the decline in water quality entering the Reef within ten years." The primary objectives identified to achieve the goal are to reduce diffuse sources of pollutants in water entering the Reef, and to rehabilitate and conserve areas of the GBR catchment that have a role in removing water borne pollutants. Restoration of wetlands has been linked to the RWQPP as a component activity for improving water quality (Baker *et al*, 2002)
- Capricorn Sunfish has been monitoring barramundi use of wetlands in Central Queensland since 1999 to determine when and how juvenile barramundi access wetlands. This monitoring is ongoing and two reports have been produced.
- The Coastal CRC has recently commenced a project titled "*Contribution of Wetland Habitats to Fisheries Output and Food Chains in the Fitzroy River Estuary*". This project will look at the contribution of wetlands to the fishery production of the Fitzroy River.
- The EPA is currently coordinating a project to map wetlands along the entire Queensland coast and to identify demonstration sites that could be used to promote the benefits of productive wetlands and be used as education tools for the community.
- DPI&F has submitted a proposal titled "*Great Barrier Reef – Freshwater Fish Habitat Strategic Investment Proposal*" (*pers comm.* T Marsden) for NHT funding. This project aims to develop a strategic approach to wetlands management and undertake rehabilitation work on identified key wetlands.
- ACTFR has developed a proposal for NHT funding to look at the tolerance of fish species to low levels of dissolved oxygen. This project is awaiting consideration by NHT.
- Sunfish Queensland, in partnership with the ACTFR, is seeking Envirofund funding for a project titled "*Recognising the Fishery Value of Wet Tropics Coastal Swamp Wetlands*". This project will assess the use of key tropical wetlands by fish and fill some of the knowledge gaps identified in this report. (*NB. This project did not get funded.*)
- WCA is undertaking a project in the Burdekin area to assess grazing as a management tool for control of exotic pasture weeds. This project is not directly related to fish, but addresses both water and habitat quality which are essential to fish.

- The DPI&F is currently working on a policy document for dealing with ponded pastures. It is expected that the document will be available in August 2004.

9. Use of Freshwater and Marine Habitats by Fish Species

Fish species can be categorised by the way they use freshwater and marine habitats during their life cycle. All categories of species are found in the rivers and creeks adjacent to the GBR; however, different species use different habitats to varying degrees. The terminology used to describe their behaviour is:

- Anadromous fish (eg snubnose garfish) spend most of their lives in coastal or estuarine habitat and migrate to freshwater to breed.
- Catadromous species spend most of their lives in freshwater and migrate to saltwater to breed. For example, eels, particularly the longfinned eel (*Anguilla reinhardti*), pacific eel (*Anguilla obscura*) and shortfinned eel (*Anguilia australis*) live in freshwater but breed in the Coral Sea beyond the GBR (Allen *et al*, 2002; Pease *et al*, 2003; Shiao *et al*, 2002).
- Amphidromous species migrate between between freshwater and saltwater but not for the purposes of breeding. For example, mangrove jack (*Lutjanus argentimaculatus*) (*figure 2*) use all habitats from freshwater to offshore coral reefs where they breed (Russell *et al*, 2003).
- Euryhaline species such as bream can tolerate a wide range of salinities without necessarily migrating between freshwater and saltwater to breed.
- Potamodromous species such as golden perch migrate wholly in freshwater and marine species including threadfin and red emperor migrate between different saltwater habitats.

Figure 2: Mangrove jack and barramundi are important species that use marine and freshwater habitats

A total of 79 species have been identified as using both freshwater and marine habitats along the GBR coast within the last 15 years. A complete list of marine species recorded from both freshwater and saltwater within regions of the study area is contained in Appendix 1. A summary of key or representative species and the range of habitats that they use is shown in *table 1*. One example of a marine pelagic fish that inhabit coral reefs and are known to enter freshwater on an opportunistic basis are trevally species (Herbert and Peters, 1995; Allen and Coates, 1990).

The use of wetlands by barramundi is becoming well understood. Juvenile barramundi enter freshwater and brackish wetlands from January to April during local freshwater flows, especially if associated with king tides. Fish sizes generally range from 50 to 450mm. These fish remain in these habitats for 1 or more years before returning to the estuary on subsequent flows (Russell and Garrett, 1983, 1985, 1998; Sawynok, 1998, 2002, 2003). In 1986, Russell suggested a correlation between commercial landings of barramundi on Queensland's east coast and the loss of wetlands (Garrett, 1991) highlighting the need for barramundi to access wetlands and for these wetlands to be protected.

Stocking of marine species, particularly barramundi, has been used to restore fish to freshwater wetlands where they were previously found but have become locally extinct due to loss of connectivity. With artifical breeding of mangrove jack there is some possibility that this species could also be stocked in freshwater wetlands where it is locally extinct. However stocking is unlikely for the full range of marine species that previously used these areas as the full life cycle for many species is not known and artificial breeding of most species may not be possible or be too costly to be economically viable.

There is a matrix of interaction between species across this chain of habitats that shows the necessity for connectivity to allow fish to move between these habitats. Connectivity between these habitats can be affected by both physical and water quality barriers (see Section 10.1 below).

Species	Scientific name	Habitats
Barramundi	*Lates calcarifer*	FW/ES/CS
Mullet	*Mugil spp*	FW/ES/CS
Tarpon	*Megalops cyprinoides*	FW/ES/CS
Giant herring	*Elops hawaiensis*	FW/ES/CS
Milkfish	*Chanos chanos*	FW/ES/CS
Mangrove jack	*Lutjanus argentimaculatus*	FW/ES/CS/RF
Eel	*Anguilla spp*	FW/ES/RF/OC
Jungle Perch	*Kahlia rupestris*	FW/ES

Australian bass	*Macquaria novemaculeata*	FW/ES
Yellowfin bream	*Acanthropagrus australis*	FW/ES/CS
Bull shark	*Carcharhinus leucas*	FW/ES/CS
Subnose garfish	*Arrhamphus sclerolepis*	FW/ES
Forktail catfish	*Arius graffei*	FW/ES
Bony bream	*Nematalosa spp*	FW/ES
Butterfish	*Selenotoca spp*	FW/ES
Archer fish	*Toxotes chatareus*	FW/ES
Glass perchlet	*Ambassis spp*	FW/ES
Trevally	*Caranx spp*	FW/ES/CS/PL/RF
Flathead	*Platycephalus spp*	FW/ES/CS
Whiting	*Sillago spp*	FW/ES/CS
Snapper	*Pagrus australis*	ES/CS/RF
Coral trout	*Plectropomus spp*	ES/CS/RF
Grass emperor	*Lethrinus fletus*	ES/CS/RF
Pinkear emperor	*Lethrinus lentjan*	ES/CS/RF
Nannygai/Fingermark	*Lutjanus spp*	ES/CS/RF
Estuary cod	*Epinephalus spp*	ES/CS/RF
Black spinefoot	*Siganus spinus*	ES/CS/RF
Mackerel	*Scomberomorus spp*	ES/CS/PL/RF
Barracuda	*Sphyreana spp*	ES/CS/PL/RF
Queenfish	*Scomberoides spp*	ES/CS/PL/RF
Javelinfish	*Pomadsys spp*	ES/CS
Jewfish	*Protoibea/Argyrosomus spp*	ES/CS
Threadfin	*Eleutheronema/Polynemus spp*	ES/CS

FW=freshwater ES=estuary CS=coastal PL=pelagic RF=reef OC=oceanic

Table 1: Key species using a range of habitats from freshwater to reef

10.Impacts on the Function of Freshwater Wetlands

There are a range of factors that affect the function of wetlands in relation to their use by fish. While the issue of global warming is acknowledged its affects have not been specifically included; however, the general effect of increased temperatures such as reduced available oxygen, an increase in algal blooms and more variable water supply are likely to have further adverse impacts on freshwater wetlands (US EPA, 1995; Lake *et al*, 2000) and many of these impacts are interrelated with water quality.

10.1. Connectivity

Connectivity is the extent to which fish and other biota can move between different habitat types. The period of time water flows between wetlands, in-stream pools and estuaries and the extent and effectiveness of barriers determines the level of connectivity. In the Wet Tropics there are often permanent flows in rivers and larger creeks that provide continuous connectivity although off-stream wetlands may be isolated for long periods. In the dry tropics most waterways flow intermittently with sporadic connectivity.

The extent of connectivity between freshwater wetlands and the marine system is a primary factor in determining the value of wetlands to marine fish. Physical barriers affect connectivity and in some waterways there are natural barriers such as rock bars and waterfalls. However artificial barriers such as dams, weirs, barrages, causeways and ponded pastures have the greatest impact on connectivity (Anon, 2000). The effect of artificial barriers can range from minor obstacles to completely stopping fish passage (Clague, 1991; White *et al*, 1999). Loss of connectivity can be mitigated by barrier designs that reduce the impact on fish passage or by providing fishways that allow fish to bypass the barrier (White *et al*, 1999; Marsden *et al*, 2003a, 2003b, 2003c).

Barriers not only impact on upstream migration of marine species but can also affect freshwater species (Anon, 2000). During flooding, freshwater species are often washed downstream past barriers and are then unable to migrate back upstream. However, even on barriers where there are fishways adult fish may not be able to use them. In the Burnett River following flooding in 1999 lungfish were trapped in the tidal waters below the Burnett River barrage and could not use the fishway to get back up to the freshwater (Stuart and Berghuis, 1999). Freshwater fish trapped this way may perish when salinity levels return to normal, through reduced oxygen levels in shallow warm water or through predation by birds and terrestrial animals.

There are also less obvious causes for reduction of connectivity. Culverts under roadways may not physically stop connectivity but may effectively block fish passage if the water velocity through these culverts exceeds the swimming ability of fish (Clague, 1991). This effectively prevents or severely limits fish movement through the culvert. Native fish avoid swimming through darkened areas and this has been recognised as a barrier in long culverts (Cotterell, 1998). Water quality can also create a barrier with limited studies showing avoidance behaviour by juvenile fish (Kroon *et al*, 2004) that may prevent access to important habitat. Weeds are also an effective barrier (Perna, 2003).

Changes to hydrology and flow regimes can reduce connectivity. Floodplain drainage lines have been used for irrigation supply channels to assist with farm production in some areas i.e. lower Burdekin. These drainage lines can result in changes to the flow regime from an intermittent flow associated with rainfall to a constant flow throughout the year (Perna, 2003). Many native fish species using freshwater wetlands use natural intermittent flows as spawning and migration triggers and these triggers are therefore affected by constant flows (Anon, 2000). Constant flows may also result in water velocities that inhibit migration. Water running at a velocity of greater that 0.3 metres per second for any significant distance is not conducive to migration as most native fish cannot sustain a swimming speed to overcome the flow (Clague, 1991).

10.2. Water Quality

Poor water quality often results from poor land management (Roth *et al*, 2003). A comparison of flood plumes from a small undeveloped catchment (Ella Bay) and a developed catchment (Johnstone River) is shown in *figure 3*. This highlights the different water quality associated with developed and undeveloped catchments during the same rain event.

Figure 3: Comparison of flood plumes from a pristine catchment (left) and a developed catchment (right)
Photographs © Great Barrier Reef Marine Park Authority

Water quality can be affected by habitat quality, prevailing climatic conditions such as long periods without rain, high temperatures causing evaporation and reduced oxygen concentrations, decomposition of organic material in the water which uses up dissolved oxygen, the composition of soils over or through which the water moves (especially acid sulfate soils), sediment and nutrient loads, in-stream aquatic vegetation and algae, and pollutants such as herbicides and pesticides (Lukacs, 1997).

Water quality is generally the key determinant of the in-stream capacity of a waterway to support fish populations if habitat is suitable. Suitable water quality in a waterway is more likely to hold a healthy population of fish. Dissolved oxygen and water temperatures are the most important factors that affect fish. As water quality deteriorates the population is likely to decrease and change in species composition can occur as some species can tolerate changes in water quality better than others (Perna, 2003).

In freshwater wetlands of coastal GBR waterways, water quality can naturally fluctuate considerably (Hunt and Christiansen, 2000) and many species that use these areas are tolerant of large variations. Chronic low levels of dissolved oxygen and high temperatures have been identified as limiting the range of species in many wetlands (Hogan and Graham, 1994). Bony bream are one species that are sensitive to poor water quality and should be used as an indicator species (Allen *et al*, 2002). The absence of bony bream in a wetland not impacted by connectivity is likely to be attributed to the presence of poor water quality (Allen *et al*, 2002).

Deterioration in water quality beyond that within the range that fish can tolerate often results in fish kills (Veitch, 1999). Bony bream are often the first species to die in fish kills related to water quality (Allen *et al*, 2002) (*pers obs* Sawynok). While some fish kills are a natural occurrence it is likely that their frequency and severity have increased as a result of changes to wetlands functional values and catchment sediment and nutrient loads (Wannamaker and Rice, 2000).

10.3. Habitat Quality

Habitat quality relates to the status of the in-stream habitat and the adjacent riparian and floodplain habitat. Habitat quality is at its best when the area adjacent to and upstream of a wetland is in its natural state. When a wetland has been filled in or shallowed by siltation, choked by aquatic weeds and riparian vegetation has been removed, habitat quality is at its poorest.

Figure 4: Invasion by woody weeds such as pond apple and complete removal of trees from a catchment are two extremes of the impact on riparian vegetation

Habitat quality directly affects water quality. A critical factor in habitat quality is the use of the surrounding land. Generally, large areas of natural vegetation surrounding a waterway will enhance water quality (Bunn *et al*, 1997). Where adjoining land use has removed vegetation but retained a natural riparian zone a buffer is formed between the waterway and the adjacent land use (Johnson *et al*, 1997; Giller and Malmqvist, 1998). Wide natural riparian zones are particularly important for lower order streams and contribute significantly to stream health (Giller and Malmqvist, 1998).

Riparian vegetation supplies organic matter to the food chain and harbour important food sources such as insects (Pearson and Connolly, 2004), acts as a filter for water entering the waterway, provide shade that reduces water temperature and can also provide in-stream cover for fish when trees fall into the waterway (Johnson *et al*, 1997; Giller and Malmqvist, 1998). Many fish species are known to use in-stream snags as cover (Russell and Hales, 1996) and they are recognised as important in both erosion control and as a food source (Giller and Malmqvist, 1998).

Invasive weeds are often the result of riparian zone damage (Bunn *et al*, 1997). These weeds fall into two categories being woody weeds (*figure 4*) and grasses. Woody weeds that are of concern in riparian zones of wetlands adjacent to the GBR include mimosa, rubber vine, pond apple, chinee apple and numerous others. Woody weeds can often out-compete native riparian vegetation as they grow more quickly, seed more prolifically and are more tolerant of a wide range of environmental conditions. Woody weeds can increase erosion as a result of land degradation.

Not all invasive weeds are introduced. In some areas where flow regimes in wetlands have been altered native species such as cumbungi and typha have proliferated and reduced the area of wetlands that fish can use (Perna, 2003).

Aquatic weeds affect both the water quality and the physical area of a waterway available to fish. Weed growth and associated organic loading in the water uses oxygen and reduces the area available for oxygen uptake from wind action. Proliferation of weeds can affect dissolved oxygen levels (Roth *et al*, 2003; Perna, 2003). High nutrient loads can rapidly increase weed growth and result in waterways being choked with weeds and reducing the physical area available to fish (Perna, 2003). Areas of waterways darkened by dense coverage of floating aquatic weeds may inhibit fish use of these areas (Cotterell, 1998). The main issue with these 'darkened' areas is the development of completely anoxic reaches which effectively form chemical barriers to fish movement and also result in the increased liberation of nutrients from the bottom sediment – further exacerbating weed infestation problem (Perna, 2003).

Feral animals, particularly pigs can affect riparian zones by digging up the ground. This can increase sedimentation and nutrients in the waterway if there is rainfall while the ground is dug up and exposed.

10.4. Risks and Threats

There are a wide range of risks and threats that affect the fisheries values of freshwater wetlands. The following is a summary of the risks and threats that were identified in this study:

1. Continuing poor recognition by the broader community of the value of wetlands, especially their use by and importance to fish.
2. Lack of recognition of the importance of wetlands in local authority and catchment management plans.
3. Lack of reference sites that can be used to demonstrate the value of wetlands.
4. Limited knowledge of fish use of some important wetlands.
5. Expansion of residential and industrial land use adjacent to waterways.
6. Practices associated with rural land uses in catchments that may impact on the functioning of wetlands, particularly agriculture and irrigation.
7. Vegetation clearing and changes in land use from grazing to intensive agricultural activities.
8. Litter, rubbish and illegal waste dumping, especially in urban areas.
9. Drainage of wetlands for conversion of land for other uses such as industry and agriculture.
10. Adjacent mining activities.
11. Continuing changes to drainage patterns in catchments and flood mitigation works.
12. Water extraction for rural and urban use.
13. Disturbance and/or exposure of ASS.
14. Large and small barriers to fish migration including tidal barrages, dams, weirs, floodgates, tide gates and road culverts.
15. Reduced ability of fish to migrate as a result of changes in water velocities from “improved” drainage.
16. Impacts on fish migration and spawning triggers due to changes from natural flow patterns associated with use of water for irrigation and power generation.
17. Connection of wetlands by artificial channels and altered flow regimes for irrigation that restrict migration.

18. Use of wetlands for ponded pastures that block fish migration or if they allow fish migration do not support survival of fish (through drying out).
19. Reduction of the extent of riparian zones and degradation through invasion by woody weed such as pond apple, introduced grasses such as para grass, and the impact of feral animals such as pigs.
20. Increase in in-stream introduced weeds such as water hyacinth and hymenacne.
21. Expansion of native aquatic plants such as cumbungi and water lily as a result of increased nutrients and reduced water depths in wetlands.
22. Introduced noxious fish such as tilapia and gambusia.
23. Removal of in-stream cover such as snags.
24. Reduction in water quality, especially dissolved oxygen from increased nutrient loads, algae and plant growth, and water temperatures.
25. Sediment inputs that accumulate and reduce water depths in wetlands.
26. Pesticide, herbicide and other contaminant residuals entering wetlands.
27. Inappropriate fire management practices in and adjacent to wetlands.

11. Wetlands and their Connectivity to the Great Barrier Reef

This section outlines the status of wetlands in the GBR catchment including the extent of habitation by fish species and the importance of these wetlands as a connection between the freshwater and marine environments.

11.1. Wet Tropics Region

The Wet Tropics region, for the purpose of this report, extends from the Daintree River in the north to Ingham in the south. A report prepared for the EPA (formally Department of Environment) in Cairns provides details of waterways from the Daintree River catchment to Cardwell. This report identified key waterways and wetlands and provided rehabilitation priorities. It also identified freshwater fish species using these waterways (Burrows, 1998).

In his series Spinifex and Wattle originally printed in “Queenslander” from 1903 to 1905, early explorer Robert Arthur Johnstone described the Barron District. His reports included reference to “crossing a piece of open forest” after cutting though much thicker vegetation, “shallow, isolated lagoons” which were made muddy to catch the fish and, “a chain of blue lily lagoons” … feet deep where “immersed blacks” hid by using reed stems to breath under the water. From Johnstone’s descriptions of the region, it was a mixture of extensive lowland rainforest and ephemeral and permanent wetlands perhaps much like what is left in remnant areas such as the Mount Coom area on the Tully flood plain.

11.1.1. Daintree River to Mossman

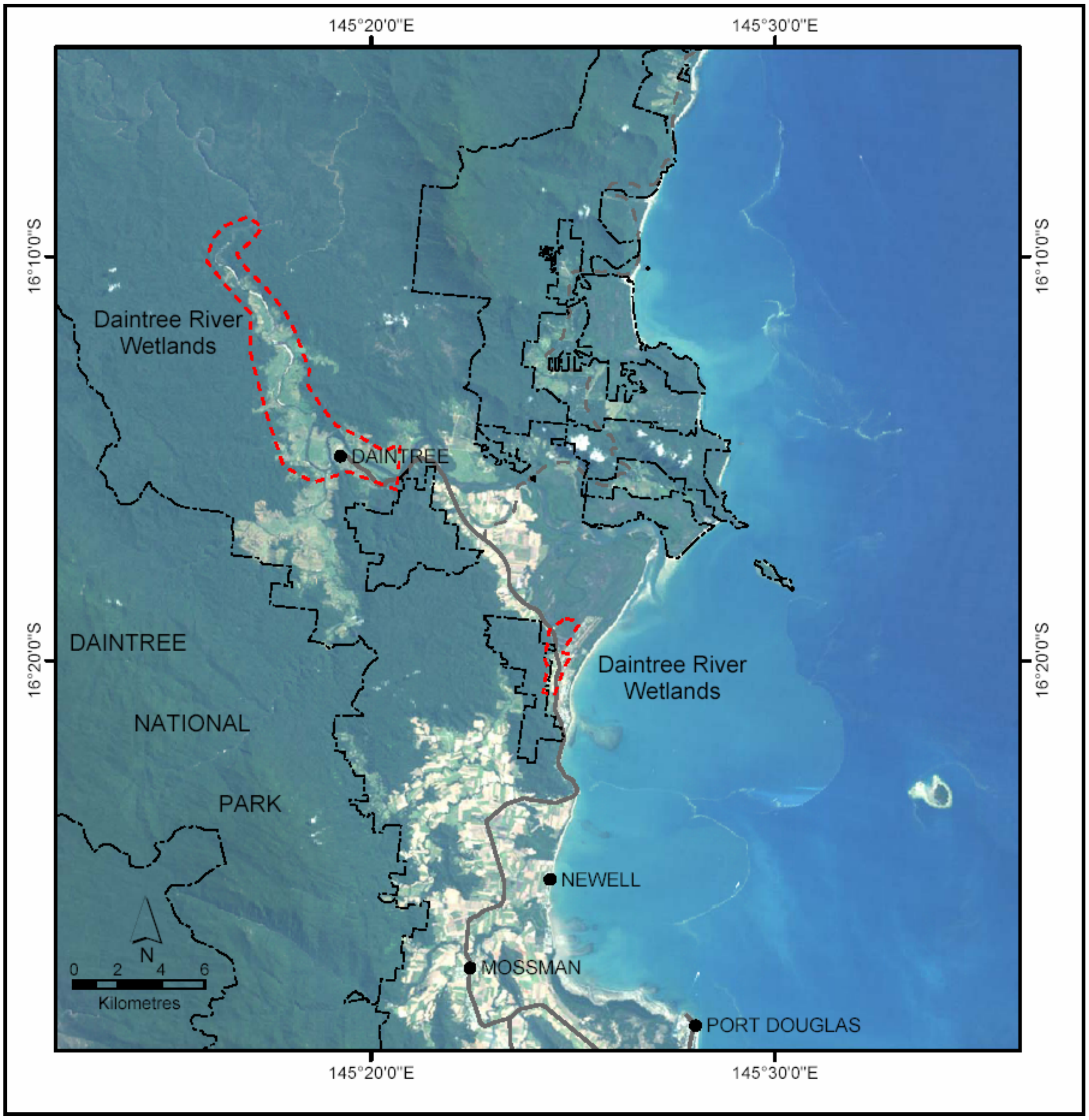


Figure 5: Wetland areas associated with the Daintree River

North of Cairns there are few off-stream wetlands remaining that are significant to fish. While the Daintree River is a permanent flowing river it is considered to be the most important freshwater habitat for marine and freshwater species in this district (Russell *et al*, 1998). Its upper reaches are in pristine rainforest that is part of the WTWHA and is protected from future impacts. While the lower reaches have been developed along the narrow floodplain the condition of the riparian zone varies from good to non-existent.

The Daintree River has some of the best examples of tidally influenced freshwater wetlands in the Wet Tropics but they are relatively narrow and confined within the lower banks of the river. The riparian zones in the developed middle section of the catchment are not contiguous. In many areas the vegetation has been cleared to the water's edge for agriculture and grazing. The Daintree River has a large oxbow lagoon in its middle reaches that is separated from the main river. This is now a melaleuca swamp with no permanent deep water that could be suitable for fish. Invasive weeds, including para grass and pond apple, dominate the understorey. This wetland presently has limited fishery values but in heavy rain may still function effectively as a sediment and nutrient trap (*pers obs* Veitch).

An important but presently degraded wetland area remains in the upper reaches of the south arm of the Daintree River. It is sited behind beach sand ridges adjacent to the Wonga Beach township (*figure 5*). Strong consideration should be given to restoring and protecting this area as it is a high profile site that could be used as a demonstration site for the district.

The Daintree River remains important to fish as connectivity with the estuarine part of the river has not been altered and there are no impoundments on the river. A survey of fishery resource identified 132 fish species in the Daintree River, Saltwater Creek (*figure 6*), Mossman River and Mowbray River catchments (Russell *et al*, 1998). Of these at least 20 use both freshwater and marine habitats.

Figure 6: Well shaded freshwater section of Saltwater Creek in the Mossman area

Both the Mossman and Mowbray Rivers are also important freshwater resources for fish. In-stream habitat is mostly only lightly impacted; however, riparian vegetation is confined to between the banks of the streams in many areas of the floodplain. Of concern are the numerous culverts (*figure 7*), most of which are likely to make fish passage difficult except in major floods. Invasive weeds including hymenacne, para grass, Singapore daisy and a range of other weeds narrow the waterways at critical flow points.

Figure 7: Culvert with high velocity water flow that reduces fish migration on a Saltwater Creek tributary

The original extent of wetlands in the Douglas Shire could not be established and the relatively short catchment areas may have restricted the original extent of natural freshwater wetlands. It is likely, however, that changing river courses would have resulted in some remnant lagoons. There are no natural off-stream wetlands that are significant to fishery resources remaining in the district.

Presently, the Douglas Shire Council promotes a high level of environmental awareness and there is little threat of further destruction of waterways. Restoration projects to re-establish quality habitat areas along watercourses are strongly encouraged within Douglas Shire.

As there are no off-stream wetlands of significance remaining in the Daintree and Mossman River area that presently have fishery values, the perceived risks or threats to off stream wetlands are limited. However, the freshwater reaches of waterways are therefore of high importance and a number of risks and threats to these areas are identified. They are:

1. Continued pressures on the riparian zone from adjacent land use and pest animals such as feral pigs.
2. Increase in in-stream weeds such as para grass, Singapore daisy, hymenacne, pond apple and numerous other invasive species.
3. Culverts that impede fish migration.
4. Expansion of horticulture where many crops require higher levels of pesticides, herbicides and fertilisers, and management practices may increase sheet soil erosion.

On-farm improvements on cane farms have been extensive in the district but habitat restoration projects are still limited in extent. Restoration of the wetland at Wonga Beach would benefit fishery resources. Major improvements to fish productivity could also be achieved through improvements to passage at culverts to reduce water velocity during flow periods and through an intensive, in-stream weed management program.

11.1.2. Barron River and Trinity Inlet

The City of Cairns has the largest population in the Queensland Wet Tropics. Its land use is highly diversified with some extensive rural areas and other highly developed residential, tourist and industrial areas. Impacts on wetlands are complex and are related to adjacent land uses. Only very small remnant pockets of the habitat described by Spinifex and Wattle now remain and no freshwater wetlands, other than in-stream habitat such as Lake Placid on the Barron River, could be found in the Barron district that may be significant to fishery resources (*figure 8, 9*).

Some native fish species continue to occupy various habitats but the full diversity of native fish is restricted by poor habitat quality and the inability of most fish species to negotiate degraded sections linking areas of good habitat (*figure 10*). Such degraded habitats cannot sustain healthy and diverse fish populations due to inadequate food supplies and subsequent water quality impacts including anoxic water (Bunn et al, 1997). These areas are likely to suffer significant problems from mosquitoes and other disease vectors that can thrive in such habitat and require expensive, and environmentally damaging pesticide control programs that further increase the impact on native fish. Introduced fish species such as tilapia and gambusia thrive in these degraded urban aquatic habitats (*pers comm*. John Russell).

Large areas around Cairns including East Trinity (Fitzpatrick *et al*, 1999), Earl Hill (Skells, 2000) and parts of Cairns City are underlain by coastal acid sulfate soils

(ASS). East Trinity has been used to investigate the impacts of large scale ASS disturbance including a 3 year study by CSIRO (Fitzpatrick *et al*, 1999).

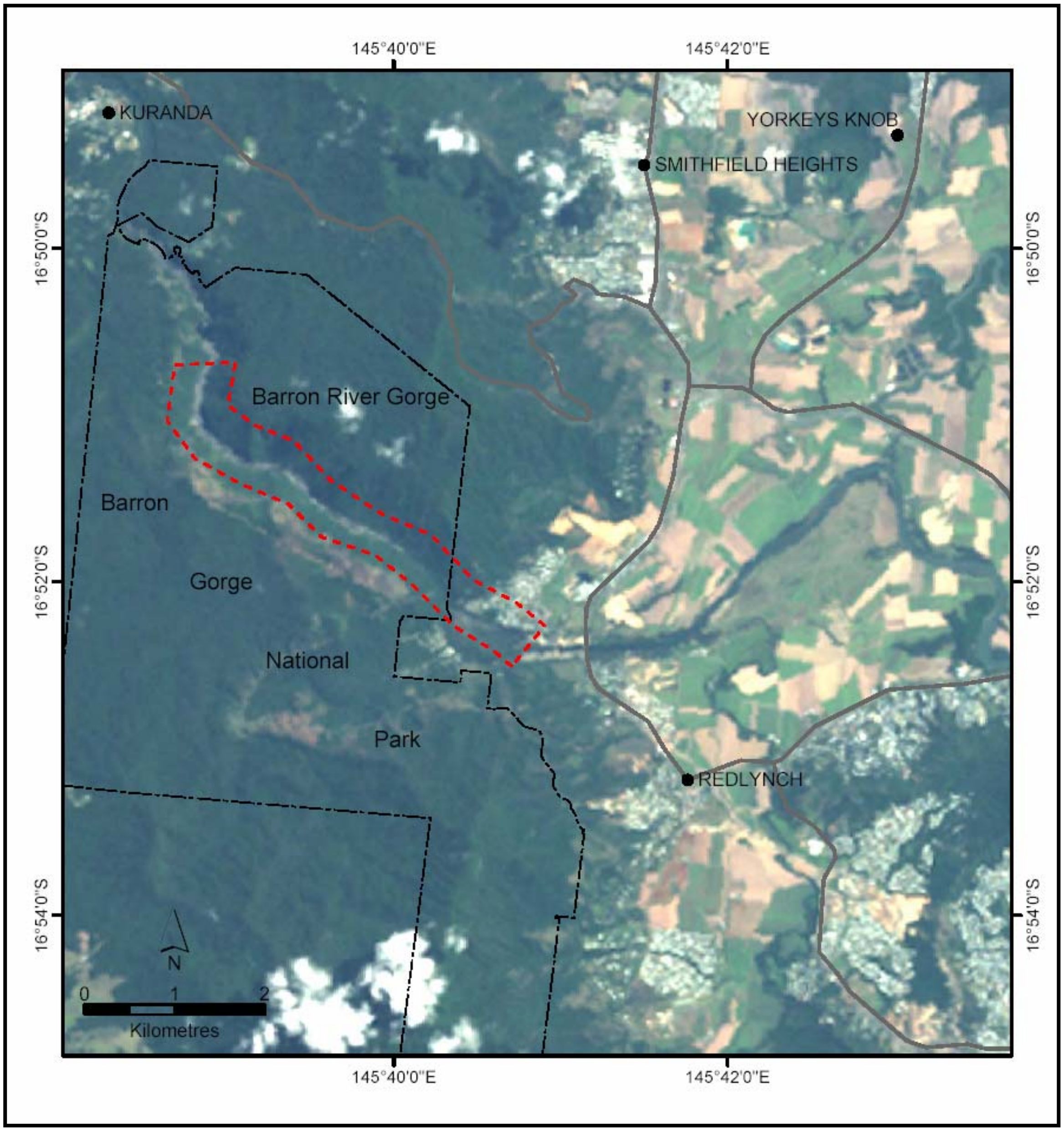


Figure 8: Wetland area on the Barron River

Despite extensive studies on land degradation and other environmental impacts, very limited studies have been undertaken in tropical areas on impacts affecting fishery resources despite acknowledgement that acid production at East Trinity was two orders of magnitude higher than for estimated rates in Northern NSW (Fitzpatrick *et al*, 1999). Unlike seawater, freshwater has limited buffering capacity to neutralise acid production but impacts in North Queensland have not been documented.

Figure 9: Outflow from Lake Placid into the Barron River

Figure 10: Middle reaches of Freshwater Creek in Cairns choked by para grass

Risks or threats to The Barron River wetland areas:

1. Residential development further reducing riparian vegetation.
2. Residential and industrial development in the lower reaches.

3. Disturbance and/or drainage of ASS.
4. Invasive weeds, particularly para grass.
5. Nutrient contamination from catchment run-off.
6. Sedimentation from upstream erosion.
7. Pesticide, herbicide and/or industrial pollution.

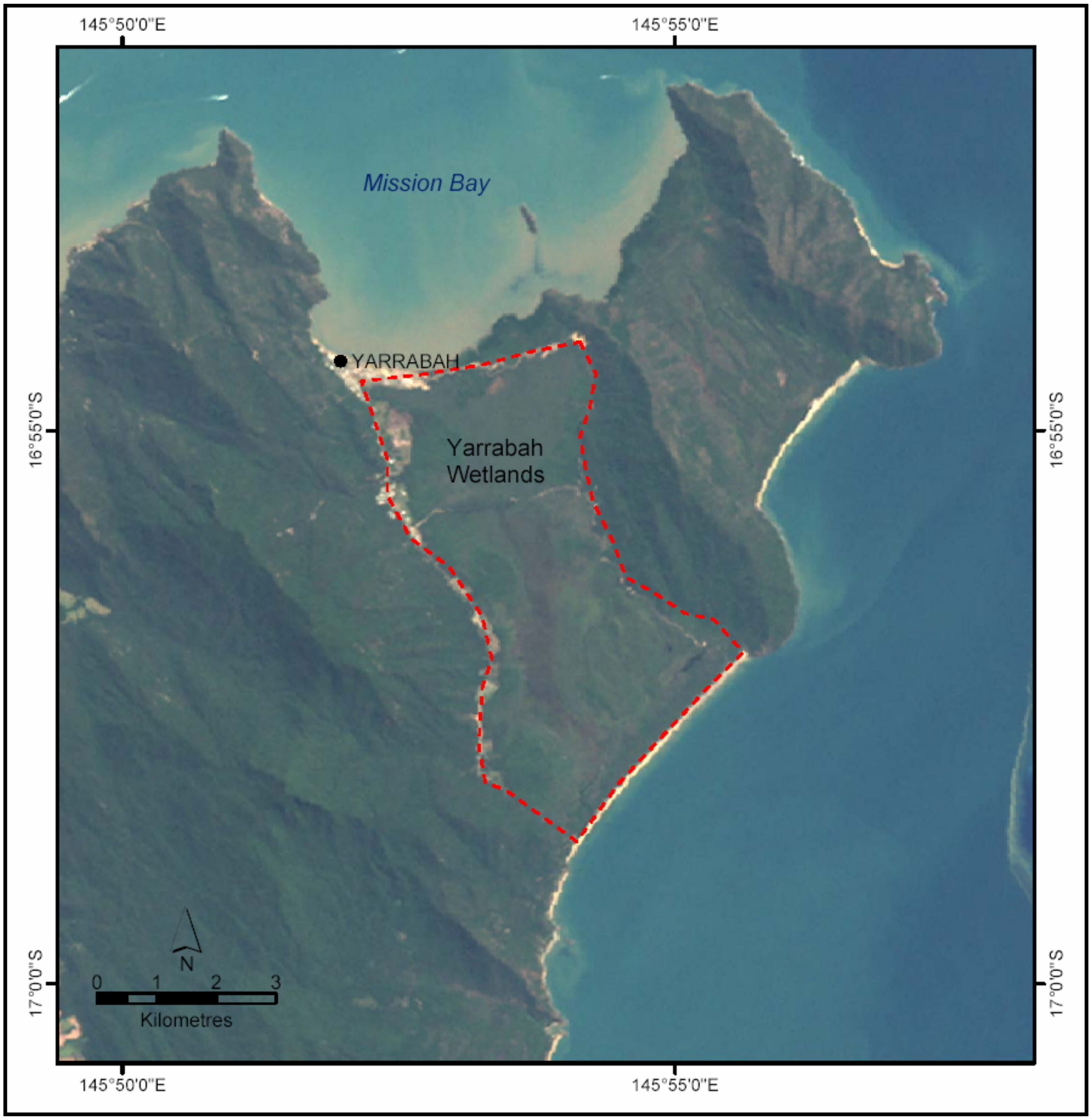


Figure 11: Yarrabah wetlands

The wetlands in the Yarrabah area (*figure 11*) are almost pristine with the only impacts arising from increased access by mostly traditional owners using modern transport. Impacts from development in the catchment are considered to be negligible. The main threats to these wetland areas are the natural threats that apply to most wetlands such as fire, introduced weeds and feral animals such as pigs. No study of the use of these wetlands by fish species has been undertaken.

11.1.3. Russell and Mulgrave Rivers

Figure 12: Mulgrave River lagoons

Unlike the Barron River, the Russell and Mulgrave River catchments are dominated by rural land uses although there is an increasing expansion of residential development from the Cairns City area. Both the Russell and Mulgrave Rivers have had extensive development of intensive agriculture, particularly sugar cane, in their middle and lower reaches while the upper reaches are well protected by world heritage listing of wet tropical rainforests. Both rivers maintain natural connectivity but some in-stream habitat values have been lost due to reduced riparian vegetation and intensive land use such as grazing and cropping that result in sedimentation and changes to the natural habitat (Rayment and Bohl, 2002).

Despite the regular heavy rainfall experienced in the area, the lower floodplain areas have been extensively drained and cleared. Where the area was once dominated by lowland rainforest and wetlands, there is little remnant habitat remaining. There are three deepwater off-stream wetlands, referred to as the lower Mulgrave lagoons (*figure 12*), remaining on the Mulgrave River immediately adjacent to the present course of the river upstream of Deeral Landing. Above Gordonvale, there are numerous in-stream ponds of varying depth that continue to have high fishery values.

Figure 13: Part of the wetlands in Eubanangee Swamp

The Russell River has similar impacts to the Mulgrave River and they join together before entering the GBR Lagoon at Mutchero Inlet. There is less likelihood of large-scale residential development on the Russell River in the foreseeable future. The Russell River has lost some important wetland areas such as Babinda Swamp.

Eubenangee Swamp (*figure 13*) joins the Russell River through the Alice River and numerous agricultural drains. Water quality in the Alice River after early season rain was particularly turbid. Eubenangee Swamp has undergone significant hydrological and drainage changes as a result of adjacent development of intensive agriculture. There are numerous farm drains that result in faster run-off into the swamp and then drain the area more quickly than was the case before development. Eubenangee Swamp has an artificially lowered water level that results in reduced surface area during dry periods and reduced water quality. Drainage from adjacent upstream land use is likely to have resulted in increased sediment and nutrient loads flowing into this wetland. Eubenangee also suffers from terrestrial and water weed infestations.

Eubenangee Swamp is likely to have maintained its fishery values although no specific assessment of fish use of the area has been undertaken. Due to the loss of similar habitat in the catchment, the importance of Eubenangee to fishery values is significant. Eubenangee Swamp is protected from any further on-site impacts due to its declaration as a national park.

The fish resources of the Russell-Mulgrave Rivers were assessed by Queensland DPI in 1996. A total of 94 species were recorded of which 56 were found in the estuary, 29 in the freshwater tidal areas and 33 on the floodplain (Russell *et al,* 1996b).

Risks or threats to remaining wetlands on the Russell and Mulgrave Rivers:

1. Increased residential development.
2. Sediment and nutrient inputs from adjacent and upstream land use.
3. Continued reduction on the riparian zone from encroaching land use.

Risks or threats to Eubenangee Swamp:

1. Lack of knowledge of the use of this area by fish;
2. Invasive terrestrial and aquatic weeds;
3. Nutrient enrichment from adjacent farms;
4. Introduced noxious fish species;
5. Lowering of water levels by drainage works on adjacent properties;
6. Poor water quality affecting both the wetland and the Alice River below it.

11.1.4. Wyvuri and Ella Bay Swamps

Wyvuri and Ella Bay swamps (*figure 14*) are significant areas because there are only a small number of similar wetlands within the Wet Tropics area of the GBR. Wyvuri Swamp is a small catchment that is bounded by the Graham Range and drains into the GBR Lagoon through a small coastal estuary. It does not feed a large riverine ecosystem and the range of habitats available to fish between the shallow melaleuca wetland areas and the estuarine areas is significantly less than in other adjacent areas such as the Russell-Mulgrave floodplain.

Despite its relative isolation, Wyvuri Swamp has been significantly degraded. At its southern end (*figure 15*), access to the swamp is along sealed roads that lead to the Brampston Beach community. Wyvuri Swamp has been grazed extensively and suffers from invasion by para grass and other common weeds associated with grazing. It has been mined for sand in places and partly drained for horticulture. At its southern end, Wyvuri has been burned apparently igniting the underlying peat and risking stability of the surface area. Most of Wyvuri Swamp is privately owned with approximately 20% of the area in national park at the northern end. There has been no assessment of fish use of Wyvuri Swamp.

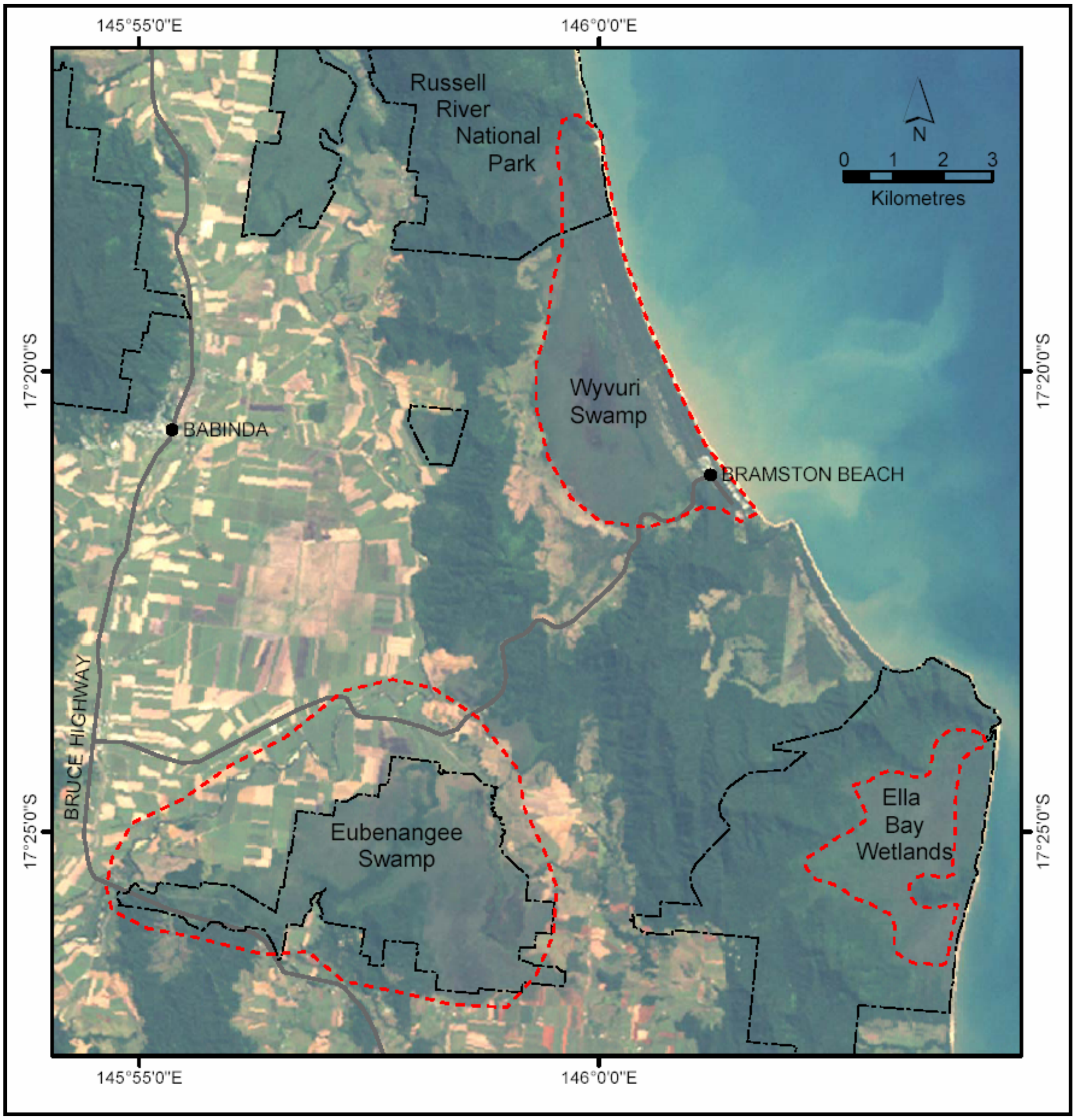


Figure 14: Eubenangee Swamp, Wyvuri Swamp and Ella Bay wetlands

Risks or threats to Wyvuri Swamp:

1. Lack of knowledge of the use of this area by fish.
2. Disturbance of ASS.
3. A potential tourist development in the area adjacent to Brampston Beach.

4. Burning of underlying peat.

Ella Bay swamp is located approximately six kilometres further south from Wyvuri and is enclosed by the Seymour Range which comprises its catchment. It is bounded on the coast by a beach sand ridge. Although smaller in area than Wyvuri, Ella Bay is similar in character draining through a small estuary. Ella Bay is pristine with negligible development in the catchment and no road access. Access limitations prevent an on-ground assessment of habitat condition for this report and there are no studies on use of the area by fish.

Figure 15: Southern end of Wyvuri Swamp

Ella Bay is a declared national park and although there are no perceived anthropogenic threats monitoring should be undertaken to ensure that invasive plants do not become established and feral animals do not cause environmental harm. Ella Bay could be assessed and used as a benchmark for habitat quality in other similar wetlands.

11.1.5. Johnstone Rivers

The Johnstone catchment stretches from the headwaters between the Russell and Johnstone Rivers south to Maria Creek and is situated in the Queensland wet tropical coast. The upper reaches of the North and South Johnstone Rivers are in the Great Dividing Range in the WTWHA and they are similar in habitat to the upper reaches of the Russell and Mulgrave Rivers. The floodplain is relatively short and confined, although in major floods the Johnstone River can link to the Moresby River to the south.

The North Johnstone River has been impacted by reduced riparian vegetation in its lower freshwater reaches that will progressively reduce in-stream habitat (Bunn *et al*, 1998) and increased sedimentation resulting in reduced depth of the river bed. The South Johnstone River has been similarly impacted with land clearing increasing sediment loads as evidenced by a large fish kill in the river in February 2004 that was attributed to suffocation by sediment (EPA, 2004).

Figure 16: Sand dam on the South Johnstone River
Photograph © G Vallance

Fish access to in-stream habitat in the South Johnstone is reduced due to a DNRM&E licensed sand dam built annually in the river for water extraction (*figure 16*). This sand dam may also contribute significantly to the available sediment load in the South Johnstone River in early wet season rain events. Three exotic fish species, including tilapia, have been recorded from the Johnstone River (*pers comm*. J Russell).

Apart from in-stream habitat, the only remaining wetland with potential fishery values that drains into the Johnstone River is at the top end of Ninds Creek adjacent to Etty Bay Road (*figure 17*). It is known locally as the Bulkuru Swamp and much of it has been drained and cleared, however it still has some extensive areas of melaleuca and palm vegetation. Drainage has resulted in a reduced level of permanent water in this wetland and its value to fisheries has been significantly diminished. The area drains under Etty Bay Road through a culvert and there are signs such as iron flocculation and concrete corrosion that are associated with ASS (*figure 18*). Further downstream, there is an outlet for a sewage treatment plant that is a nutrient source for lower reaches of the creek and the Johnstone River. Culverts are barriers to migration in most flow events.

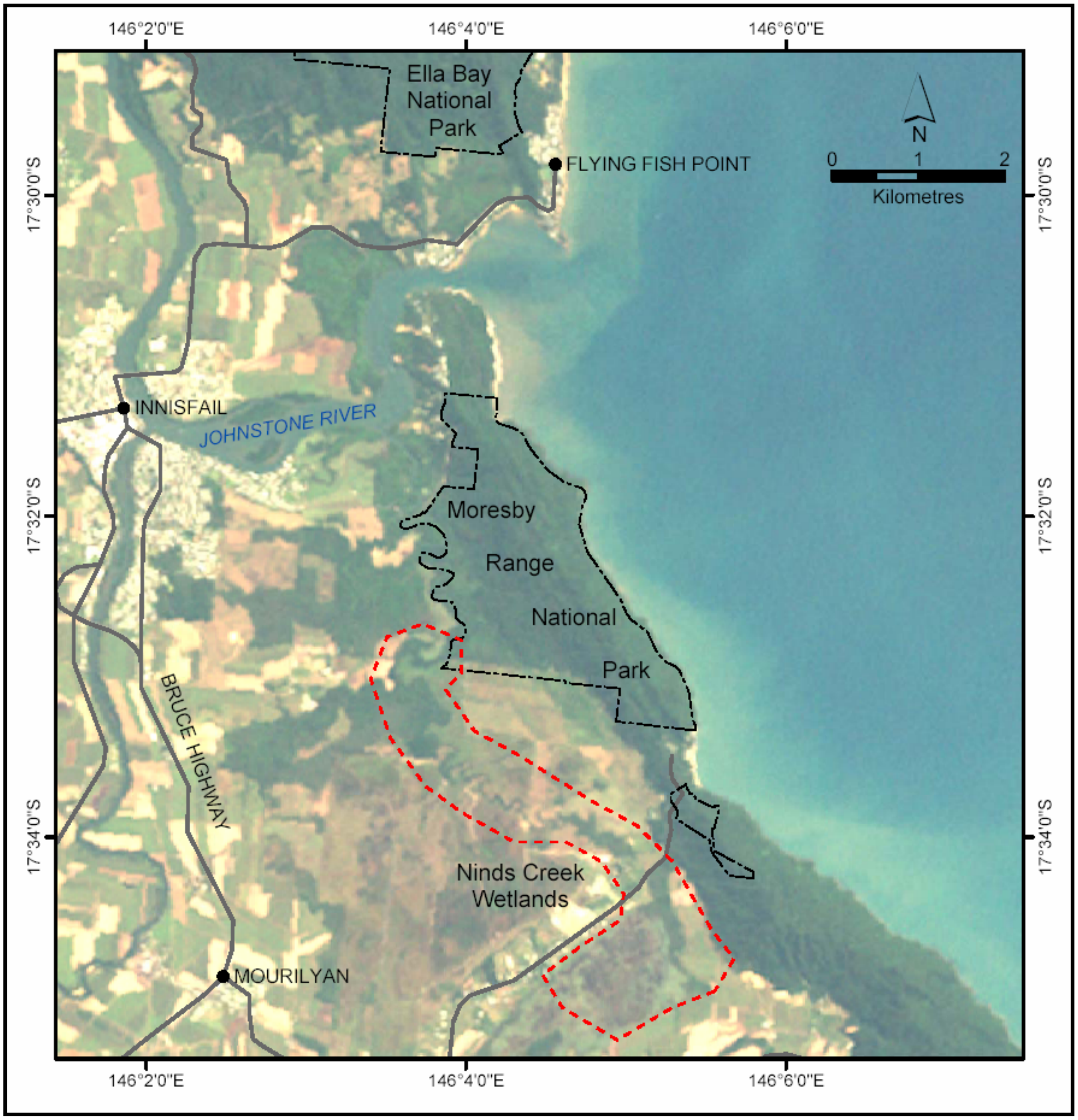


Figure 17: Ninds Creek wetlands south of Innisfail

Other remnant wetlands such as an area near the airport are heavily impacted and cannot presently be considered significant to fishery resources although they serve a role in mitigating water quality impacts from other catchment uses. There is a swampy area in the centre of Innisfail that is badly overrun with pond apple and has strong signs of acid sulfate soil disturbance. There is an opportunity to develop a large freshwater wetland with connectivity to the North Johnstone River in this degraded area and its location would assist in raising awareness of the benefits of wetlands.

Figure 18: Crossing on Ninds Creek below Bulkuru Swamp showing iron flocculation and concrete corrosion associated with drainage of ASS

Risks or threats to Ninds Creek wetlands (Bulkuru Swamp):

1. Lack of knowledge of the use of this area by fish.
2. Invasive weeds, exotic fish and feral pigs.
3. Further exposure of ASS and ongoing impacts of ASS run-off downstream into the estuary.
4. Further draining for flood mitigation.
5. Impacts from treated effluent release from the sewage treatment plant.

11.1.6. Moresby River to Hull River

This district includes the Moresby River, Liverpool Creek, Maria Creek, Hull River and numerous smaller creeks. The freshwater reaches of the creeks and rivers are badly degraded, with riparian vegetation completely removed in many areas and too narrow or thin to be of value in others. In-stream habitat for fish in this area has been significantly degraded by land clearing and drainage works on the coastal floodplain, resulting in sedimentation and altered hydrology affecting water courses. Wetlands have been modified by drainage works to benefit agricultural land use within the catchment.

Cowley Beach to the north and south of Liverpool Creek has two significant wetland areas. The shallow black water swamp at Cowley Beach drains north into Mourilyan Harbour (figure 19). It is subject to saltwater intrusion could be as a result of relative sea level change but is more likely due to the dredging and deepening of the mouth of Mourilyan Harbour, resulting in larger volumes of tidal exchange entering the inlet as has occurred at other sites where dredging has been undertaken (MHL, 2002). The use of this wetland above the tidal limit by fishery resources has not been studied.

Figure 19: Cowley Beach wetlands near Mourilyan Harbour

Cowley Beach South wetland has a different character and is characteristic of an ephemeral wetland that appears to be landlocked by beach sand ridges except in heavy rain events. Whilst impacts on this wetland appear minimal from aerial photography, it is likely that the natural landscape would see use by fish restricted to flood events.

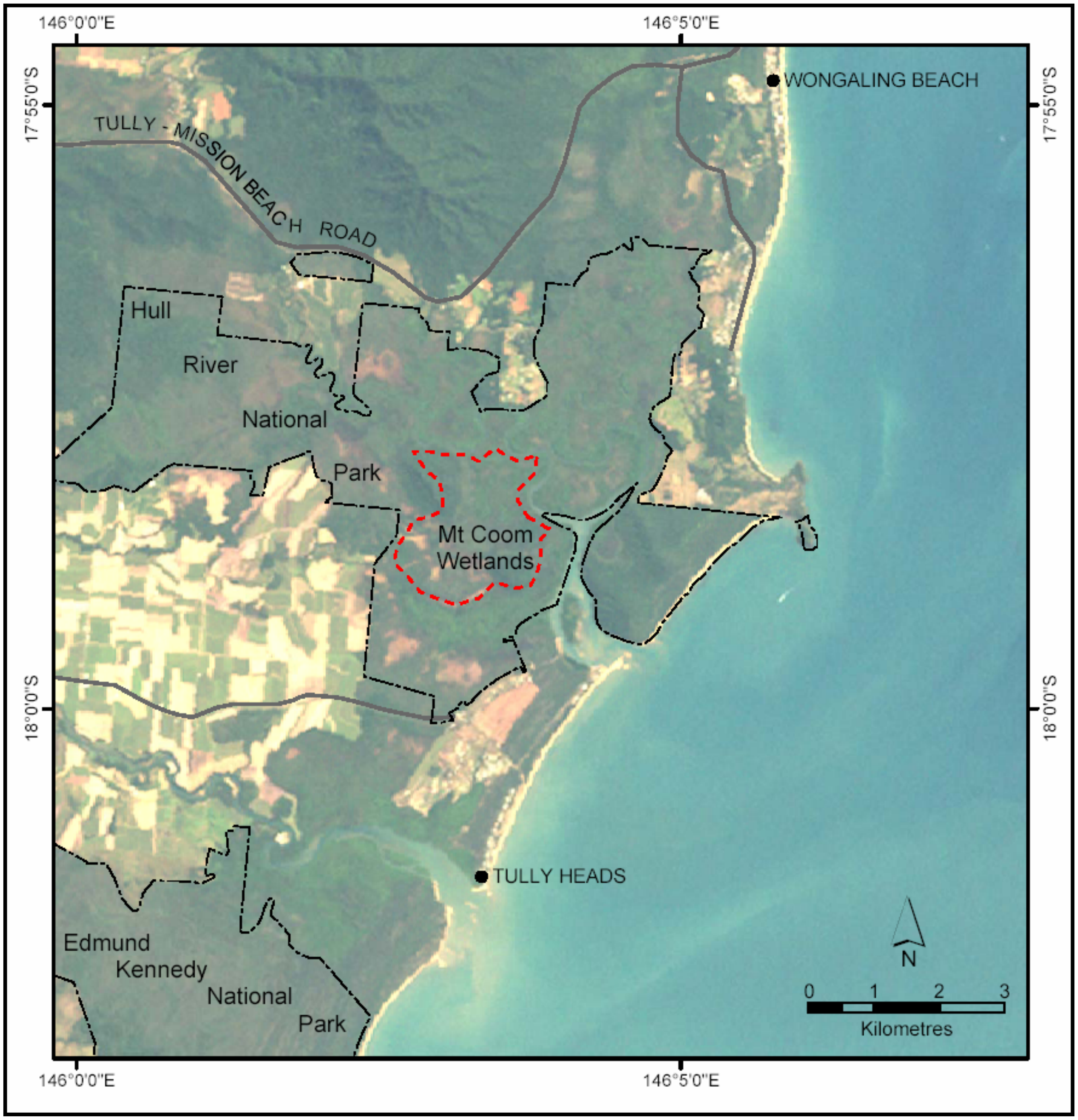


Figure 20: Mount Coom wetlands adjacent to the Hull River

The fishery resources of Liverpool Creek, Maria Creek and the Hull River (figure 20) have been assessed with 134 species recorded of which 16 species were recorded in both freshwater and saltwater (Russell and Hales, 1997). There are no significant barriers to fish migration on these waterways although improved drainage for agriculture is likely to have changed the water velocity in flood events that, in addition to water quality issues, may impact on migration.

The Hull River is primarily estuarine although it has large freshwater areas and off-stream wetlands above tidal influence. The in-stream habitat in the North Hull River and the Hull River catchments are both likely to be significant to fishery resources although catchment impacts have reduced the diversity and extent of habitat available due to sedimentation, nutrient inputs and the loss of dense riparian vegetation. However, in most areas, some riparian vegetation remains and provides large stretches of creeks with habitat for fish. Carmoo Creek and upper reaches of the Hull River have in-stream habitat areas for fish. In flood events the Tully River overflows into the Hull River.

Figure 21: Brackish wetland at Mount Coom adjacent to the Hull River

Remaining areas of low lying ephemeral and permanent wetlands adjacent to tidal areas of the Hull River, particularly around Mount Coom (figure 21), may be important off-stream wetlands of significance to fish in this catchment. While topographical maps show nearly all of this area to be mangroves, there are large areas of melaleuca and bulkuru swamp and some areas of open water above the tidal limit. Anecdotal information reports large numbers of barramundi in this wetland during flood events (pers comm. J Galliano) and during a brief visit to the area numerous fish species including gudgeons, mullet and rainbow fish were observed. There was evidence of the use of this area by numerous native fish species suggesting a healthy ecosystem.

Presently, there is no suggestion of expansion of agriculture into these areas although a large part of it is privately owned. The impact of adjacent agricultural land use is currently minimal due to the nature of the soils, relatively small sub-catchments and shallow drainage. Local landholders are taking a leading role in managing this area including encouraging wildlife through maintenance of vegetation buffers and corridors and controlling feral animals and plants.

In drier areas within this wetland complex, fire has destroyed some underlying peat. According to locals, the fire was reportedly part of the management program for the area but once the peat ignited, it was unable to be controlled or extinguished until heavy rain intervened. The fire was reportedly deliberately lit to reduce the fuel load at ground level, however this has not been achieved as the peat has collapsed, killing many large trees and causing them to fall over. The fuel load has increased significantly over what was observed in adjacent unburnt areas. This area and Wyvuri Swamp have both been degraded in a similar manner. It is strongly recommended that fire should not be used for fuel hazard reduction in or near peat wetlands.

Risks or threats to Mount Coom wetland:

1. Lack of knowledge of the use of this area by fish.
2. The impacts of fire on the underlying peat.
3. Invasive weeds and feral pigs.
4. Agricultural, residential and tourism development.

11.1.7. Tully and Murray Rivers

The Cardwell Shire has a network of wetlands that represent the best of what remains in the Queensland Wet Tropics at a catchment scale providing an insight into how a much larger area from Ingham to Daintree may have once interacted with the GBR lagoon. The Tully and Murray floodplain has the most extensive areas of off-stream freshwater wetlands of importance to fishery resources remaining in the Wet Tropics.

The Tully River is the main river system on this part of the floodplain and has high rainfall throughout its catchment. Its headwaters are in the WTWHA. The Tully River has few tributaries on the floodplain and overflows extensively into the Murray River in its middle reaches and the Hull River in the lower reaches during large flood events.

The Tully River is typical of many larger rivers in that during flood times it is distributary to the floodplain (Summerfield, 1991). In-stream habitat in the Tully

River has been affected by a range of impacts from artificial bank stabilisation to sedimentation as a result of land clearing.

Figure 22: Lagoons and wetlands on the Tully-Murray floodplain

Koombooloomba Dam is located in the upper reaches of the Tully River but has minimal impact on fish migration as it is above a large natural waterfall. It causes the Tully River to have an artificial flow regime due to daily releases from the dam for electricity production and white water rafting. The impact of these modified flows has been the subject of investigation as there is concern that it is affecting spawning sites for Sooty Grunter (Digman, 2003; *pers comm*. A Hogan). The impact on other species is unknown and has not been investigated. The Tully River still has a wide variety of habitat available to fish.

The Murray River also starts in the WTWHA but has a much smaller catchment than the Tully in its upper reaches with less rainfall. Although the Murray River receives floodwaters from the Tully River and tributaries on the floodplain, it is also distributary in its middle and lower reaches and even in moderate rainfall it backflows into many of its feeder creeks and some permanent wetland areas. The Murray River suffers from sedimentation and the impact of this muddy water on fish productivity in a stream that once ran clean for most of the time is unknown but potentially significant.

Despite extensive clearing for agriculture, there are still large areas of ephemeral and permanent melaleuca and bulkuru wetlands. An extensive network of permanent deepwater lagoons still remains although there is a range of impacts that, in many cases, degrade their suitability as fishery resources. This network of lagoons is the most significant wetlands to fishery resources remaining in the Wet Tropics section of the Queensland coast. The main wetlands are complemented by a network of smaller natural and artificial lagoons, some of which have been developed primarily to reduce the impacts of adjacent farming by acting as sediment and nutrient sinks, flood detention basins or both.

Permanent wetlands between the Tully and Murray Rivers (*figures 22 and 23*) include:

1. Raccanello Lagoon
2. Jalum Lagoon
3. Bunta Lagoon
4. Boar Creek wetland
5. Kyambol Lagoon
6. Selby's Lagoon
7. Lillipocket Lagoon
8. Blue lagoon
9. Hassell Lagoon
10. Barretts Lagoon

Some of the above lagoons have been surveyed for fish by DPI&F, however formal reports are not currently available detailing the species. It is expected that species would be similar to those found in the survey of the adjacent Hull River.

Numerous other lagoons have high fishery values including the network of artificial lagoons on the Digman property (Digman, 1996), which have the highest diversity of fish species of any lagoon on the floodplain (Hogan, 2000).

A total of 10 marine species were identified in the lagoons along with 14 freshwater species (Hogan, 2000).

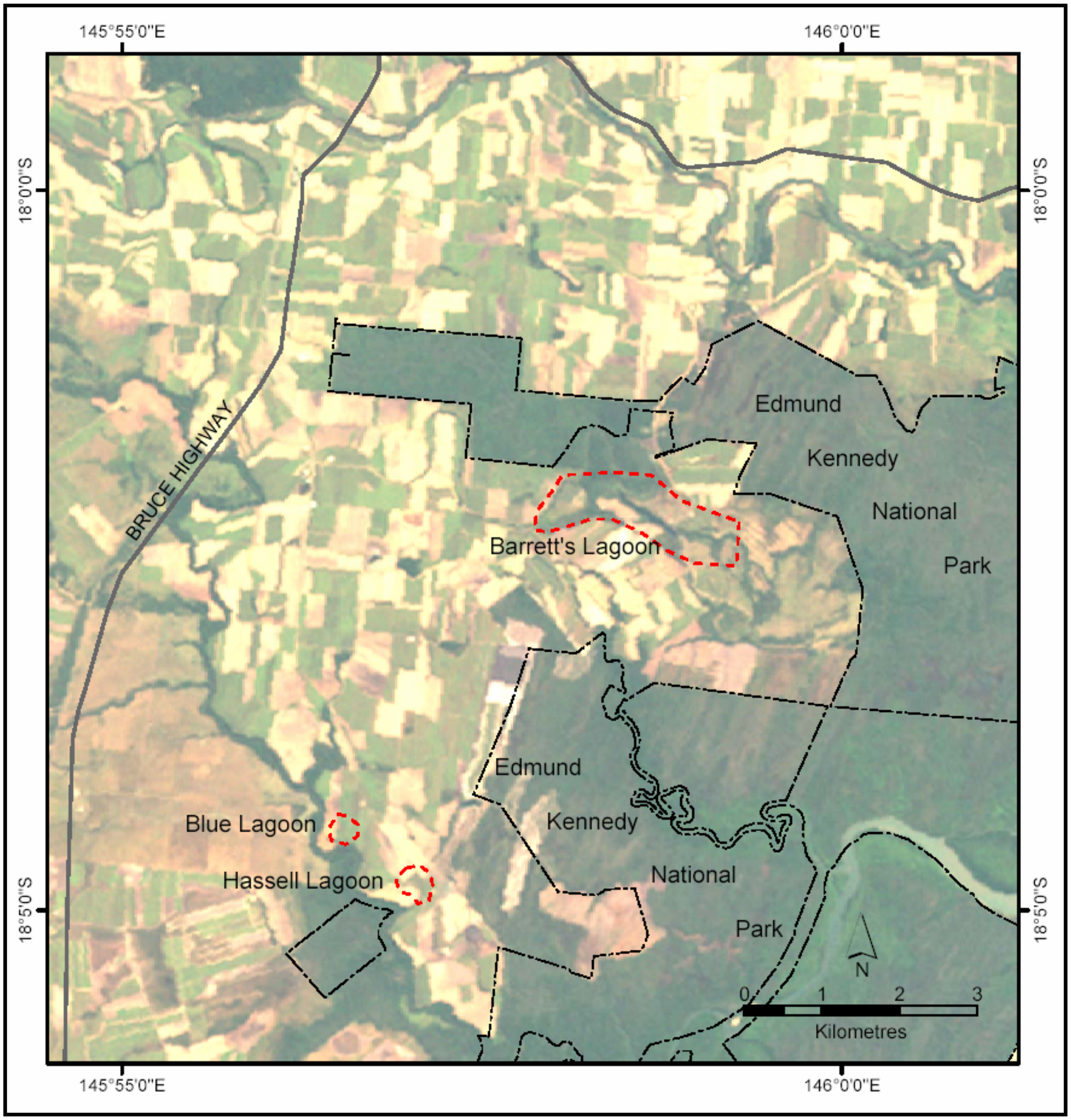


Figure 23: Barrett's Lagoon, Blue Lagoon and Hassell Lagoon on the Murray River floodplain

A description of the floodplain and the full range of impacts on it was described in detail during the SIIP planning process (Tait, 1994); however, further development has taken place since that time. While the district has suffered from numerous minor fish kills over the last five years, a better indicator of chronic long-term problems is the reduced diversity of fish species in many remaining wetlands, probably as a result of water quality and habitat quality impacts from upstream land use and/or changed downstream hydrology affecting fish passage.

An inspection in December 2003 identified that the Tully/Murray floodplain suffers from a wide range of introduced woody weeds and grasses including but not restricted to pond apple, mimosa, chinee apple, lantana, rubber vine, hymenacne, para grass and aleman. Woody weeds are also affecting hydrology, increasing sheet, bank and gully erosion and, in some areas, effectively reducing the nutrient removal role that deep-rooted trees have on groundwater (Johnson, 1997).

Drainage works, including paddock drainage such as coil pipes and deeper canal drainage, impact significantly on the fishery values of freshwater wetlands (*pers comm*. R Digman). Groundwater drainage carries mostly deoxygenated water from the paddocks into adjacent surface drainage networks (Rayment and Bohl, 2002) that, in some cases, drain into areas occupied by fish. This deoxygenated water can lead to fish kills and is likely to be a cause of sub-lethal stress that can reduce the productivity of the fishery. Deep, surface drainage reduces the detention time of surface waters and therefore increases sediment and nutrient transportation (Rayment and Bohl, 2002). Most of the drainage network, whether natural or artificial, has little or no riparian vegetation. In areas that have extensive groundwater drainage it may be beneficial to install rock areas in the bed of drains to increase water aeration (Hunt and Christiansen, 2000).

Figure 24: Cheerin Creek on the Tully River floodplain in the King Ranch area

In many cases, major drainage works impact significantly on the large remaining natural wetlands in the area (Tait, 1994). Outlet points at some waterholes such as Bunta and Jalum Lagoons are two metres or more below their natural height. This effectively reduces the depth and volume of water in the lagoons. Reduced water volume results in higher and increased fluctuations in water temperatures and reduced dissolved oxygen levels (Tait, 1994), less dilution of contaminants, increased risk of algal blooms and increased invasion of introduced grasses. Consideration should be given to reinstating the normal discharge levels of the remaining natural lagoons.

Recent land clearing in the King Ranch area of Cherrin Creek (*figure 24*) at the top of the catchment has reduced its flood retention capacity. This area drains into the Murray River and since being cleared and having drainage improved, the area now suffers from significant levels of sheet erosion. Field observations in December 2003 revealed increased sediment loads in the Murray River to the extent that when the river backs up into lower floodplain wetlands, the water entering these wetlands from the river appears to be carrying much larger volumes of sediment than that coming off adjacent floodplain farms. The increased sediment load has been identified in the long-term monitoring program undertaken on the Tully floodplain by AIMS (Furnas, 2003). Sheet erosion in the upper catchment appears to be leading to increased gully erosion. There is a need for a large detention basin as originally recommended in the Murray-Riversdale SIIP proposals. Alternately, an extensive network of smaller lagoons such as has been developed in the lower catchment may provide some sediment and nutrient sink capacity that will improve downstream riverine water quality in heavy rain events.

The Tully River flood plain lagoons have been monitored for fish on a regular basis and there is also an extensive set of scientific and community water quality data for the region (Furnas, 2003). The loss of wetlands in this region, and the further degradation of those remaining is likely to impact significantly on the productivity of the fishery including marine species such as mangrove jack, mullet, bream, barramundi and smaller species, many of which are important sources of food for predators. There has been no assessment of heavy sediment loads on estuarine and marine fish.

Barramundi tagged in Barrett's Lagoon (*figure 25*) have been recaptured in Hinchinbrook Channel with one fish recaptured in the Gorge area of the Herbert River. A barramundi tagged in Hassell Lagoon was recaptured at Lucinda (Suntag, 2004).

A survey by DPI&F staff in 2004 showed large numbers of Barramundi had occupied a recently constructed artificial lagoon upstream from Selby's Lagoon (*pers comm*. R Digman). Approximately 80 fish were identified with electro-fishing and an estimated 300 fish occupied the lagoon. This again highlights the importance of freshwater wetlands to the productivity of coastal fishery resources.

Figure 25: Barramundi tagged in Barrett's Lagoon

Risks or threats to wetlands on the Tully and Murray River floodplains:

1. Continued loss or degradation of lagoons by adjoining land use.
2. Increased or ongoing sedimentation and reduction in depth.
3. Invasive weeds.
4. Loss of riparian vegetation.
5. Further impacts on water quality from works to improve drainage.
6. Loss of connectivity resulting from increased use of water for production.

11.1.8. Murray River to Cardwell

Numerous small creeks join the coast between the mouth of the Murray River and the northern end of Hinchinbrook Island. There are a number of lagoons that appear to have permanent deep water along the coastal strip including a lagoon to the east of Bilyana and Black's Lagoon that could not be accessed.

There are also a number of lagoons that feed into Wreck Creek and associated wetlands and known locally as Wreck Lagoons (*figure 26*). The lagoons are within Edmund Kennedy National Park and protected from on-site impacts. Barramundi have been tagged in the lower brackish lagoon. The relatively small catchment above the lagoon provides some protection from catchment impacts associated with intensive agriculture. The melaleuca wetland complex that provides a buffer between the coast and floodplain agricultural land between the Murray River and Cardwell appears similar to that found around Mount Coom. The fishery values of this wetland have not been determined but are likely to be important.

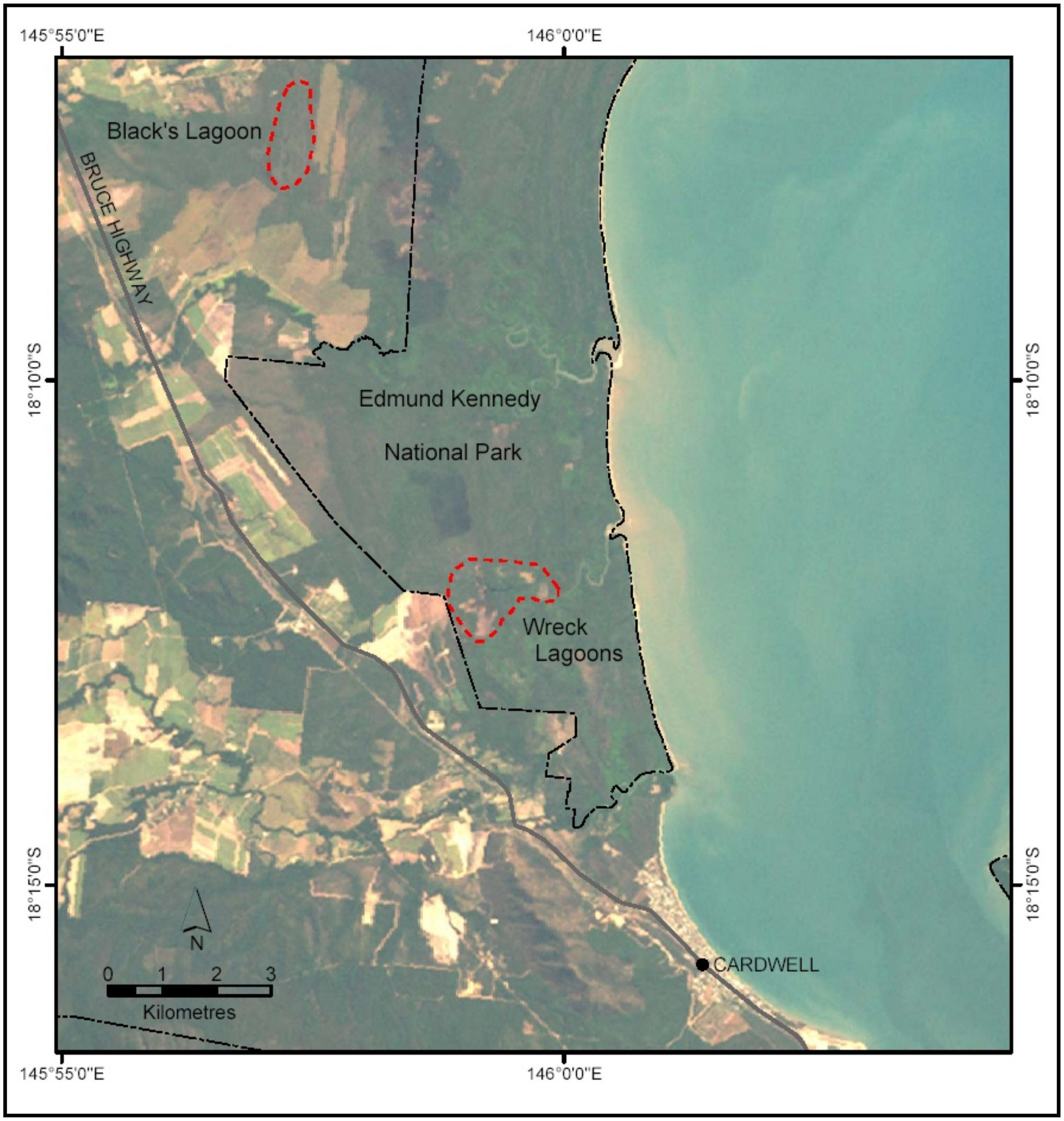


Figure 26: Black's Lagoon and Wreck Lagoons north of Cardwell

11.1.9. Hinchinbrook Island and the Cardwell Range

There are only small areas of freshwater wetland from Cardwell to the Cardwell Range and no off-stream habitat that is significant to fishery resources. Hinchinbrook Island has in-stream habitat that is pristine in numerous creek systems and there is a small freshwater wetland complex that drains into North Zoe Bay Creek but it is remote and difficult to access. The primary threat is from a relatively small population of feral pigs that are subject to intensive control program by the QPWS. In-stream freshwater habitat above the tidal limit in Deluge Inlet has outstanding environmental values but is small and may not contribute significantly to local fishery resources. Threats to wetlands in this district are primarily restricted to feral animals and introduced weeds.

11.1.10. Herbert River Floodplain

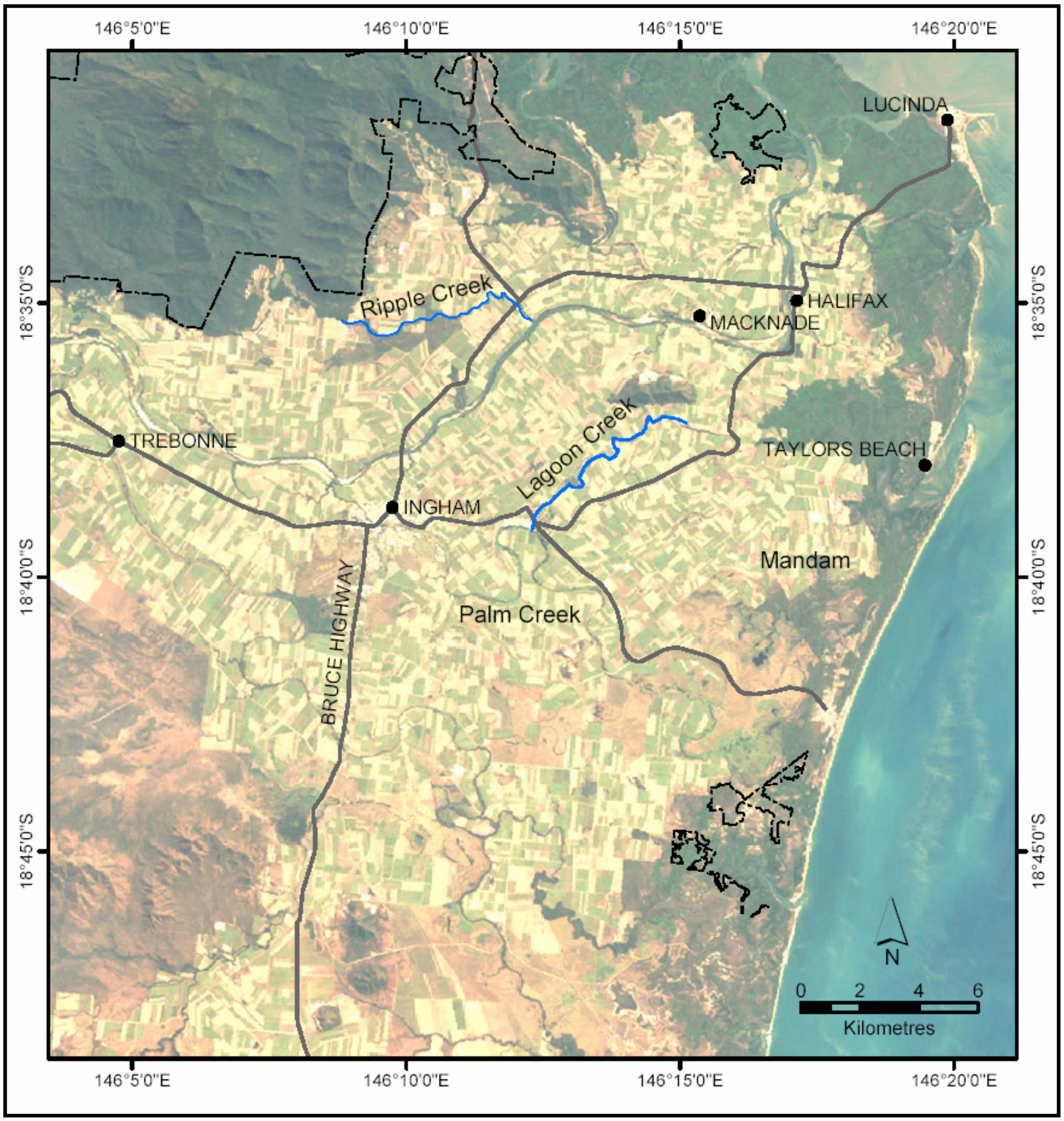


Figure 27: Lower Herbert River and Mandam wetlands

The Herbert River has meandered extensively across its floodplain in recent geological history as evidenced by old flow paths from the Seymour River to Cattle Creek. RA Johnstone (1905) described the area as having extensive swamps and it is likely that, in its natural state, there were dozens of wetlands that were significant to fishery resources.

The Ingham District (*figure 27*) has been extensively developed for intensive agriculture, primarily sugar cane, resulting in extensive draining and clearing of floodplain wetlands and riparian vegetation (Hogan and Graham, 1994; Johnson, 1997). There is significant and valuable in-stream habitat in the Herbert River that has been only lightly impacted, however the river rarely stops flowing and has permanent connectivity with the GBR Lagoon and does not have the same values as an off-stream wetland.

There are few off-stream freshwater wetlands remaining that could be considered significant. Areas not mentioned are considered to be significantly degraded and unlikely to be able to be restored to a condition that would allow a diverse range of native fish to survive for more than a few months after the wet season.

11.1.10.1 Mandam Wetlands

Figure 28: Part of Mungulla wetlands on the Herbert River floodplain showing lack of riparian vegetation

The Mandam wetlands are at the bottom of the Herbert River floodplain, immediately above to tidal waters (*figure 28*). The district now has a recent history of chronic water quality problems that resulted in numerous fish kills (Veitch, 1999). It is now likely that fish are adopting “avoidance behaviour” where they sense reduced water quality and move to other areas as has been observed with numerous sub-tropical species (Kroon *et al*, 2004).

The Mandam wetlands are impacted with artificial flow paths cut through the mangroves that resulted in disturbance of ASS; tide gates increase the impacts of this disturbance (Sammutt et al, 1994, 1996; White et al, 1996) (*figure 29*). While some areas close to the coast remain in good condition (Blackman et al, 1999) they are connected to tidal areas through farm drains that are potential barriers due to water quality issues.

Figure 29: Floodgates preventing tidal intrusion on Mandam wetlands

While works are being undertaken on this catchment through the SIIP, restoration of these wetlands to improve fishery productivity would be costly and should be considered lower priority in this district compared to less affected wetlands.

Risks or threats to Mandam wetlands:

1. Further reduction of connectivity between wetlands and estuaries through installation of tide gates.
2. Ongoing water quality impacts resulting in avoidance behaviour by fish and potential fish kills.
3. Wetlands areas are highly impacted and restoration costs will be high.

11.1.10.2 Seymour River and Ripple Creek Sump

The Seymour River and middle reaches of Ripple Creek are on an old flow path of the Herbert River (*figure 30*). The drainage system has been substantially modified and the only connectivity that the Seymour now has with Ripple Creek is in major flood events. Ripple Creek drains into the Herbert River along a deep narrow canal by the same name in low flows but overflows into the Seymour River in flood events.

Figure 30: Ripple Creek sump

Figure 31: Ripple Creek sump at top right and farm detention area at middle left after moderate rainfall.

Ripple Creek Sump (*figures 30 and 31*) is still a valuable and significant wetland but floodgates approximately 100 metres upstream from its present junction with the Herbert River reduce its value to fish. In addition, recent works by an adjacent landholder appear to have intersected a shallow aquifer that in the past has leached fine sediments into the sump. Recent sampling of Ripple Creek Sump has shown improved water quality but this may not be representative due to the recent drought and further monitoring needs to be undertaken during and following wet periods to assess the impacts of these works.

Ripple Creek is a known habitat of jungle perch in its upper reaches (*pers obs* Veitch). According to local anecdotal reports, jungle perch are now rare in the Herbert Valley except in pristine creeks (*pers comm*. V Vitale 2004). Ripple Creek's connectivity to the Seymour River is particularly important as fish passage is denied by the flood gates where it drains into the Herbert River.

Risks or threats to the Ripple Creek Sump are:

1. Loss of connectivity to the Seymour River.
2. Sedimentation, nutrient enrichment and further degradation of water quality.
3. Invasion by aquatic weeds and pasture grass species, particularly hymenacne.
4. Riparian zone destruction.
5. Further change to natural surface and ground water levels from drainage works on adjacent land.

11.1.10.3 Lagoon Creek and Palm Creek

Lagoon Creek is an old distributary channel of the Herbert River (*figure 27*) that suffers from the cumulative impacts of farm run-off from trash blanketing, inappropriate storage of mill mud, fertiliser application and sugar mill effluent that has reduced dissolved oxygen to chronically low levels for long periods (EPA, 1998) which has resulted in numerous fish kills (Veitch, 1999). Many adjacent landholders have undertaken riparian vegetation projects in recent years but Lagoon Creek is likely to need dredging of its contaminated sediments and rotting weeds. These have sunk to the bed of the creek and will continue to recycle their contaminants and prolong water quality impacts. The removal, and ongoing management, of invasive plants and changes to adjacent land management practices to reduce nutrient run-off, and increases in natural vegetation, is needed if fishery and water quality values are to be restored.

Recent agricultural development on the south bank of the lower reaches of Palm Creek adjacent to Mungulla has resulted in significant loss of riparian vegetation, disturbance of PASS and increased sediment and nutrient loss into this system. In addition, tidal barriers in the lower reaches are likely to restrict fish movement at critical times and may be contributing to impacts from PASS (Sammutt *et al*, 1994, 1996; White *et al*, 1996). When combined with other impacts on Palm Creek including weirs, storm water, farm run-off and a sewage treatment plant outlet, restoration of this system would be a major task.

Palm Creek is now significantly degraded from a fishery perspective. It has major weed infestation, chronic low dissolved oxygen levels (Hogan and Valance, 1999), barriers to migration in low flows, riparian vegetation has been almost completely removed and it suffers from major nutrient inputs from upstream land uses. While fish may still be able to move into Palm Creek during larger floods, fish survival during dry periods may not be possible due to the degraded state.

Risks or threats to the Lagoon and Palm Creek wetlands are:

1. Loss of connectivity to downstream tidal waters.
2. Sedimentation, nutrient enrichment and further degradation of water quality.
3. Invasion by aquatic weeds and pasture grass species, particularly hymenacne.
4. Riparian zone destruction.
5. Further change to natural surface and ground water levels from drainage works on adjacent land.
6. Drainage/disturbance of ASS.

Due to their degraded state, both Palm and Lagoon Creeks are considered to be lower priority for restoration works compared to other wetlands in the Herbert district. In the longer term, issues in these wetlands need to be addressed if ongoing impacts on water quality and fishery resources in the district are to be mitigated.

11.1.10.4 Cattle Creek

Cattle Creek is an old channel of the Herbert River. Prior to development there were extensive areas of wetlands from Trebonne in the north to Bambaroo in the south across an almost flat floodplain (*figure 32*).

Cattle Creek was the most important wetland complex remaining on the Herbert River floodplain until it was developed in the early 1990’s but over the last 12 years has become increasingly degraded. In the early 1990’s, Cattle Creek held large numbers of native fish and was used by many marine species. Barramundi, tarpon, mangrove jack and other marine species as well as freshwater species have previously made extensive use of the Cattle Creek wetland (*pers obs* Veitch). One of many barramundi tagged in the fresh water sections of Cattle Creek in the mid 1990's was later recaptured near Forrest Beach.

Figure 32: Cattle Creek wetlands

The development of the Pomona area in the early 1990's has substantially impacted on the fishery values of Cattle Creek. Since then, sediment and nutrient runoff, irrigation from adjacent aquifers and levy construction for flood mitigation have impacted heavily on both the habitat quality and water quality. The fish habitat values of wetlands are significantly impacted by hydrological changes (Johnson *et al*, 1997) in this area.

A small range of fish species still survive in low numbers but Cattle Creek is no longer considered significant to fishery resources. Sampling of water quality undertaken for assessment for fish stocking showed Cattle Creek to have chronic oxygen depletion (Hogan and Vallance, 1999). Invasive weeds, particularly water hyacinth and hymenacne, have choked the wetland in recent years significantly reducing its value as a fishery resource. Ironically, the preferred method of weed control in the Herbert Valley (herbicide spraying) (*pers comm*. V Vitale) may be compounding the problem by leaving the dead weeds in situ as well as providing another threat to fish through poisoning.

Risks or threats to the Cattle Creek wetlands:

1. Continued development of the catchment for agriculture.
2. Increased sedimentation and reduction in depth.

3. Invasive weeds, particularly water hyacinth and hymenacne.
4. Spraying for weeds.
5. Modified hydrology due to adjacent and upstream levies.
6. Water extraction during dry periods.

11.2. Townsville Region

The Townsville region, for the purpose of this report, extends from Rollingstone in the north to Upstart Bay in the south.

11.2.1. Rollingstone to Yabulu

The area from Rollingstone to Yabulu, just to the north of Townsville, has a series of small creeks that run off the Paluma Range. The coastal plain is narrow being less than 10km wide in most places and no more than 20km wide in any area resulting in very short intermittently flowing creeks. This section of the coastal plain has little or no off-stream wetlands associated with these creeks.

11.2.2. Bohle River

The Bohle River has some small deepwater perennial ponds and natural riparian vegetation in its middle reaches (*figure 34*). Schools of mullet and tarpon have been observed and the area is used by juvenile barramundi. Further upstream, fish become stranded in the pools during prolonged dry periods and fish rescues by Sunfish have included the above species as well as mangrove jack and some freshwater species including rainbow fish, flyspecked hardyhead and empire gudgeons. Upstream impacts include improved drainage and past inputs from a secondary treated sewage treatment plant that has recently been upgraded to tertiary treatment. In-stream impacts include nutrient run-off from both the sewage treatment plant and residential areas, invasive aquatic weeds such as pistia, water hyacinth and para grass. The water quality remains acceptable for fish and the area is important remnant in-stream habitat within the district (Lukacs, 1996). Tilapia are known to inhabit some section of the river (*pers obs* Veitch).

Risks or threats to the Bohle River:

1. Urban development as Thuringowa City expands.
2. Changes to river hydrology from urban and industrial development.
3. Invasive aquatic weeds including pistia, water hyacinth and para grass.
4. Tilapia and potentially other non-native fish species.

11.2.3. Town Common and Louisa Creek

Louisa Creek (*figure 33*) and the Town Common have recently had artificial wetlands built in the catchment, but it is unlikely that these will achieve their full potential without further major works to address water quality and connectivity issues in the remainder of the catchment. The upper reaches of Louisa Creek have heavy infestations of introduced weeds, particularly singapore daisy and chinee apple (*pers comm.* S McDermott). Nutrient runoff from adjacent residential properties exacerbates the weed growth and leads to exotic aquatic plant outbreaks and algal blooms (Lukacs, 1996). As a result, the upper reaches suffer from chronic depletion of dissolved oxygen in the water (*pers comm.* D Reid). Further downstream, para grass and other invasive weeds choke the waterway at a number of sites and provide effective barriers to fish migration.

Figure 33: Wetlands on waterways in the vicinity of Townsville

Louisa Creek, like all waterways in the Townsville District, has a significant infestation of tilapia and gambusia. Many of the introduced species identified in Ross River (see 11.11.2 below) are shared with Louisa Creek (Webb, 2004). While major restorations have improved the visual aspect in the middle reaches of Louisa Creek (*figure 34*), works are necessary downstream if native fish are to be able to migrate in anything other than major floods. Louisa Creek and the Town Common are capable of sustaining healthy and significant fish populations however their current status limits their use by fish.

Risks or threats to Louisa Creek and the Town Common:

1. Litter and contaminants from upstream urban areas.
2. Reduced water quality from urban and industrial runoff.
3. Invasive weeds such as para grass, Singapore daisy and pistia.
4. Introduced noxious fish species such as tilapia and gambusia.
5. Lack of riparian vegetation.

Figure 34: Middle reaches of Louisa Creek

11.2.4. Cleveland Bay Wetlands

The main freshwater habitat remaining on the Ross River floodplain is in-stream above Aplins Weir and the two other upstream weirs plus Ross River Dam that all reduce the connectivity within this system. There are no fishways on the weirs to allow fish migration. Monitoring of the in-stream freshwater habitat shows the area used by 15 exotic species and 23 native species, including eight translocated native species, some of which are not native to the Ross River (Webb, 2004). Townsville has the somewhat dubious reputation of having the most diverse range of introduced fish species of any freshwater system anywhere in Australia. The only marine species are barramundi and mangrove jack and these fish are stocked.

Of creeks that drain into Cleveland Bay, Stuart Creek (*figure 33*) has the only remaining freshwater wetland habitat with connectivity for native fish. Of the other systems, only Ross River and Alligator Creek have significant freshwater reaches but access to these areas is blocked by weirs.

Stuart Creek is a distributary system on the floodplain. Below the Bruce Highway it becomes indistinct and has numerous flow paths. There is a network of small freshwater wetlands (*figure 35*) above the tidal limit with some including Stuart Creek above the highway maintaining permanent deep water areas that are refuges for many species.

Monitoring in the freshwater wetlands of Stuart Creek has identified 20 fish species of which 10 are known to use both freshwater and marine habitats (Perna, 1998).

Figure 35: In-stream freshwater pool on Stuart Creek

Although most of the catchment is relatively natural, some small areas in the middle reaches of Stuart Creek are heavily impacted. It suffers from an infestation of tilapia, gambusia and possibly other introduced species, has been used as a dump site for illegal dumping of industrial waste, has a low level private road with pipe culverts in its middle reaches that is a small but significant barrier to migration for native fish and it suffers from weed infestations including chinee apple, rubber vine, para grass and various other introduced species both in the water and along the banks. Despite this, riparian vegetation is being actively re-established and in-stream macrophyte diversity is outstanding including rare species (Perna, 1998). It has good water quality and a high integrity and diverse native fish community including all catadromous species lost from Ross River, and is a functional nursery area for Mangrove Jack and Barramundi.

Stuart Creek is part of the area earmarked by the Queensland Government for future development of heavy noxious industries in the Townsville District (DSD, 2003). It is likely to be subjected to the range of impacts already experienced in Gladstone from similar development.

Risks or threats to Stuart Creek:

1. Invasive plant and fish species.
2. Illegal industrial and domestic waste dumping.
3. The area has been declared for development of heavy noxious industries as part of the Townsville State Development Area. DSD concept plans include infrastructure straddling one of the remaining permanent wetlands in the vicinity of Colinta Holdings homestead.

The freshwater reaches of Alligator Creek have been degraded due to an old weir downstream from the highway that prevents fish migrations for most species in most flow conditions and adjacent development that has reduced riparian vegetation in its middle reaches and increased contaminant inputs. Jungle perch are able to migrate into the upper reaches Alligator Creek during flooding but most other species are unable to bypass the barrier. Alligator Creek has chronic weed and water quality problems in its middle reaches as a result of water extraction, sediment and nutrient runoff and litter that limits its suitability as dry season habitat to native fish species (Lukacs, 1996).

Risks or threats to Alligator Creek:

1. Expanding horticulture and rural residential development.
2. Water extraction.
3. Weir/tidal barrier near tidal limit.
4. Farm litter including plastic weed covering.
5. Loss of riparian vegetation.

11.2.5. Burdekin River Floodplain

The Burdekin Floodplain includes the area east of Cape Cleveland to the western shores of Cape Upstart. In addition to the Burdekin River, the Haughton River enters the floodplain from the north-west.

Wetlands on the Burdekin River floodplain are mostly old distributary channels from a time when the river was flowing along one of its many previous paths. The distributary system still includes, from west to east, Barratta Creek, Sheepstation Creek and Plantation Creek to the north of the river and Saltwater Creek to the south. The Burdekin River has the highest total average flows of any river running into the GBR Lagoon (Roth *et al*, 2002). The Haughton River also has numerous wetlands that are the result of its geological history.

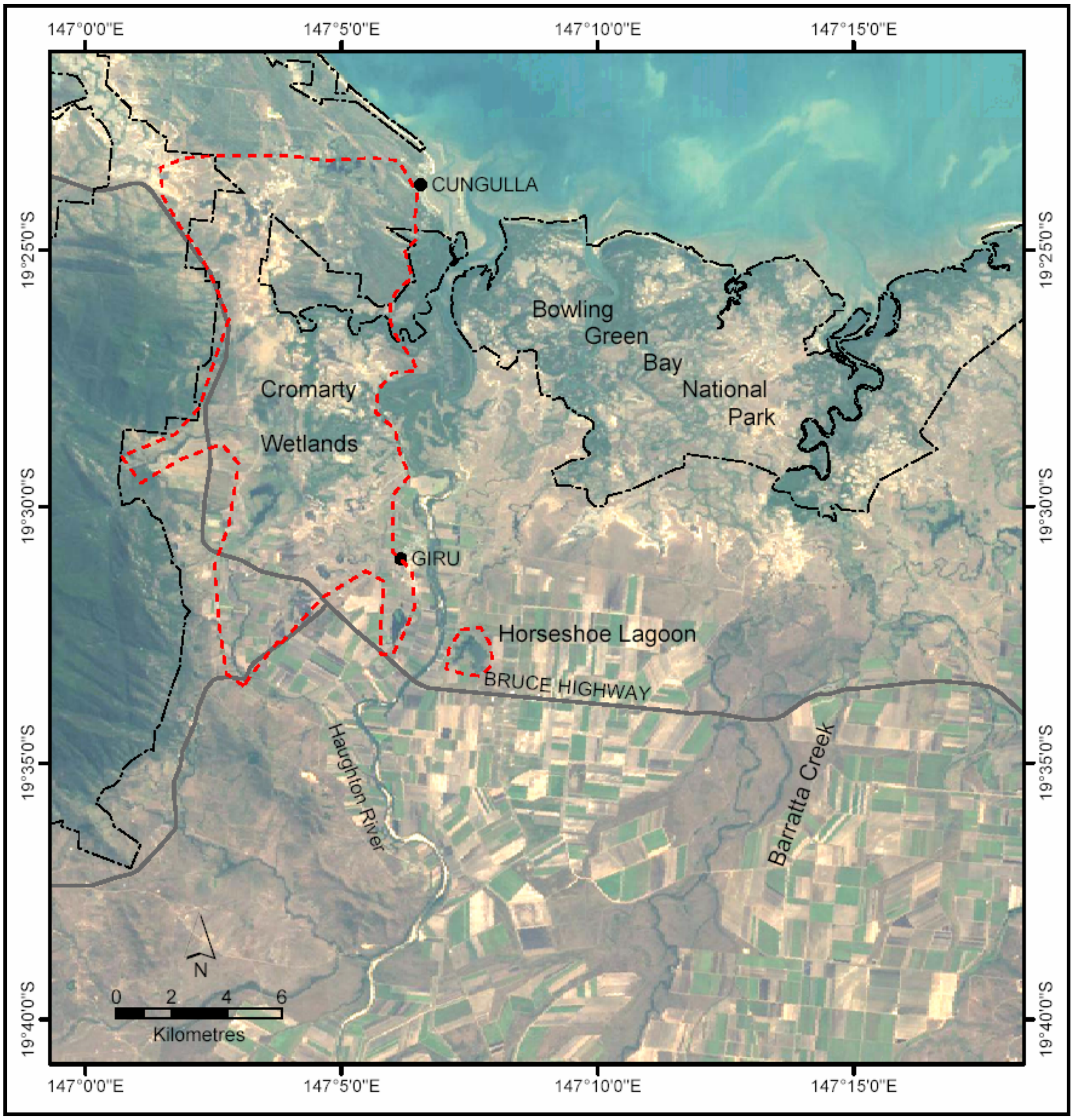
Studies undertaken by the ACTFR have estimated that 50% of large ephemeral wetlands in the Burdekin have been lost (Lukacs, 2004), although this is not specific to those that are productive to the fishery. Most deepwater wetlands on the floodplain still remain in one form or another today but even those that appear healthy are heavily impacted from a fishery perspective due to fish barriers that reduce connectivity (White and O'Brien, 1999). Including riverine areas of the Burdekin River, it is estimated that fish have lost access to more than 80% of the areas that they would have occupied when the district was in its natural state.

11.2.5.1 Haughton River and Cromarty wetlands

The Haughton River has large lagoons on both sides of the river. To the west, the Ironbark Creek network flows through two significant lagoons before draining into the tidal Cromarty Creek (*figure 36*). Healey Lagoon is approximately five kilometres long but narrow, averaging less than 35 metres width. It is heavily impacted by introduced aquatic plants including water hyacinth and pistia and introduced pasture grasses including para grass and hymenacne (*figure 37*).

Healey Lagoon is now part of the irrigation network for the Haughton floodplain and is kept at an artificially constant level with water diverted from the Burdekin Dam. It is used as both an irrigation channel and an aquifer recharge pit. In the past, it has also received nutrient enriched tail-water although recently there have been attempts to reduce the impacts of this (Burrows, 1998). Like nearly all of the lagoons on the northern side of the Burdekin River, constant flow has altered the functioning of these lagoons although there has been no research done on this to assess the impacts on the full diversity of fish species.

Like the majority of remnant lagoons in the developed areas of the GBR catchment, riparian vegetation has been thinned to a very narrow strip of large trees that in most places is only a single row deep or completely missing. Unlike some other lagoons in the district there are no significant barriers to fish movement although some culverts may restrict movement in certain flow regimes.



\Figure 36: Cromarty Wetlands and Horseshoe Lagoon adjacent to the Haughton River

An inspection in January 2004 noted toxic smells of hydrogen sulfide coming from the water, probably as a result of the northern end of the lagoon being choked with aquatic weeds on the surface with dead rotting weeds beneath. This has been recorded previously (Burrows, 1998). It is likely that this water was toxic to fish. It was overflowing from Healey Lagoon downstream into the Reed

Beds Lagoon (see below). In the past, Healey Lagoon was a significant resource for at least 20 species of native fish such as barramundi (Burrows, 1998) but weed infestation and resulting poor water quality may limit its current value.

The Reed Beds Lagoon is a large lagoon downstream from Healey Lagoon. It does not have permanent connectivity in either direction and relies on wet season flooding. Although shorter than Healey Lagoon, it is approximately 200 metres wide in places and has a more diverse range of habitats from tree lined narrow areas to broad open water areas. The Reed Beds Lagoon now has a large weed infestation despite its use as a grazing area that previously limited some of the pasture grasses. It has a significant invasion of hymenacne and other pasture grasses both under the canopy and in open sunlight and is also now affected by aquatic weeds such as pistia and water hyacinth.

Figure 37: Healey Lagoon covered in water hyacinth, pistia and other aquatic weeds (Oct 2004)

Reed Beds Lagoon is on private property and no longer accessible to recreational fishers although barramundi were tagged here from 1985 to 1992. Fish tagged in this lagoon have been recaptured in downstream tidal areas and as far away as Plantation Creek and Hellhole Creek. Reed Beds Lagoon is part of the Cromarty Wetlands and as it is perennial, it is likely to be an important link to wetlands further up the coast. It is clearly significant from a broader environmental view but from a fishery perspective its water quality is now contaminated from catchment runoff including the poor quality water from

Healey Lagoon. Despite this, recent sampling has shown that in open areas it still maintains fishery values.

Risks or threats to Healey Lagoon and Reed Beds Lagoon:

1. Artificial water heights and flows from use for irrigation in Healey Lagoon.
2. Invasive aquatic weeds, particularly water hyacinth and pistia.
3. Loss of riparian vegetation and invasion by para grass and hymenacne.
4. Reduced water quality.

Pink Lily Lagoon is a large shallow lagoon on the western bank of the Haughton River. It has suffered from adjacent farming practices with shallow areas reclaimed for cropping and remaining open areas are weed infested and nutrient enriched with subsequent reductions in water quality. In the past it may have been significant to the fishery but with the degraded state of both the lagoon and downstream areas such as Crooked Waterhole, it is now unlikely that fish could migrate to and from or survive in this lagoon during the dry season.

Runoff from this sub-catchment is suspected as part of the cause of fish kills in the upper tidal sections of Cromarty Creek, although Healey Lagoon also contributes large volumes of de-oxygenated water into the system. On Crooked Waterhole, where the riparian vegetation has not been removed, it has been contaminated by weed infestations including the noxious turpentine weed (*pers comm.* J Luly). Both lagoons have turbid water for most of the year with only gambusia apparent. Three barramundi were tagged in Crooked Waterhole in 1998 after major floods but no fish have been reported since that time (Suntag, 2004).

Risks or threats to Pink Lily Lagoon and Crooked Waterhole:

1. Nutrient enrichment that has promoted weed infestation, including turpentine weed.
2. Chronic low dissolved oxygen levels.
3. Low level and poor state of riparian vegetation.
4. Introduced and noxious fish due to the degraded habitat quality.

Horseshoe Lagoon is a large lagoon to the east of the Haughton River. It is similar in its general description to Pink Lily Lagoon although larger in area. Horseshoe Lagoon drains downstream into Barramundi Creek. Nutrient enrichment from farm and irrigation runoff resulted in an explosion of a native lily that covered the whole of the surface area of the lagoon until it was mechanically removed in mid 2003. It is likely that poor water quality would have limited native fish species use of the lagoon prior to harvesting but the next localised flood should see an increase in fish populations. Horseshoe Lagoon is an excellent example of the commitment of Burdekin district landholders to ensure that they reduce their impacts on waterways. The Burdekin district has set an example for restorations that needs to be followed by other regions. At the same time, the restorations need to continue and be extended to other waterways in the district.

Risks or threats to Horseshoe Lagoon:

1. Nutrient enrichment that may cause further lily infestations.
2. Invasive aquatic weeds.
3. Loss of remaining riparian vegetation.

The Haughton River once provided access to a network of upstream in-stream and off-stream lagoons including Major Creek and within the river itself. Passage to these waterholes is now effectively blocked by a series of weirs that do not have fishways.

1.2.5.2 Barratta Creek

The Barratta Creek system (*figure 38*) is an overflow system for both the Burdekin and Haughton rivers. In its natural state, Barratta Creek was once a series of isolated in-stream lagoons that were connected during flooding. It is now used as an irrigation and tail-water canal and runs perennially with the associated concerns that this can have on fish migration and spawning (White and O'Brien, 1999). Barratta Creek is the healthiest system still remaining in the Burdekin District. It has relatively wide riparian vegetation for most of its length and pockets of land adjacent to the creek have been reserved as habitat areas. In the mid 1990's, Barratta Creek suffered from unacceptably high nutrient loads (Congdon and Lukacs, 1996). Recent improvements in Sunwater's channel flow management to reduce nutrient loads have resulted in a reduction of algae and aquatic weeds (*pers comm*. J Tait) whilst providing benefits to farmers with water and sediment recycling.

While there is a need for ongoing management and monitoring of Barratta Creek, there is now greater awareness and commitment in the district for this to occur and it is now unlikely that impacts on this system will increase. As there are no barriers to fish migration, a diverse range of native fish are able to use the Barratta Creek system.

Fish have been surveyed in a number of Barratta Creek wetlands along with other Burdekin wetlands. A total of 30 species were recorded across the Burdekin floodplain (Perna, 2003). This is less than that recorded in other systems along the coast with fewer marine species. Reason for the lower number of species may include loss of connectivity (Perna, 2003), naturally lower numbers compared to the Wet Tropics or changes to environmental flows.

Unfortunately, no baseline data could be identified. Barratta Creek is presently being assessed for declaration as a freshwater fish habitat area by DPI&F.

Figure 38: Freshwater lagoon on Barratta Creek

Risks or threats to Barratta Creek:

1. Altered water flow from use for irrigation.
2. Nutrient loads increasing algae and aquatic weeds.
3. Sediment loads increasing siltation.

11.2.5.3 Sheepstation Creek

Sheepstation Creek (*figure 39*) remains one of the major overflow paths for the Burdekin River in flood events that occur, on average, once every 20 years. Sheepstation Creek has a series of deepwater lagoons that are now permanently used as irrigation canals and aquifer recharge pits. In their natural state, these lagoons had significant depth fluctuations and some have been observed almost dry during droughts prior to water diversion from the Burdekin River. The network of wetlands includes at least eight lagoons between 500 metres and two kilometres long and up to 100 metres wide with numerous smaller lagoons. In the past, this entire network held the full diversity of native fish that could be found in this type of habitat but various factors now restrict a number of species from using this system.

Until 1999, these wetlands had been allowed to degrade to weed infested swamps that could not sustain most native fish. Despite being metres deep, weed infestations were so thick that it appeared there was no water at all (*figure 40*). A commitment by the community and support by the Queensland Government resulted in a weed harvester being trialled on Payard's Lagoon. The trial was so successful that the Queensland Government subsequently purchased a machine for use in the district (*figure 41*). This was a very successful initiative and there is now continual improvement to the health of wetlands throughout the Burdekin floodplain. Despite this, weed control will be needed in perpetuity on the Burdekin floodplain and an ongoing commitment is required to ensure that these wetlands do not return to a degraded condition.

Figure 39: Burdekin River floodplain and associated wetlands

The removal of weeds brought about an almost immediate improvement in oxygen content of the water, and within days, bird populations on the wetlands had increased and diversified (*figure 40, 41*). Fish species diversity improved over a period of about seven months and continues to improve (Perna, 2003). Despite the improvements in water quality the system continues to be restricted from a fishery perspective due to physical barriers.

The Sheepstation Creek lagoons are connected by a series of irrigation channels. Long, narrow channels have water running on average at significantly more than 0.3 metres per second and are not conducive to fish migration as most native fish cannot sustain this swimming speed (Clague, 1991; *pers comm.* A Hogan). In addition, there are significant barriers to migration in the form of drop boards that, although less than a metre high, in most cases prevent fish migration (White and O'Brien, 1999) except during major floods.

Figure 40: Before and after water hyacinth harvesting on Payard Lagoon

For the Sheepstation Creek wetlands to again become significant to coastal fishery resources, a system of fish passage devices will need to be designed and installed. While passage at drop boards could be achieved simply (*figure 42*), improving fish migration opportunities in the irrigation channels that join the lagoons may be more difficult.

The lower reaches of Sheepstation Creek have a network of ponded pastures and other tidal barriers that act as both a barrier to fish migration except when they are breached in major floods and as a trap for fish that cannot get either upstream or downstream as flood waters recede. Nutrient enrichment and denial of tidal salt water has seen the proliferation of cumbungi, a native reed that has become an aquatic weed in the district (Perna, 2003). A review of the role and effectiveness of these tidal barriers should be undertaken as with more freshwater now available to manage aquifer salinity, the role of these tidal barriers for agricultural production may be outdated.

Figure 41: Aquatic weed harvester on Payard Lagoon

Figure 42: Drop boards on Sheepstation Creek that prevent fish migration except in flooding

Like many waterways throughout the developed GBR catchment, invasive fish species such as gambusia are now of increasing concern, predating on native species (Ivantsoff and Aarn, 1999). In addition to gambusia, blue-spot gouramis have been captured in Sheepstation Creek (Perna, 2003) and the long-term impact of these species is presently unknown. Other noxious species have not yet been identified in the Burdekin floodplain although there is the real threat of tilapia infesting the waterways as they are present in large numbers in the Townsville District and have been recorded on farm dams near Clevedon. Tilapia is known to thrive in areas that have degraded habitat or where access to native fish is restricted due to barriers (Arthrington et al, 1983, 1984).

Risks or threats to Sheepstation Creek lagoons:

1. A large number of barriers to fish passage.
2. Altered water flow patterns from use for irrigation.
3. Aquatic weed growth requiring continual control.
4. Introduced fish species, especially gambusia and blue-spot gourami.

11.2.5.4 Plantation Creek

Whilst some lagoons such as Hutchinson's have been maintained as open waterways, many wetland areas in Plantation Creek are weed infested and degraded in its lower reaches and are linked by irrigation channels. The channels, culverts and weed infestations provide effective fish barriers to most native fish species except during floods. Irrigation and tail-water runoff provide a nutrient source to downstream cumbungi, a native plant that has proliferated. As with Sheepstation Creek, this situation is exacerbated by artificial tidal barriers that prevent saltwater from flooding in on the higher tides (Perna, 2003) that would otherwise cause the Cumbungi to die off. Some native fish are able to survive these impacts but restoration is needed for this system to contribute its full potential.

11.2.5.5 The Burdekin River

The Burdekin River remains the main flow path for catchment water in most rain events and rarely breaks its banks. Its importance as fishery habitat should therefore be significant but it is restricted by Clare Weir that presently provides a total barrier to migration. Fishing records from the Collinsville annual fishing competition show that prior to the construction of the weir and for a few years after its construction, barramundi were caught near Collinsville in the Bowen River, a tributary that joins the Burdekin River above the weir. Despite a stocking program in Clare Weir, barramundi have not been recorded upstream in the Bowen River in recent times. Other weirs on the river including sand dams that restrict flows may be reducing the migration window of opportunity and may also be physical barriers.

In August 2004, Tilapia were identified in Keelbottom Creek, a tributary to the Burdekin River. In December 2004, heavy rains in the area washed the fish downstream and they have been confirmed as being at the junction of the two streams.

Risks or threats to the Burdekin River include:

1. A large number of barriers to fish passage.
2. Altered water flow patterns from weirs and irrigation.
3. Introduced fish species, especially gambusia and tilapia.

11.2.5.6 Saltwater Creek

The Stokes Range restricts the Burdekin River overflow paths to the east and south. There are a few small wetlands upstream of the range on Cassidy Creek but their fishery values are unknown. Saltwater Creek is the main flood flow path on the south side (*figure 39*) of the river when it breaks its banks in the vicinity of The Rocks.

Like Barratta Creek and Sheepstation Creek, Saltwater Creek is a series of long narrow lagoons that once provided important freshwater habitat to a range of fish species. Most of these lagoons are now badly degraded and most native fish species are unable to tolerate the combined impacts from the catchment. The most important of these lagoons, being closest to marine environments is Warren's Gully on Sheepstation Creek to the south of Mount Inkerman. This is a moderate-sized lagoon with good riparian vegetation and some deep water. This lagoon does not have the weed infestations that are affecting many of the lagoons on the north bank of the river as Saltwater Creek is not used as an irrigation canal although it receives tail-water from farms in the catchment, particularly during heavy rain events. Warren's Gully has natural connectivity with the estuary and was sampled during the Burdekin floodplain survey.

Risks or threats to Saltwater Creek lagoons and Warren Gully:

1. Weed infestation from hymenacne and para grass.
2. Nutrient runoff during rain events.

Fish have been surveyed in a number of Burdekin floodplain wetlands with a total of 30 species recorded. This is less than recorded in other systems in the region with few marine species and the main reason for the lower number of species being loss of connectivity (Perna, 2003).

11.3. Mackay Region

The Mackay Region, for the purpose of this report, extends from Cape Upstart to the north of Bowen to Clairview in the south.

11.3.1. Upstart Bay to Proserpine

From Upstart Bay to Proserpine the coastal range is from 10-30 km from the coast so most of the creeks that drain from the range are short. The area also has significantly lower rainfall than areas to the north and south. Most creeks are estuarine with perhaps a few small semi-permanent in-stream freshwater pools; they are also sand based, further limiting surface freshwater. There are few off-stream freshwater wetlands that are significant to fish.

To the south of Cape Upstart on the east coast of the peninsula is a significant wetland and dune complex. While it is ephemeral in nature and cannot sustain fish during dry periods, it is recognised as being the best remaining example of its type in the district (Blackman *et al*, 1999). This wetland is on the Register of the National Estate and is it is presently subject to aquaculture development proposals from an adjacent landholder that may impact its integrity.

The Abbot Point-Caley Valley wetlands aggregation are some small permanent wetlands that are adjacent to Abbot Point that are of high value to migratory and local water birds (Blackman *et al*, 1999). The system is described by Blackman as containing a lake with fresh to brackish water and associated swamp. No reference is made to the use of the area by fish although during spring tides and heavy rain events, it is likely that small fish would migrate into the area but it is likely that most of them would be consumed by the rich bird life.

The largest river in the area is the Don River near Bowen. The estuarine area of this river is very small and above the tidal limits there it is a flat, sand based riverbed that has no surface water for most of the year. There may be semi-permanent or permanent freshwater pools up in the ranges however these are totally disconnected from the marine system naturally and are unlikely to be usable by marine fish.

11.3.2. Proserpine to Mackay

The Proserpine River is a heavily modified and impacted river in its upper and middle reaches. The Peter Faust Dam is in the upper reaches but there is no access by fish from downstream. The lake has been stocked with barramundi. In addition, the middle reaches of the river are flood-proofed with a large levy. The river has nutrient inputs from adjacent farms and the Proserpine sewage treatment plant which has secondary treatment levels (Hardy, 2002). In the freshwater reaches, the Proserpine River appears to suffer from ongoing macrophyte and algal blooms although no studies are available on the use of the fresh water reaches by native fish.

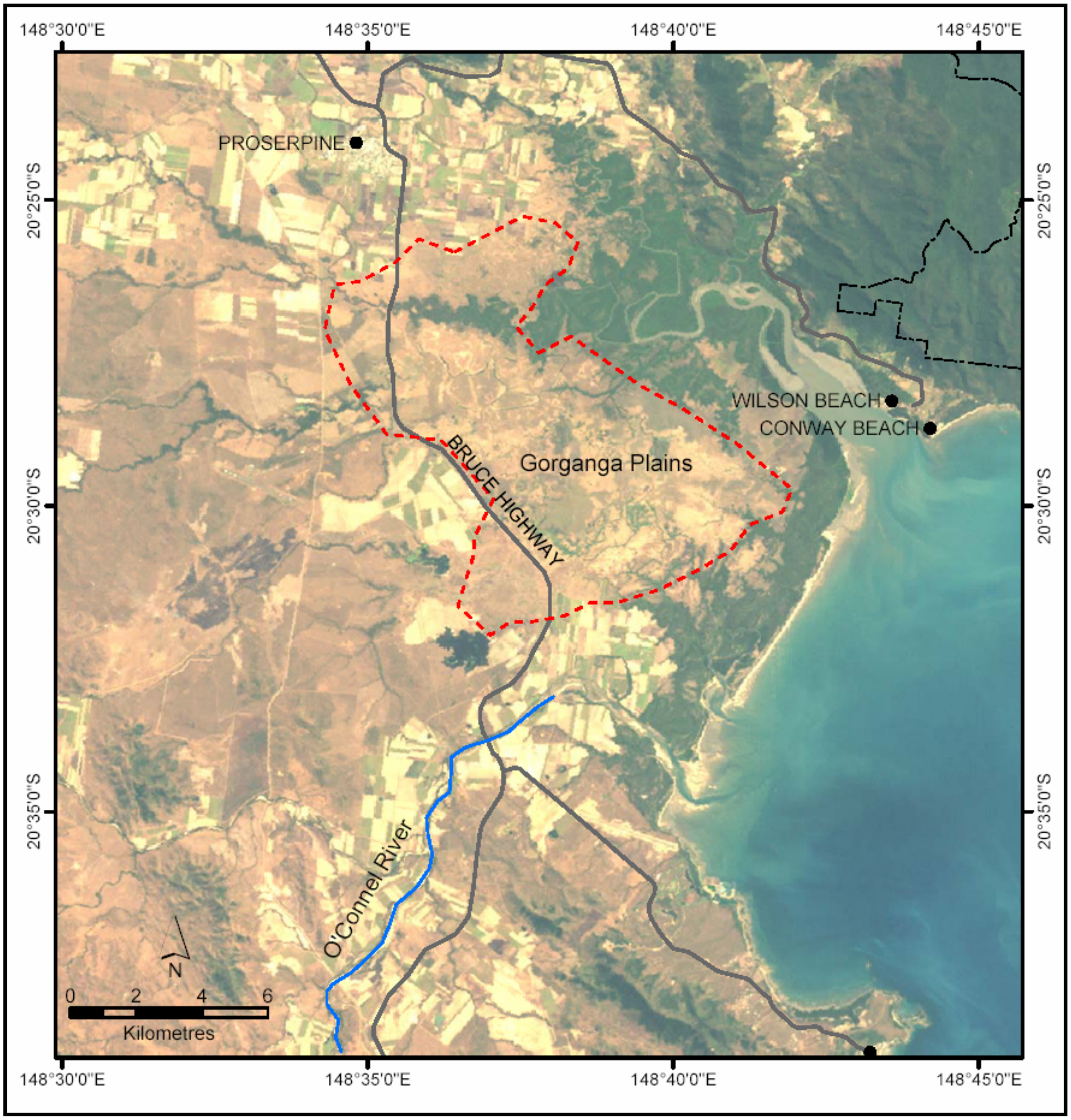


Figure 43: Gorganga Plains wetlands south of Proserpine

The Gorganga Plain to the south of Proserpine (*figure 43*) includes three creeks that are used extensively by fishery resources. The creeks include Lethe Brook, Gorganga Creek and Thompson Creek. Much of the floodplain has been cleared with some remnant riparian vegetation remaining along the waterways. Both Lethe Brook and Gorganga Creek (*figure 44*) have permanent fresh waterholes during extended dry periods. Whilst the Gorganga Plains are extensive, little information is available on the use of the area by fishery resources other than in the main streams.

Connectivity of Gorganga Creek and Thompson Creek to estuarine habitat remains largely intact. There is a network of shallow off-stream waterholes that are also used by fish but these dry up during extended dry periods.

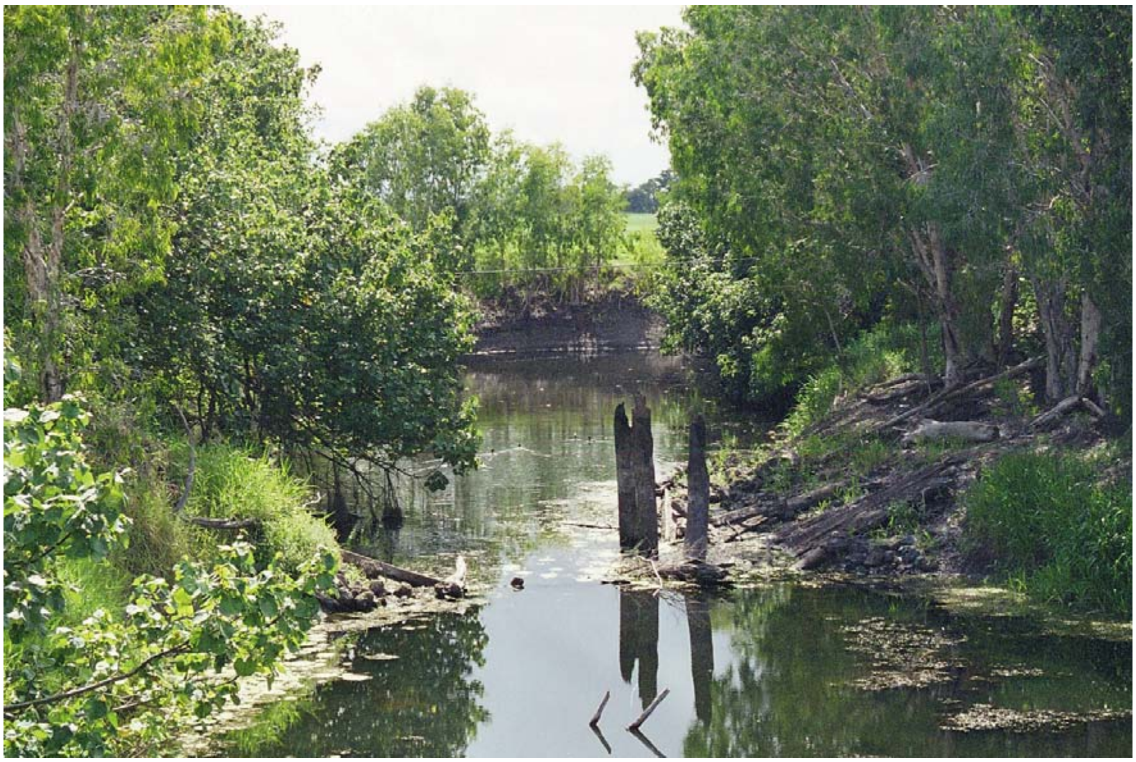


Figure 44: In-stream wetland of Gorganga Creek

Risks or threats to Gorganga Plains wetland:

1. Lack of knowledge of fishery resources using the wetlands.
2. Use of wetlands for ponded pastures.
3. Continued reduction of riparian zone from adjacent grazing use.
4. Nutrient runoff during rain events.

The O'Connell River and its tributaries to the south of Proserpine provides important in-stream habitat for a wide range of species with barramundi reportedly captured well above the tidal limit in permanent deep in-stream waterholes (*pers comm*. F Baxter).

South of the O'Connell River, there is a coastal range stretching from north of Bloomsbury to Yalboroo. While there are a number of creeks that drain into the Dempster Creek estuary, the only freshwater areas are small in-stream ponds that are not considered significant.

Alligator Creek and Blackrock Creek are small, narrow creeks with no remaining wetlands on their floodplain. St Helens Creek is deep-cut into the coastal floodplain with some permanent freshwater stretches that are likely to be locally important in the absence of other remnant habitat. St Helens Creek has lost most of its riparian vegetation to adjacent cane farming (Bunn *et al*, 1997).

Murray Creek has some important freshwater in-stream habitat but is impacted by riparian clearing and adjacent farming. There is a small sand dam approximately 300 metres downstream from the Bruce Highway that is an effective barrier to fish migration except during major floods.

11.3.3. Mackay District

Figure 45: Waterways and wetlands in the Mackay district

A map of wetlands in the Mackay district is at *figure 45.* A detailed report for the Pioneer Valley Water Resource Plan is available on fish use of the Pioneer

River, Bakers Creek and Sandy Creek that includes data from a number of earlier surveys (Pusey, 2001).

Dumbleton Weir separates the estuarine and saltwater reaches of the Pioneer River and effectively prevents upstream migration of marine species. There is a fish lock on the weir but its use by marine species is limited. Pusey (2001) identified that in thepondage area above Dumbleton Weir only 11 of the expected 25 species were recorded and of these only three were marine species. Above Dumbleton Weir there are the Marion and Mirani Weirs. Marian Weir fishway is not suitable for fish passage and Mirani Weir lacks any fishway at all making fish passage only possible during major flooding (Pusey, 2001).

Figure 46: Gooseponds Creek in suburban Mackay

The Goosepond Creek system is a series of lagoons where DPI&F has worked with local community groups and Mackay City Council to redevelop fish passage by establishing fish passage devices of various designs (*figure 46*). Fish usage of these fishways has been monitored with marine and freshwater species using the fishways (Marsden *et al*, 2003a, 2003b, 2003c). As fishways on the creek are within the urban area of Mackay, they are used to educate the community on the benefits of fish passage. Maintenance remains a concern with the upstream fishway choked by weeds during our inspection in January 2004. A maintenance program is being negotiated (*pers comm*. T. Marsden).

The wetland at Andergrove in the upper reaches of McCready Creek is of limited value to fishery resources as most of the wetland has disappeared through urban development. This wetland is under threat from land-based infrastructure for port expansion. This area, if disturbed, has the potential to cause major long-term problems to downstream marine resources due to the oxidation of ASS over an extended period of time. To restore fishery values this area would require a complete rebuild however it would be a high profile site, and restoration is currently under discussion.

Sandringham Lagoons south of Sandy Creek were previously significant for fishery resources however they have been degraded by adjoining agricultural land use. Riparian vegetation is poor to non-existent and they have been impacted by sediment and nutrient runoff (*pers comm*. T Marsden).

11.3.4. Sarina to Clairview

The area from Sarina to Clairview has a series of small creeks that drain the coastal range running inland along the entire length of this part of the coast. The coastal plain is narrow, being less that 10 km in width in most places and no more than 20 km wide in any area. In the northern area there is a mixture of sugar cane and grazing however grazing dominates from around Carmila south.

Most creeks in this area are short, have small estuaries and small permanent in-stream freshwater wetlands. Because of their short length and the undulating landscape they run through there are few off-stream freshwater wetlands. Most have natural connectivity along their length, with some remaining riparian vegetation and good water quality. The creeks in the agricultural areas have been affected the most while those in the grazing areas have mainly been affected by tree clearing. The most important creeks are Boundary Creek, Rocky Dam Creek, Marion Creek, West Hill Creek, Carmila Creek and Flaggy Rock Creek. The fishery resources of creeks in the Sarina and Broadsound shires have been reported (Laxton et al, 1995).

Rocky Dam Creek (*figure 47*) is the most important creek in this area due to its extensive network of wetlands. East of Koumala some high value wetlands remain in the Tedlands area. Alligator Waterhole on Tedlands Creek is reportedly over seven metres deep and is important to fishery resources (*figure 48*). This and adjacent shallow wetlands are now subject to a voluntary conservation agreement and protected from on-site impacts, however the long-term impacts of downstream water extraction by adjacent landholders is harder to assess. Water extraction can lower adjacent water tables (Tait, 1994) and this can result in oxidation of ASS with flow on impacts to the environment in general and fishery resources in particular (Sammutt *et al*, 1994, 1996; White *et al*, 1996). This wetlands complex is used for irrigation and some of the more important shallow wetland areas have been pumped dry during the recent dry period for the first time in memory according to locals (*pers comm*. Local Landholder 2004). The impact of ponded pastures is recognised as it continues to reduce fisheries productivity.

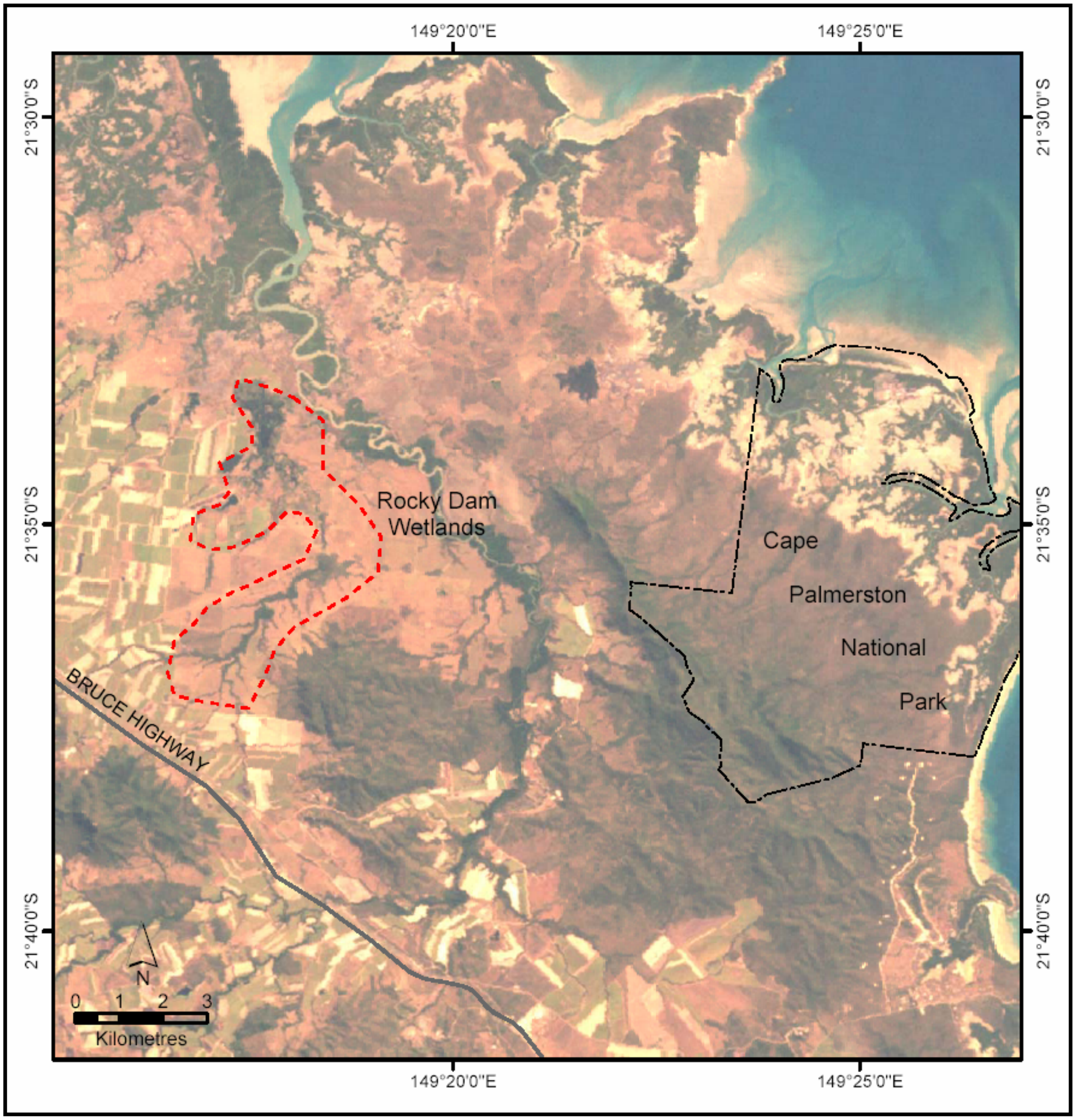


Figure 47: Rocky Dam Creek wetlands near Koumala

Risks or threats to Rocky Dam wetlands and Alligator Waterhole:

1. Ponded pastures and downstream barriers that reduce connectivity.
2. Water extraction for irrigation.
3. Feral pigs and invasive weeds, particularly hymenacne and para grass.
4. Disturbance of ASS.

Figure 48: Alligator Waterhole on Tedlands Creek

11.4. Central Queensland

Central Queensland, in the context of this report, is from Clairview in the north to Rodds Bay in the south.

11.4.1. Broadsound and Shoalwater Bay

Access by marine fish to both in-stream and off-stream freshwater wetlands in the Broadsound District have been severely limited by ponded pastures. The district has 80 pondage systems with a total length of pondage banks of 57 km, one bank on the northern side of Herbert Creek being 18 km in length. Most of the systems are used for pasture and cattle production and many dry completely during the dry season. Hyland (2002) reported on the use of these ponded areas by fish. The fishery resources of creeks in the Sarina and Broadsound Shires have been reported (Laxton *et al*, 1995).

In the northwest part of the Broadsound District, many creeks between Clairview Creek and St Lawrence Creek have barriers at the upper tidal limit. These barriers are bank high causeways that were part of the old alignment of the Bruce Highway and now provide permanent freshwater for adjoining cattle properties. The barrier on St Lawrence Creek has been upgraded in the past few years (*figure 49*) with no allowance made for fish passage. These barriers effectively prevent fish passage except during major flooding and fish use of these areas is unknown.

Figure 49: Tidal barrier on St Lawrence Creek

To the south of St Lawrence Creek many creeks have significant in-stream freshwater wetlands that have natural connectivity to their estuaries. Most significant off-stream wetlands have been converted to ponded pastures. The most important creeks with instream wetlands are Waverley Creek, Granite Creek, Tooloombah Creek and Wellington Creek. These creeks run through grazing country that has been extensively cleared but on most creeks in-stream riparian vegetation remains in good condition and water quality is also likely to be acceptable.

Herbert Creek is the largest creek that runs into Broadsound (*figure 50*) and has significant in-stream and some off-stream wetlands in the Tilpal area. Off-stream wetlands downstream of Tilpal have been largely converted to ponded pastures.

Off-stream wetlands above Tilpal include Bull Lagoon and Potty Lagoon. These lagoons are connected to Herbert Creek. During the wet years in the late 1980s through to 1991 this area was targeted for the tagging of barramundi and around 500 fish were tagged in Herbert Creek and lagoons. Fish were subsequently recaptured at Hay Point south of Mackay in the north to Frogmore Lagoon at Rockhampton in the south as well as throughout Broadsound (Suntag, 2004). The current status of Herbert Creek and the lagoons has not been assessed.

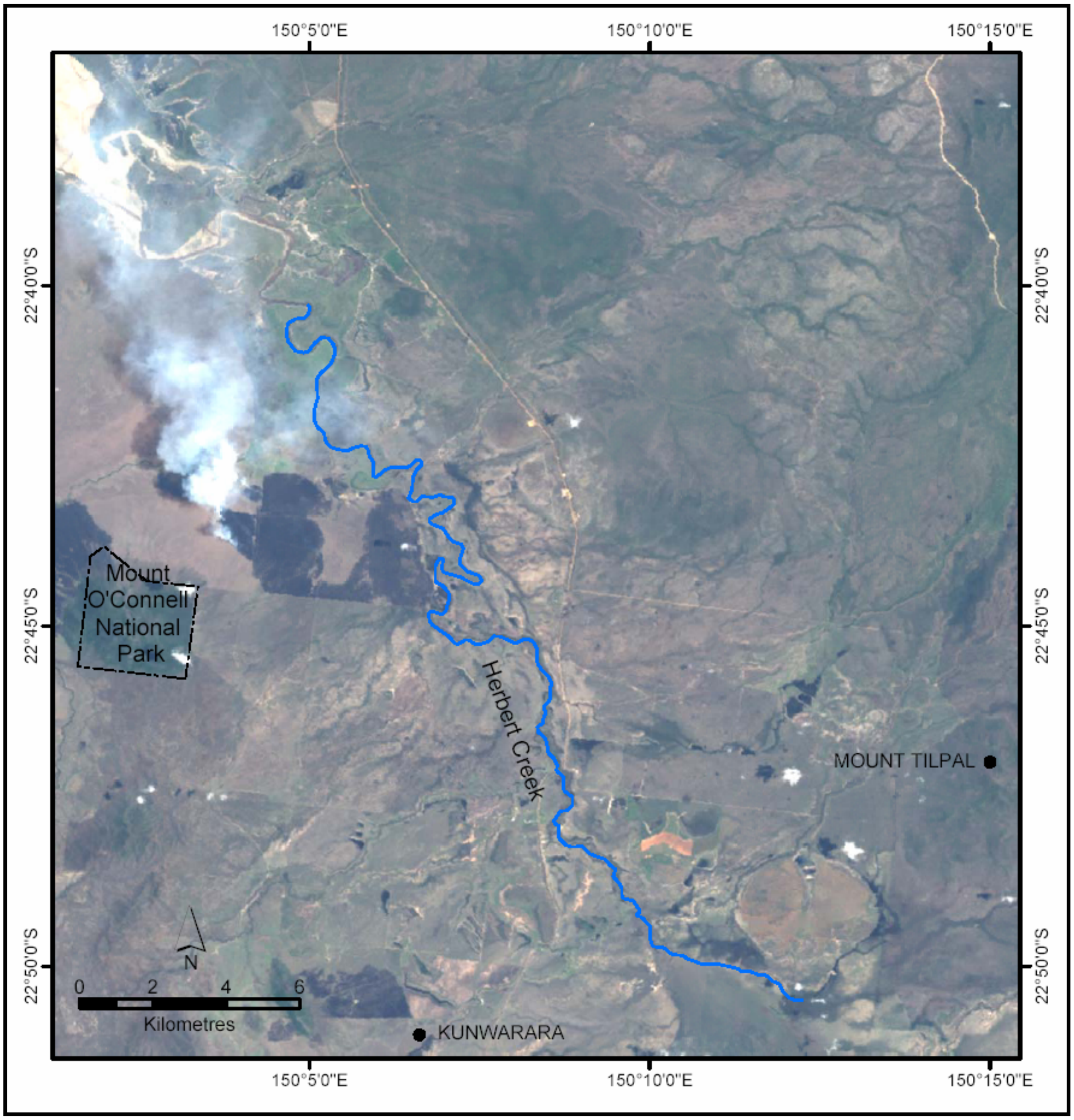


Figure 50: Herbert Creek and adjacent wetlands in Broad Sound

On the eastern side of Herbert Creek there are a small number of in-stream wetlands adjacent to the Stanage Bay Road on Boundary Creek called Boundary Flat Lagoons. While small in size these lagoons remain close to pristine with natural connectivity to the estuary. Barramundi have been tagged in these lagoons with one recaptured at Double Heads south of Yeppoon (Suntag, 2004).

To the south of Stanage Bay is the largest freshwater wetland area in Central Queensland. The Torilla Flats wetland is estimated to be 170 square kilometres in size (*figure 51*). It is primarily a grassed wetland with some treed areas. The wetland has been ponded along the upper tidal limit and the use of this wetland by fish is unknown. It is probable that before being ponded, this wetland was significant to fisheries resources.

In the SWBTA there are a number of small in-stream freshwater wetlands on creeks that flow into Shoalwater Bay. These include Raspberry Creek, Oyster Creek, Shoalwater Creek and Head Creek. All these are small, mostly pristine and are not under any known threat being in the SWBTA. The estuarine creeks in Shoalwater Bay are pristine and fishing effort is low. Barramundi stocks in these creeks are considered to be lower than other heavily fished areas such as the Fitzroy River (*pers obs.* Sawynok). This could be due in part to the healthy stocks of other competing species or the very small extent of freshwater wetlands supporting these estuaries.

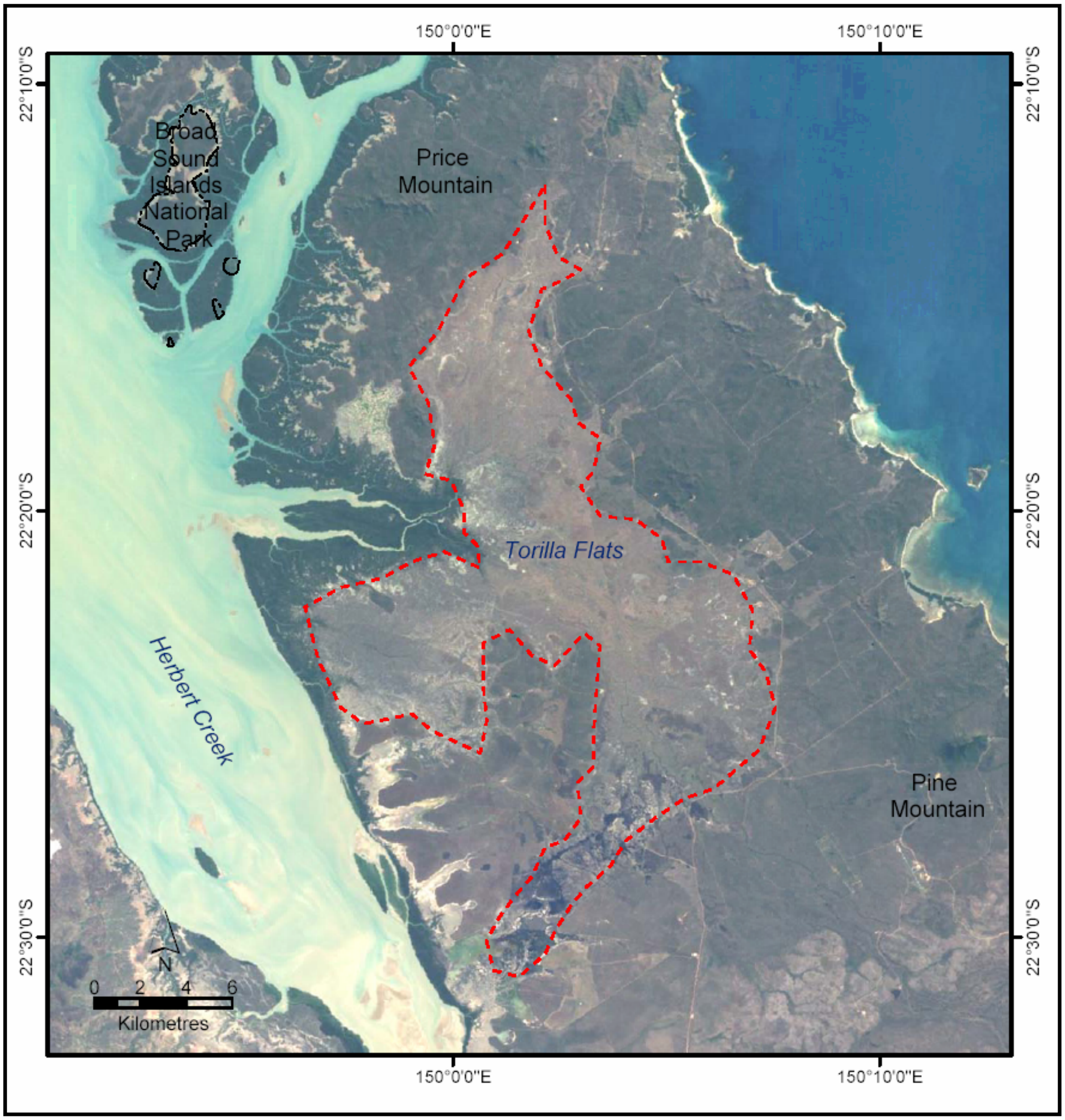


Figure 51: Torilla Flats wetlands south of Stanage Bay

Risks or threats to Broadsound wetlands:

1. Ponded pastures that reduce connectivity with the marine system.

2. Open cut mining of magnesite in the Kunwarara area.

11.4.2. Corio Bay Wetlands

Figure 52: Corio Bay wetlands north of Yeppoon

The Corio Bay wetlands (*figure 52*) are an extensive area of coastal wetlands to the north of Yeppoon on the southern side of Corio Bay. The wetland area has a series of bund walls that separate freshwater wetlands from the tidal creeks. The walls have some low areas that allow fish passage during flooding however passage is limited at other times. Capricorn Sunfish (Sawynok, 2002, 2003) and DPI&F (Hyland, 2002) have monitored fish use of this area. The wetlands vary in type from bulkuru swamps to melaleuca and palm forests and open wetland areas.

The Corio Bay wetlands have virtually no grazing and this is leading to an increase in grassy weeds such as para grass. There are also areas of woody weed that require ongoing management. While some areas of ASS have been allowed to oxidise, the impact appears minimal due to the waterlogged nature of the area for substantial periods of time.

Tarpon have been recorded approximately three kilometres upstream from the tidal limit and barramundi have been tagged and released approximately five kilometres above tidal influence in a feeder creek connected through the wetland in an area with undefined watercourses that is semi-permanently inundated (Sawynok, 2002, 2003). Following the 1991 flood, 185 juvenile barramundi were tagged in the wetland. Subsequent to the flood, some of these fish were recaptured throughout Corio Bay, as far north as Island Head Creek north of Port Clinton and as far south as Gladstone (Suntag, 2004).

Figure 53: Pipe under the roadway and levee bank separating brackish water in foreground from freshwater wetlands in background (juvenile barramundi and other species have been recorded below the pipe)

The wetland includes an artificial saltwater pondage in an area adjacent to Fishing Creek where material was extracted for road construction in the 1980s (*figure 53*). This pondage is connected to the creek on king tides and 38 species have been recorded using this habitat (Sawynok, 2002, 2003). While the creation of this wetland was largely incidental it demonstrates that viable wetlands can be created to replace those that have been lost.

Risks or threats to Corio Bay wetlands:

1. Bund walls that limit access to the wetlands to during periods of flooding.
2. Road construction without suitable fish passage devices.

11.4.3. Fitzroy River Floodplain

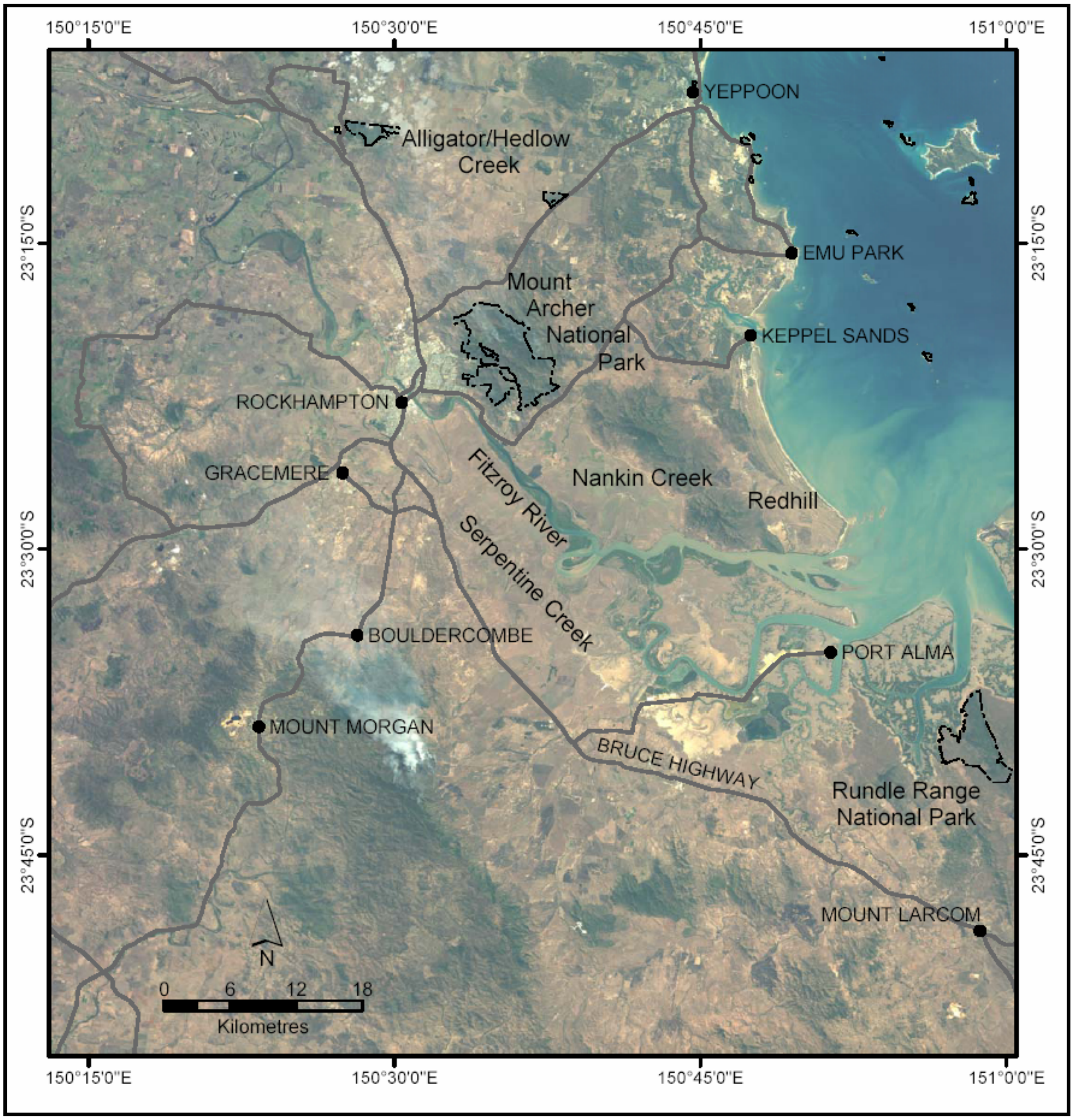


Figure 54: Fitzroy River floodplain and associated wetlands

The Fitzroy River and its tributary and distributary system (*figure 54*) is the largest in area in the GBR (EPA, 2003). Before development, the river and floodplain allowed marine fish access to thousands of kilometres of riverine habitat and numerous off-stream wetlands (Dunstan, 1959).

The construction of the Fitzroy River Barrage in 1970, to supply water to the City of Rockhampton, resulted in access to a large part of the river above the barrage, and off-stream wetlands, largely denied to fish. The barrage, despite having a functioning fishway since 1997, significantly reduces the number of fish that can migrate upstream. The combined impacts of a number of barrages, weirs and ponded pastures is now denying fish access to approximately 80% of the original extent of habitat that was available, except during major flooding (Sawynok, 2002). Therefore the significance of remaining areas is considerably more important.

The fishway provides good passage for many species, but it is only moderately successful for key species such as barramundi (Stuart, 1997). Following the major flood in the Fitzroy River in 1991 seven barramundi tagged below the barrage were recaptured upstream. Since that time there have been no fish tagged below the barrage recaptured above the barrage (Sawynok, 1998, Suntag data, 2004). The area above the barrage is now regularly stocked with barramundi in areas where these fish have previously been recorded but have largely been absent since the construction of the barrage and upstream weirs.

11.4.3.1 Alligator and Hedlow Creek

Figure 55: Hedlow Creek has good in-stream habitat with modest riparian vegetation

Alligator Creek is a tributary of the Fitzroy upstream of the barrage. Alligator Creek drains a large sub-catchment that extends northwards and eastwards to the coastal hills inland from Yeppoon (*figure 54*). The lower reaches of Alligator Creek are part of the storage of the Fitzroy River Barrage. Hedlow Creek is one of many creeks that flow into Alligator Creek. Part of Hedlow Creek forms a permanent deepwater in-stream habitat 12 kilometres long. Canal Creek is another tributary of Alligator Creek with smaller permanent deepwater in-stream habitat. Serpentine Lagoon to the north is part of the drainage basin with similar significant habitat. There are also a number of smaller creeks and off-stream lagoons in this area that drain into Alligator Creek.

Hedlow Creek, Serpentine Lagoon and Green Lake have been stocked with barramundi in the last decade to include these fish in a habitat that was previously available to them. Barramundi tagged in Serpentine Lagoon in 2002 were recaptured in the estuarine part of the Fitzroy River following the February 2003 flooding demonstrating that downstream movement is possible during flood events (Suntag, 2004).

Riparian vegetation is poor along both Hedlow Creek (*figure 55*) and Serpentine Lagoon however is more natural along Canal Creek.

Risks or threats to Alligator Creek and Hedlow Creek:

1. The ongoing fish passage restriction through the Fitzroy River barrage.
2. The loss of remaining riparian vegetation.

11.4.3.2 Moore Creek

Figure 56: Moore Creek causeway at the upper tidal limit after moderate rain

Moore Creek is a small creek in the urban area of Rockhampton and is the last off-stream habitat available to fish below the barrage. The creek has been extensively modified in the freshwater reaches with little remaining riparian vegetation. A low causeway separates the saltwater and freshwater reaches of the creek (*figure 56*). It has some weed infestation and is shallow but now has permanent flow due to seepage from residential and parkland irrigation and water quality, although impacted, supports fish life.

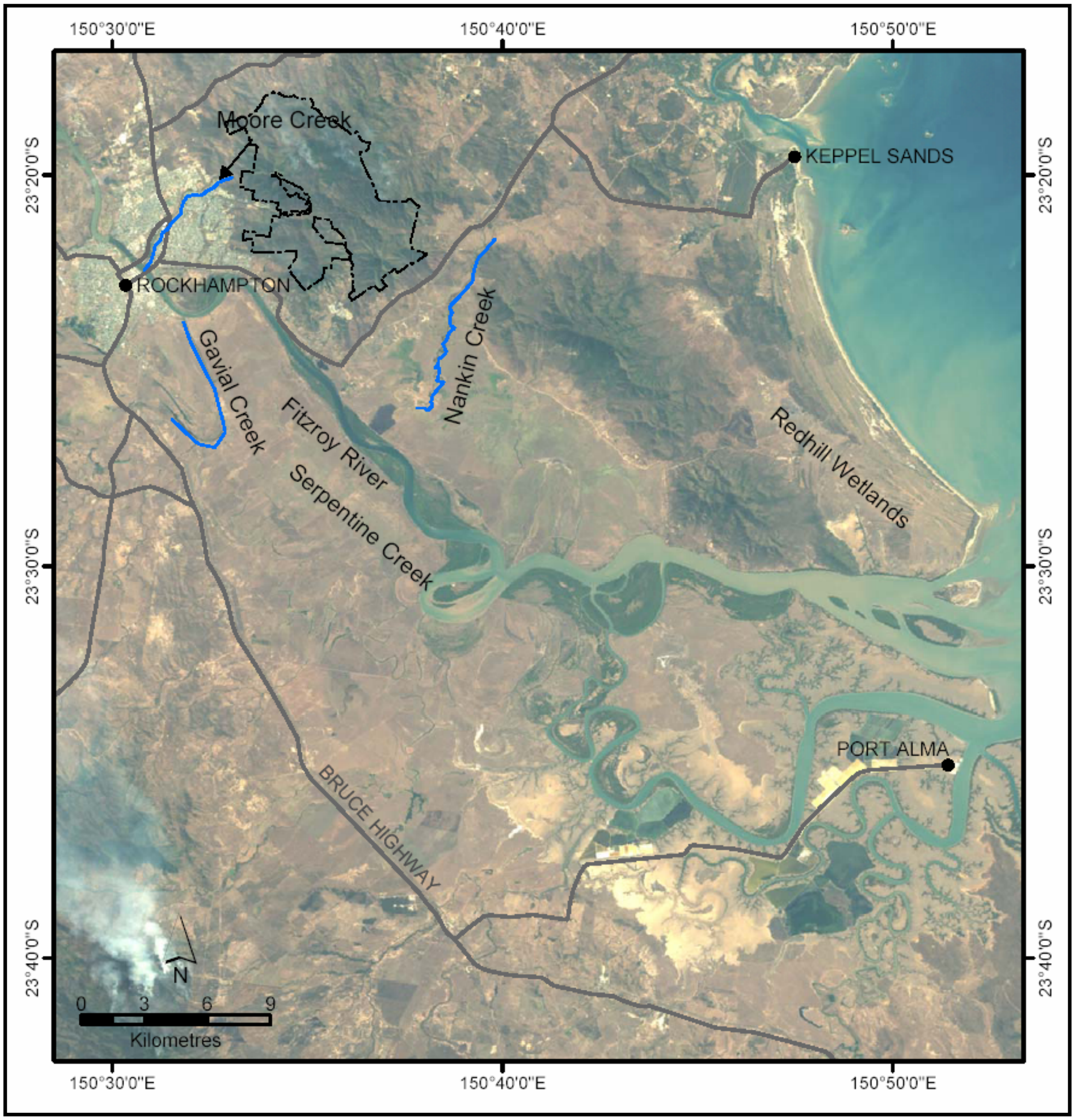


Figure 57: Wetlands adjacent to the Fitzroy River near Rockhampton

While small native fish and gambusia were observed during inspection, the freshwater habitat is not suitable for larger natives such as barramundi, mullet and bony bream that could otherwise reach the area. Over 40 marine and freshwater species have been recorded in the tidal, but mostly fresh, section of Moore Creek below the causeway (Sawynok, 2002, 2003) with few likely to be found in the freshwater above the causeway.

Rockhampton City Council has a program of establishing artificial wetlands in Moore Creek however they are not aimed at improving use by fish.

11.4.3.2 Nankin Creek Wetlands

Approximately 15 kilometres downstream from Rockhampton, the Fitzroy River has a wide floodplain that acts as both a tributary and distributary system, depending on the pattern of rainfall. Nankin Creek is a narrow flow path through a broad flat floodplain forming the Nankin Creek wetlands (*figure 57*). When the Fitzroy River is in flood parts of this plain are inundated. Nankin Creek carries localised runoff when the river is not in flood. Nankin Creek has a large in-stream deepwater hole in it lower section that remains naturally connected to the river. A large oxbow lagoon (*figure 58*) immediately to the east of the creek forms an important part of this wetland and juvenile barramundi are know to use this area (Hyland, 2002).

Figure 58: Oxbow lagoon east of Nankin Creek and part of the Nankin wetlands

While the Nankin Creek wetland is almost devoid of trees, a narrow riparian strip within the creek banks occurs along most of the length of the creek (*figure 59*). During heavy local rainfall and flood events, numerous shallow wetlands form on this floodplain. While some of these dry completely during long dry spells these shallow ephemeral wetlands are important to fish and birds.

Risks or threats to Nankin Creek wetlands:

1. Depth reduction as a result of siltation of the oxbow lagoon.
2. Lack of riparian vegetation.

Figure 59: Nankin Creek saltwater-freshwater interface with ephemeral wetlands in the background

11.4.3.3 Barramundi Creek and Red Hill Coastal Wetlands

Barramundi Creek is a relatively small tidal creek that joins the Fitzroy River near its mouth and drains extensive coastal wetlands that extend northward behind the coastline in the area known as Red Hill (*figure 60*). Barramundi Creek has a barrier at the upper tidal limit that allows ponding of freshwater on the wetlands but limits fish access. Although this system has been subjected to the development of ponded pastures, no on-ground monitoring of fish use has been undertaken. The Coastal CRC and Capricorn Sunfish have undertaken aerial assessments of this area and these wetlands are considered likely to be of significance to fisheries resources. After rain, wetlands connected to Barramundi Creek and smaller coastal creeks extend for approximately 15 kilometres from the mouth of the Fitzroy River to Joskeleigh with extensive shallow areas and some apparent deep areas that may act as refuge during dry periods.

This wetland area may be one of the most significant remaining in the lower Fitzroy River and a priority is to assess its value for fisheries resources to determine if its values should be protected and enhanced where possible.

Figure 60: Barramundi Creek showing the interface between freshwater wetlands and tidal creek

Risks or threats to Barramundi Creek and Red Hill Coastal wetlands:

1. A lack of knowledge of the fisheries values of these wetlands.
2. The unknown impact of the ponded pastures on fish passage.
3. Possible sedimentation and nutrient enrichment of water.
4. Tilapia have been recorded from a dam in the area but are considered to have been eradicated.

11.4.3.5 Gavial Creek and Lagoons

Gavial Creek is a tributary creek on the south side of the Fitzroy River entering the river immediately downstream of Rockhampton. It comprises a number of intermittently connected lagoons that form part of the creek and are also connected to adjacent lagoons (*figure 61, 62*). During large floods, such as in 1991, the Fitzroy River breaks its banks upstream of Rockhampton and flows across this southern floodplain filling and connecting all the lagoons. Some lagoons, including those in Gavial Creek, are also filled and connected during flows in the creek. The main lagoons with known fisheries values are Yeppen, Woolwash, Frogmore and Bates Lagoons (Sawynok, 1998, 2002; Suntag, 2004).

These lagoons in the middle reaches of the floodplain are now critical habitats for a wide diversity of fish species as they are the only off-stream wetlands on the southern side of the river that still have natural connectivity to the tidal reaches of the river. Yeppen Lagoon is approximately one kilometre in length whilst Woolwash and Frogmore are both two and a half kilometres long and Bates Lagoon is one kilometre long. With the exception of Bates Lagoon all are permanent and Bates Lagoon only dries during long dry periods. In moderate to large floods, this network of lagoons is connected to the river when floodwater backs up Gavial Creek and allows migration of native fish. While this overcomes some of the impacts of the barrage, it cannot replace the major migrations that would have occurred naturally in low flow conditions in the river.

Figure 61: Gavial Creek lagoons south of Rockhampton

The impact of adjacent land practices on these lagoons is limited and a narrow riparian vegetation strip has been retained in most areas. The riparian vegetation has been partly removed and a Landcare project has replanted trees along a riparian section of Woolwash Lagoon. Para grass and other weed invasion of this section of the lagoon have been treated and infestation is now light. Cattle keep invasive grasses in check in other areas of these lagoons.

Barramundi tagged in these lagoons have been recaptured throughout the Fitzroy River estuary, as far north as Dumbleton Weir on the Pioneer River at Mackay and as far south as the Gregory River at Hervey Bay (Sawynok, 1998, Suntag 2004). This is also a site where a number of fish tagged in the Fitzroy River have been recaptured in the lagoons.

Figure 62: Woolwash Lagoon on the Fitzroy River floodplain

Risks or threats to Gavial Creek and lagoons are:

1. Reduced water flow in the Fitzroy River may reduce the connectivity of the lagoons to the river.
2. Water contaminants from rural residential development on the western side of Frogmore Lagoon and Gavial Creek.
3. Minor weed infestations, particularly para grass.

11.4.3.6 Serpentine Creek

Serpentine Creek is a small floodplain creek on the southern side of the Fitzroy River that enters the river at Pirates Point. Serpentine Creek, with at least five major barriers to fish migration along its length of just 30 kilometres, is an example of the extent to which fisheries habitat can be modified to reduce connectivity and diminish fisheries values. Fish can only access lagoons on this creek during major flooding such as experienced in 1991 and its value to marine fish is considered very low.

11.4.3.7 8 Mile Creek

On the south side of the Fitzroy River there is an extensive delta with a number of channels and feeder creeks that all once had significant fishery values. Many of the creeks have been degraded as a result of barriers at the tidal limit of feeder creeks and gullies and tree clearing for grazing. It is only some of the larger creeks such as 8 Mile Creek that have been able to maintain limited fishery values.

Figure 63: Bajool weir showing the overflow pipe on the downstream side
Inset: Juvenile barramundi of 67mm caught below the weir

8 Mile Creek has a range of in-stream habitat including some permanent and semi-permanent shallow pools from the tidal reaches upstream to the Bajool Weir, a distance of approximately two kilometres. Riparian vegetation along the creek is mostly sparse and disconnected however where present it provides an important contribution to habitat. The weir wall is part of the Port Alma Road and the dam supplies water to the nearby township of Bajool. The weir wall prevents further upstream access to fish except in periods of major flooding. Juvenile barramundi and other fish species can migrate upstream as far as the weir but when water stops flowing through the overflow pipe, they become

trapped in shallow ponds that dry up at its base (*figure 63*). This causes in regular fish kills of small fish trapped at the weir wall.

During a field inspection in early January 2004, a barramundi 67 mm long was caught and released below the weir. Further small barramundi were caught in the same location in the following weeks, while there was flow in the creek. Some of these barramundi were released upstream above the weir.

This creek is important for fisheries resources and consideration should be given to modifying the overflow arrangements so that fish passage can be restored. As the height of the wall is only around two metres and passage is only required on high flow conditions the fishway technology to deal with this is available. There is an opportunity for such works to be included in upgrade or maintenance plans for the road.

A fish passage problem existed about 5km further east along the Port Alma Road where part of Inkerman Creek was isolated by the roadway. In April 1999 a major fish kill occurred in this location involving over 2,000 fish, including 1,200-1,500 barramundi (Sawynok, 2002). As a result of this the Department of Main Roads addressed the issue and placed a culvert under the roadway and alleviated the problem.

Risks or threats to 8 Mile Creek are:

1. Blocking of fish passage by Bajool Weir.
2. Further degradation of the generally poor riparian zone.
3. Minor rubber vine infestation.

11.4.3.8 12 Mile Creek

12 Mile Creek is a small narrow creek near Marmor (*figure 64*) feeding into a brackish lagoon on the edge of the delta. This lagoon is tidally influenced on 3 or 4 of the largest tides each year and is, at other times, not connected unless there is significant rainfall causing the creek to flow. Riparian vegetation is sparse, disconnected, and mostly within the creek banks along the brackish lagoon. Water quality varies considerably and a number of minor fish kills have occurred. A total fish kill was recorded in 2001 (Sawynok, 2002).

Monitoring of barramundi by the Suntag program in 12 Mile Creek has been undertaken since around 1985 and for all species by Capricorn Sunfish since 1999. 12 Mile Creek is considered to be one of the key juvenile barramundi habitats in Central Queensland with around 1,500 juvenile barramundi tagged in the brackish lagoon in 1996 (Sawynok, 1998, 2002, 2003; Suntag, 2004). The creek has been continually used by barramundi since 1985 with over 4,500 barramundi tagged. Fish have been recaptured downstream in all parts of the

Fitzroy River and as far away to the south as the Kolan River near Bundaberg (Suntag, 2004).

Figure 64: Aerial view of brackish lagoon on 12 Mile Creek showing lack of riparian vegetation

12 Mile Creek has also been a restoration site for Capricorn Sunfish whose members have planted native trees in the riparian and near riparian areas to restore habitat values (Sawynok, 2001).

Risks or threats to 12 Mile Creek are:

1. Proposed future expansion of saltworks on the Fitzroy delta.
2. Unknown causes of fish kills that appear to be increasing in frequency and severity.

11.4.3.9 Raglan Creek

Raglan Creek drains into the lower reaches of the Fitzroy River (*figure 65*). Raglan Creek has extensive in-stream freshwater wetlands that are important to fishery resources within the GBR. Although in-stream and fed by permanent springs, habitat quality and the absence of major barriers to migration results in Raglan Creek having fishery values that are as good as could reasonably be achieved in a productive rural catchment.

A range of marine and freshwater species have been caught in the lower large lagoon known locally as Blacks Hole. Barramundi, mangrove jack, tarpon, forktail catfish, bony bream, rainbowfish, mullet and yellowfin bream have been recorded at this site. Barramundi tagged in Blacks Hole have been recaptured throughout the Fitzroy River system as far up as the barrage at Rockhampton, as far south as the Calliope River, and as far north as Flock Pigeon Island near Clairview (Suntag, 2004). Blacks Hole has also been assessed for mangrove jack but there have not been any records of fish tagged here that have been recaptured elsewhere (Russell et al, 2003; Suntag, 2004).

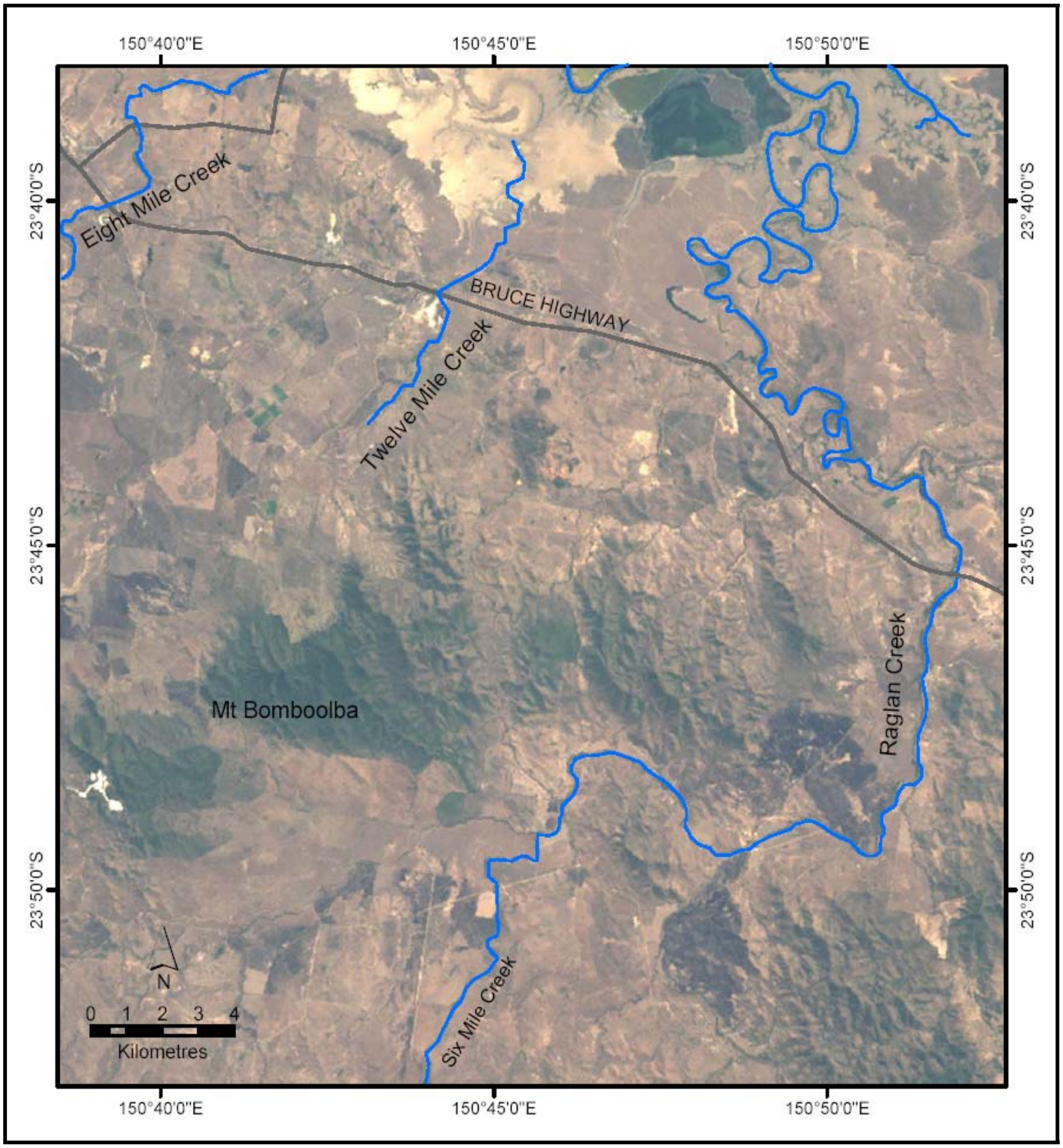


Figure 65: Raglan Creek, 12 Mile Creek and 8 Mile Creek to the south of the Fitzroy River

Fish passage, particularly upstream migration of barramundi to Blacks Hole, has been effectively stopped during low flow periods following the upgrading of an old wooden bridge to a culvert on Raglan Station Road in 2003 (*figure 66*). A

300mm drop in water level below the culvert now effectively prevents migration during low flows where previously fish were unimpeded in their upstream movement. Further upstream, the old highway culvert also presents a barrier to migration (*figure 67*).

Figure 66: The causeway on Raglan Creek during a flow event indicating obstacles to fish migration

From March to May 2004 a total of 19 barramundi up to 300mm in length were caught below the culvert and moved to above the culvert. Further barramundi were also tagged in the waterhole below the culvert.

Risks or threats to Raglan Creek are:

1. Water extraction for local irrigation has stopped the creek flowing when it would normally flow all year round.
2. Weed infestations from pasture grasses and woody weeds in the riparian zone.
3. Stopping of fish migration in low flow events from a culvert and causeway on roads crossing the creek;
4. Development of intensive agriculture to replace existing grazing use.

Raglan Creek is one of the least impacted and more important wetland systems in the developed GBR catchment and should be considered for the development of a neighbourhood catchment plan to maintain and improve its habitat and fisheries values. Resolution of the fish passage issues is a priority.

Figure 67: The culvert on Raglan Creek that now prevents upstream migration of juvenile barramundi

Figure 68: Pelican Lagoon adjacent to Raglan Creek showing the lack of riparian vegetation

Raglan Creek also has an off-stream freshwater to brackish wetland adjacent to the tidal reaches of the creek to the northwest of Raglan. Pelican Lagoon has good connectivity to Raglan Creek but it has no riparian vegetation and its water quality is unknown (*figure 68*). Local anecdotal information indicates that barramundi use this wetland but no investigation of its use by fish has been undertaken. The lagoon is located on private property.

11.4.4. Curtis Island

Figure 69: Aerial view of the extensive freshwater wetlands upstream from Yellow Patch on Curtis Island

An extensive wetland area exists at the northern end of Curtis Island that feeds into the Yellow Patch Creek system near Cape Capricorn. This wetland area has an old bund wall that was built to separate freshwater and saltwater areas of the wetland. This is an extensive grassed, mostly treeless wetland of about 30km^2 but it has little or no permanent freshwater and is not considered significant to fish (*pers comm.* P Stoneley)(*figure 69*).

A number of small, short creeks drain into the Narrows on the western side of the island. Graham Creek is a larger creek at the southern end. There are small semi-permanent to permanent freshwater in-stream pools on some of these creeks however their value to fish is likely to be limited. There are no off-stream wetlands that are likely to be significant (*figure 70*).

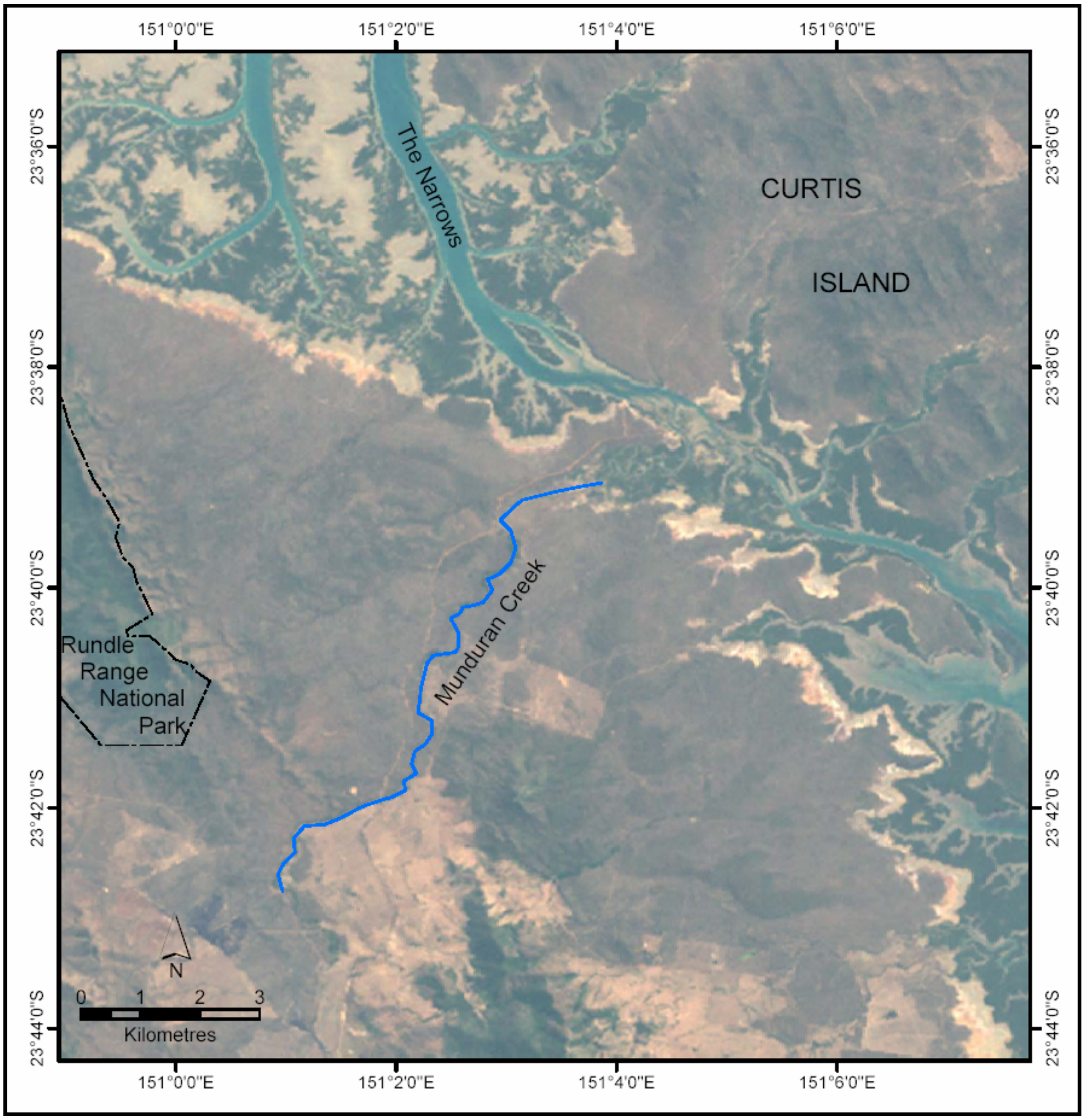


Figure 70: Munduran Creek and the Narrows between the mainland and Curtis Island

11.4.5. The Narrows

A number of small creeks drain into the Narrows from the mainland to the west. Munduran Creek is the only creek with significant in-stream freshwater wetlands (*figure 70*). There are no significant off-stream freshwater wetlands.

Munduran Creek is a small catchment entering the Narrows at Ramsay Crossing. It is largely pristine in the lower section with a significant part of its catchment in State Forest. Natural vegetation occurs for 10 kilometres from the creek's mouth at the Narrows. There are some permanent and semi-permanent sections of freshwater habitat above a relatively shallow tidal lagoon at the upper tidal limit, including a permanent deepwater hole about 0.3 km long about four kilometres above the tidal limit (*figure 71*). Mullet have been observed in this waterhole and there is anecdotal evidence of juvenile barramundi (*pers comm.* P Stoneley). Upstream of the State Forest area the creek runs through grazing country that has been mostly cleared although there is a continuous narrow riparian vegetation strip within the banks of the creek. There are no permanent waterholes or wetlands above the State Forest area.

Figure 71: Near pristine in-stream freshwater lagoon on Munduran Creek

Water temperatures in the tidal lagoon are consistently higher than in similar adjacent creeks and can be high enough to restrict use by some species. The water temperature has been measured above 35°C regularly during summer months (Sawynok, 2002). There are no artificial barriers to prevent migration and the area is protected by its present land tenure. Some rubber vine exists along the creek but weed levels are generally low and the only impact is from sediment run-off from dirt roads in the area. Although saltwater stretches of Munduran Creek are monitored regularly by Capricorn Sunfish, no monitoring has been undertaken above the tidal limit. The Coastal CRC will begin monitoring the creek for fisheries resources in a current project.

This area is presently lightly impacted by grazing and some limited cropping. It is close to industrial development from a resource perspective and some areas are underlain by extensive shale deposits. Shale mining has the potential to threaten the ecological functioning of wetlands in the vicinity of The Narrows.

Risks or threats to Munduran Creek are:

1. Possible future mining of oil shale.
2. Temperatures significantly higher than other creeks in the area may limit its use by fish during summer.

11.4.6. Calliope River

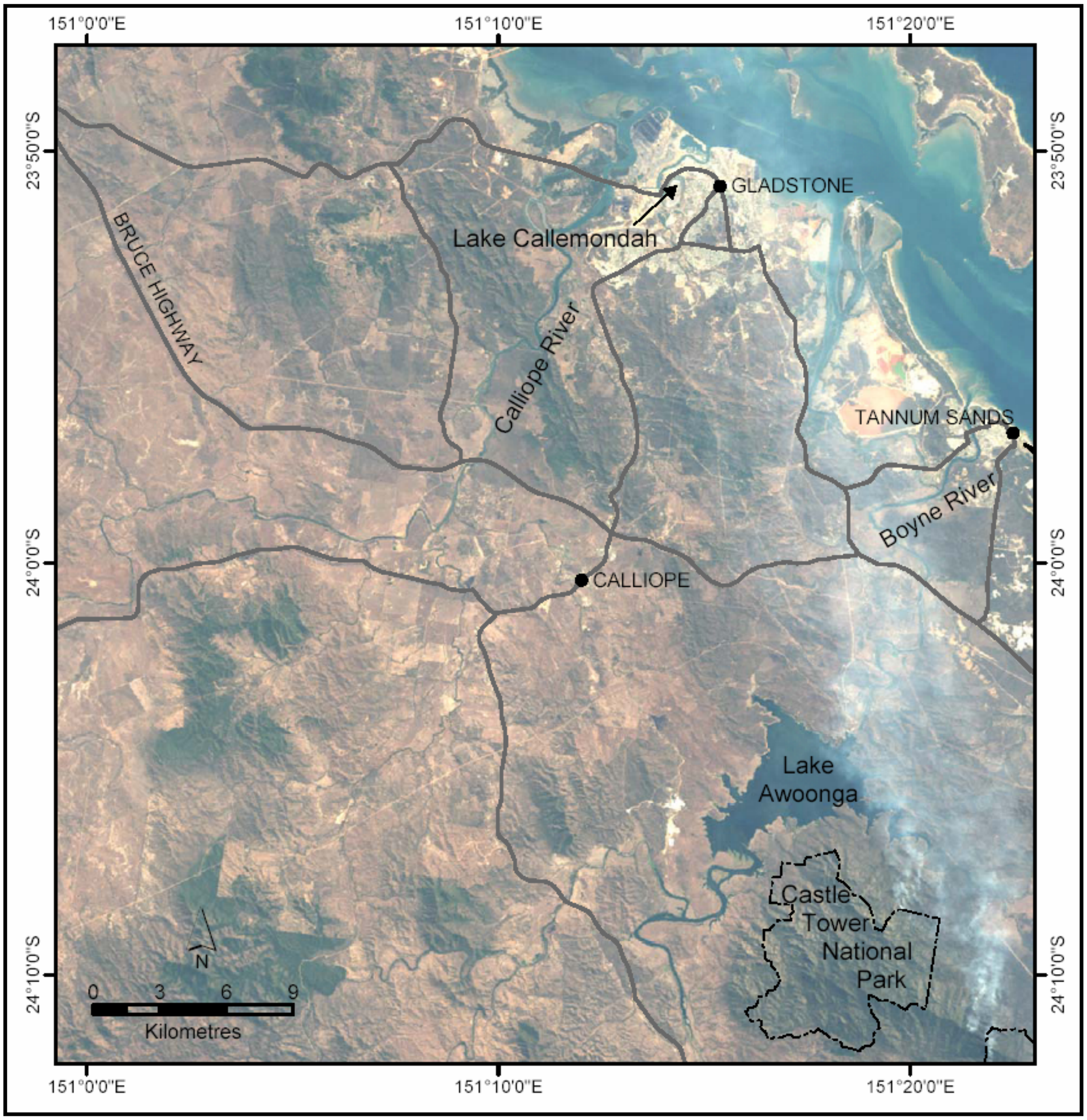


Figure 72: Calliope River and Boyne River near Gladstone

The Calliope River to the north of Gladstone is one of two rivers in the Gladstone area (*figure 72, 73*). It has no significant barriers to fish movement and has natural flows. In the upper tidal reaches there is a natural rock bar below the Bruce Highway and a causeway on the old highway bridge. Larger tides push saltwater up above these minor barriers and they do not limit fish passage to any significant extent. There are few off-stream freshwater wetlands along the

Calliope River however there are extensive in-stream freshwater pools in the river and larger tributaries such as Mount Larcom Creek. An assessment of habitat and fisheries resources in the freshwater and estuarine reaches of the Calliope River has been undertaken. A total of 27 fish species were recorded in freshwater and 16 of these were diadromous (Long, 1994). No exotic species were recorded during that assessment.

Figure 73: In-stream freshwater wetland on the Calliope River

Wilmott Lagoon is a relatively small lagoon about 1km long that connects to Mount Larcom Creek in the East End area and has connectivity to the creek during floods. Some riparian vegetation remains at the northern end of lagoon but the southern end has been cleared. It has been stocked with barramundi in recent years. Wilmott Lagoon is used for water supply for the Queensland Cement Limited (QCL) limestone mine at East End. A gully connecting the lagoon to Mount Larcom Creek is partially blocked by an earthen wall.

Risks or threats to Calliope River are:

1. Water extraction for adjacent development.
2. Damming for future water supply to Gladstone industrial and urban development (this option was considered but rejected when it was decided to upgrade the capacity of Lake Awoonga however future development may renew consideration of this option).

Risks or threats to Wilmott Lagoon are:

1. Water extraction for the QCL limestone mine at East End.
2. Partial blocking by earthen wall of connecting gutter to Mount Larcom Creek.
3. Loss of riparian vegetation.

11.5. Lake Callemondah – Gladstone

Figure 74: Water overflowing the wall on Lake Callemondah at Gladstone

Lake Callemondah is an artificial lake in Gladstone at the upper tidal limit of Auckland Creek (*figure 74*). It is in an area that has been largely modified by industrial development with significant changes in the saltwater reaches of Auckland Creek. The lake is filled by freshwater runoff from urban areas of Gladstone.

The lake has been stocked with barramundi. The catchment is small and although fish can migrate downstream, upstream migration is effectively prevented by a wall about two metres high separating the freshwater from the saltwater. Stocked fish tagged in Lake Callemondah have been recaptured in all local creeks and rivers running into Gladstone Harbour (Suntag, 2004). No fish tagged below the barrier have been recaptured above the weir wall.

Downstream of the barrier, the mangroves appear stressed with reduced and yellow coloured leaves and some trees are dead (*pers obs* Veitch).

Lake Callemondah is locally important as it raises awareness of the importance of healthy wetlands and could be used in future education programs. While the lake sustains fish, it could not be considered to be high quality habitat due to the impact of adjacent industrial and upstream residential development and poor to non-existent riparian vegetation in many areas.

11.5.1. Boyne River

The Boyne River, to the south of Gladstone, has a low earthen wall called Mann's Weir at the tidal limit that separates saltwater from freshwater. Approximately five kilometres above Mann's Weir is Awoonga Dam that effectively blocks fish passage. Lake Awoonga provides the water supply for Gladstone and the wall was extended in 2002 to increase its capacity. Prior to this there was no flow downstream from the lake except in major flooding. Following the raising of the wall there is now a capacity to allow environmental flows down the river and the first such flow occurred in late January 2004 (*pers comm.* K Cowden). This environmental flow is through a pipe in the dam wall and water can be taken from a range of depths from above the wall. The environmental flows have washed away Mann's Weir but it will be rebuilt once flows cease. The impact of this on fish below the weir and those in the dam is not yet known but will be assessed as part of monitoring the environmental flow by DPI&F and local recreational fishers.

Lake Awoonga has been stocked by a range of fish species over the past few years including sooty grunter, golden perch, silver perch, barramundi, yellowfin bream, sea mullet and more recently mangrove jack.

11.5.2. Rodds Bay creeks

A number of small creeks drain into Rodds Bay south of Gladstone. These creeks include Iveragh Creek, 7 Mile Creek, Sandy Creek, Jeyne Creek, Oaky Creek and Worthington Creek. All these creeks are less than 20 km in length and are mostly estuarine with small permanent in-stream freshwater pools above the tidal limit. None of the creeks have any significant off-stream freshwater wetlands. The catchments of these creeks are generally used for grazing. They have only been lightly to moderately cleared and riparian vegetation along the creeks is generally good although in some cleared areas it is confined to within the creek banks. Most creeks have natural connectivity to their estuaries and water quality is acceptable.

Sandy Creek is typical of these creeks and monitoring of fish has occurred immediately downstream of the tidal limit where an old road causeway provides a limited barrier to upstream fish movement (*figure 75*). A total of 29 species have been recorded at this site (Sawynok, 2002). Barramundi have been noted in the freshwater pools of this creek about 1km above the causeway. Barramundi and mangrove jack have been tagged in the freshwater pools of the other creeks (Suntag, 2004; *pers comm*. P Stoneley).

Figure 75: Old causeway over Sandy Creek about 1km downstream from tidal limit

11.5. Bundaberg Region

The Bundaberg Region, for the purpose of this report, is from Bustard Head in the north to Hervey Bay in the south.

11.5.1. Bustard Head to Agnes Waters

From Bustard Head to Agnes Waters there are a number of small tidal creeks. These are Pancake Creek, Jenny Lind Creek, Middle Creek, Eurimbula Creek and Round Hill Creek. Pancake Creek, Jenny Lind Creek and Middle Creek have little or no permanent freshwater wetlands of value to fish. Eurimbula Creek and Round Hill Creek (*figure 76*) have areas of wallum wetlands; however, the extent and value of these to fish is unknown. As both these areas are within the Eurimbula National Park threats are considered to be minimal. Barramundi and mangrove jack have been caught in the freshwater pools of Eurimbula Creek (*pers comm.* P Stoneley).

Figure 76: Creeks and adjacent wetlands from Bustard Bay to Agnes Waters

11.5.2. Agnes Waters to Hervey Bay

Deepwater Creek, south of Agnes Waters, has an extensive area of wallum wetland its upper freshwater reaches however there are only small semi-permanent pools of water in the channel of Deepwater Creek. There is a tidal barrage on Deepwater Creek that prevents normal fish movement from saltwater to the freshwater. Impounded freshwater is used for irrigation of an adjacent macadamia farm. The fisheries values of the freshwater to marine fish is likely to be low as the barrage can only be bypassed in major floods.

Baffle Creek (*figure 77*) is the most important waterway in this district as it remains relatively intact with no barriers that prevent fish movement from saltwater to freshwater. The creek has a number of off-stream wetlands in the lower reaches adjacent to the estuary but most have been converted to production use such as farm water supply, ponded pastures or for irrigation and their fishery values are unknown. An assessment of habitat quality and the fisheries resources of the freshwater and estuarine parts of Baffle Creek has been undertaken including one off-stream lagoon on Granite Creek (Lupton and Heidenreich, 1996). Of the 25 fish species sampled in freshwater seven were diadromous. The freshwater reaches of Baffle Creek have also been sampled for mangrove jack with one fish tagged in the freshwater being recaptured in the Kolan River to the south (Russell *et al*, 2003).

Figure 77: Baffle Creek north of Bundaberg

Littlabella Creek lies to the south of Baffle Creek. There are a number of weirs on feeder creeks and a tidal barrage on Walsh Creek that impound water for use in farm production associated with sugar cane and grazing. There is an off-stream freshwater lagoon on the northern side of Littabella Creek but its fishery values are unknown.

The Kolan River is to the north of Bundaberg and has a tidal barrage that separates freshwater from saltwater. The barrage has a fishway that was upgraded to a vertical slot design in 1998. Monitoring of the fishway has identified use by 22 species including 12 diadromous species (Broadfoot *et al*, 2000). Upstream of the barrage on the Bucca Weir and the Fred Haig Dam prevent any further upstream migration of fish. Lake Monduran above the dam has been stocked with barramundi. Yandaran Creek is a tributary of the tidal reaches of the Kolan River and there is also a tidal barrage on this creek.

The largest river in this region, the Burnett River, has been dammed extensively upstream from the Burnett River barrage in Bundaberg right throughout its catchment. It is likely to be the most extensively dammed river in Queensland. There is a fishway on the Burnett River barrage in Bundaberg and 34 species, of which 18 were diadromous or estuarine species, were recorded moving through the fishway (Stuart and Berghuis, 1999). Walla Weir is 50km upstream from the Burnett River barrage and has a fishlock on it to allow fish passage. A total of 33 species were recording using the fish lock of which only 8 were diadromous species. Significantly fewer diadromous species were recorded at Walla Weir compared with those at the barrage (Stuart and Berghuis, 1999).

There are no off-stream freshwater wetlands on the coastal plain adjacent to the Kolan River and Burnett River that are considered to be significant to fisheries resources.

12. Fish movement between Marine and Freshwater Habitats

Data on fish movement between marine and freshwater habitats in the GBR Catchment is generally limited, although some areas on a local scale are well documented. This section provides an overview of some of the available data.

Seventy-nine fish species have been identified that use a number of habitats from freshwater wetlands to offshore coral reefs. Mangrove jack and eels were identified as using all habitats. The complex matrix of species using different habitats supports the need for fish to have the benefit of a “chain of habitats” (Cappo *et al*, 1998) from freshwater to the outer reef and beyond.

Evidence of marine fish movement between estuaries and freshwater wetlands was obtained from the Suntag database of ANSA Qld. Since 1984 barramundi have been tagged in both estuarine and freshwater habitats. Some other species have also been tagged in freshwater but the numbers have been very low. Barramundi tagged in wetlands areas are listed in *Appendix 2*. Most tagging has occurred in Central Queensland and to a lesser extent in the Townsville and Burdekin areas.

The 12 Mile Creek at Marmor has had 4,658 fish tagged since 1984 showing a continuous usage of this site by barramundi (Sawynok, 2002, 2003). Tagging at other sites has been sporadic and dependent on angler availability, ease of angler access and climatic conditions. Over the last decade there has been below average rainfall in many of these coastal areas limiting fish access to these wetlands and use by barramundi.

Fish movement determined from the tagging data was dependent on the level of connectivity. The majority of fish movements were from freshwater to marine habitats (346) with fewer movements recorded from marine habitats to freshwater (30). This may be due in part to the greater fishing effort in estuaries or may be related to the low numbers of migration opportunities, especially in the last decade when drought conditions have prevailed along much of the coast. It may also be related to downstream migration where swimming with the current is much easier than upstream migration against the current.

A good example of downstream migration occurred in February 2003 following moderate flooding in the Fitzroy River. Four barramundi tagged in the Dawson River above Moura Weir were recaptured in the Fitzroy River estuary following the flooding. These fish had about a week to cover the 420 km down the length of the river while flows allowed them to bypass five weirs to get to the estuary. Four barramundi tagged in Serpentine Lagoon were also recaptured in the estuary. These fish covered around 130 km at about the same time but only had to bypass the barrage. No fish tagged below the barrage have been recaptured upstream following that flooding, however this may be a result of less fishing effort above the barrage.

In 1959, Dunstan reported barramundi in the Dawson River, indicating that a similar migration upstream to Moura was possible before the erection of barriers. The only time barramundi tagged below the barrage have been recaptured above the barrage was following the major flood in 1991 when 7 fish were recaptured up to 200km upstream. This is the only time when natural migration was possible upstream where the barriers were not able to prevent migration. No fish tagged below the barrage have been recaptured upstream since that time.

Apart from these fish in the Fitzroy River there have been no records of fish tagged below barriers subsequently recaptured above the barriers. All records of upstream movements were in systems where natural connectivity remains.

13. Summary

Table 2 summarises the risks and threats to wetlands identified in this study as important to marine fishery resources. Whilst the risks are mostly potential or in the future, the threats are actual and in many cases have already been realised.

It was difficult to separate off-stream wetlands from other parts of the freshwater component of waterways when dealing with fisheries values as no specific studies have been undertaken to establish differences between in-stream and off-stream wetlands. The extent to which freshwater wetlands are used by marine fish results from a combination of their connectivity to the marine system and the water and habitat quality in the variety of habitats in which the fish must live until they can again access more open systems at the next flood event.

There is only one small catchment along the GBR coast where freshwater wetlands of significance to fisheries are in almost pristine condition (Ella Bay) and the fishery values of this area have not been assessed. The specific values of off-stream wetlands have not been documented. In most regions in-stream wetlands are in much better condition than off-stream wetlands, especially in those systems with barriers to fish migration or where the development in the catchment is intensive, regardless of the land use. In reviewed studies, diversity was higher in lentic systems with their associated less frequent and less intense flows compared to lotic systems where larger species were more dominant.

From the areas considered in this study, catchments used primarily for grazing, especially smaller systems, were generally in better condition than those used for agriculture in relation to connectivity, water quality and habitat quality. Many off-stream freshwater wetlands have been converted to ponded pastures and tidal waterways disconnected from the marine system to prevent tidal inundation. These ponded pastures have been particularly detrimental to fisheries values of these areas. Although the impact of ponded pastures on fish has been recognised since 1991, there is still no policy to prevent or mitigate the impacts.

Threats and Risks	Riparian Zone Reduction	Increase in in-stream weeds and algae	Increased terrestrial weeds	Poor culvert design	Increased sedimentation	Increased nutrients	Pesticides and herbicides	Land degradation from feral animals	Lack of knowledge of use by fish	Inappropriate Fire Management	Agricultural expansion/intensification	Residential development	Tourism development	Industrial development	Drainage works	Reduced water quality (on-site)	Reduced connectivity due to downstream water	Water extraction reducing connectivity	Irrigation impacts	Ponded pasture impacts	Mining impacts (potential or actual)	Reduced water flow from dams etc.	Introduced noxious fish	Disturbance of ASS on-site or downstream
Daintree River	Y	Y	Y	Y	Y	Y	Y	Y				Y	Y			Y								
Ella Bay Swamp			Y					Y	Y															
Wetlands of the Tully-Murray floodplain	Y	Y	Y		Y	Y	Y	Y			Y				Y	Y		Y						Y
Edmund Kennedy National Park wetlands			Y		Y	Y	Y	Y	Y							Y								
Barratta Creek wetlands	Y	Y	Y		Y	Y	Y				Y					Y	Y		Y				Y	
Gorganga Plains wetlands	Y	Y				Y	Y		Y											Y				Y
Herbert Creek in Broad Sound																				Y	Y			
Gavial Creek lagoons at Rockhampton	Y		Y		Y	Y	Y					Y				Y								
Raglan Creek	Y		Y	Y		Y	Y				Y							Y	Y					
Baffle Creek	Y		Y				Y					Y	Y							Y				
Eubenangee Swamp		Y	Y	Y	Y	Y	Y	Y	Y						Y	Y	Y							
Hull River/Mt Coom Wetlands	Y	Y	Y			Y	Y	Y	Y	Y	Y	Y	Y		Y	Y								Y
Barramundi Creek and Red Hill wetlands			Y		Y	Y			Y											Y			?	
Cattle Creek wetlands	Y	Y			Y	Y	Y				Y				Y	Y	Y	Y	Y					Y
Rocky Dam Creek wetlands at Koumala		Y	Y					Y	Y		Y						Y	Y		Y				Y
12 Mile Creek at Marmor	Y		Y		Y	Y								Y		Y								

Table 2: Summary Table of Threats And Risks To Wetlands Of Importance To Fishery Resources

Catchments primarily used for agriculture, where sugar cane production is generally the dominant form of agriculture, and catchments in urban areas were the most modified with reduced connectivity, poorer water quality and poorer habitat. Many wetlands have been reclaimed or drained for other purposes such as residential or agricultural development. A general observation is that there are fewer fish and fewer species in such degraded freshwater wetlands compared with those in good condition. These waterways and wetlands are also those that have the greatest level of introduced noxious fish species and have the highest reported incidence of fish kills.

While small wetlands were considered to be individually not significant in overall terms to the fish stocks of the GBR lagoon these small wetlands are considered to be important both locally and collectively due to the overall loss of wetlands, the large number of these small wetlands remaining and their water quality and hydrological functions.

A number of marine fish species were identified that used freshwater wetlands along the entire length of the GBR coast. These are barramundi, fork-tail catfish, mullet and bony bream and to a lesser extent mangrove jack. Jungle perch is likely to be another species although their range is mainly in the Wet Tropics with isolated small populations as far south as Yeppoon. Barramundi are now regularly stocked in freshwater wetlands where they would otherwise be locally extinct through loss of connectivity.

Connectivity and access for biota is considered to be a key factor in use of freshwater wetlands by marine species. Water quality is another critical factor but this cannot be viewed separately from habitat quality as the two are closely related: good water and habitat quality ensure the maximum use of an area by fish with the widest range of fish species, poor water and habitat quality limits both fish abundance and species diversity. Sub-lethal impacts may include reduced breeding capacity or total denial of habitat as is evidenced in other areas. Numerous reports found that there was a correlation between poor wetland quality and the presence of noxious species; it is generally less desirable or noxious species that can tolerate degraded conditions and therefore further impact on native fish populations. Conversely good wetland qualities were associated with robust populations of native species although not always at the exclusion of noxious species.

14. High Value Wetlands

Whilst all wetlands are important for their hydrological and biological functions and therefore warrant protection, a number of wetlands were identified in this study as being of high value to fishery productivity along the coast adjacent to the GBR. These are based on the known or likely use of these wetlands by marine fish as well as freshwater species. Wetlands considered to be high value are those where connectivity with the marine system remains near natural, water and habitat quality within and downstream of the wetland are good and use by fish is ongoing although perhaps seasonal. These waterways and wetlands should be given priority in any programs implemented to maintain and improve the value and extent of wetlands.

In the highly developed areas of the GBR coast high value wetlands and especially off-stream wetlands have been impacted by catchment management.

Waterways and wetlands considered to be high value to fishery resources are listed from north to south:

1. Daintree River
2. Ella Bay Swamp
3. Wetlands of the Tully-Murray floodplain
4. Edmund Kennedy National Park wetlands
5. Barratta Creek wetlands
6. Gorganga Plains wetlands
7. Herbert Creek in Broadsound
8. Gavial Creek lagoons at Rockhampton
9. Raglan Creek
10. Baffle Creek

Wetlands that could be important, but there is insufficient information on their use by fish:

1. Eubenangee Swamp
2. Hull River/Mt Coom wetlands
3. Barramundi Creek and Red Hill Coastal wetlands

Important wetlands where some work is required to restore their fishery values:

1. Cattle Creek wetlands
2. Rocky Dam Creek wetlands at Koumala
3. 12 Mile Creek at Marmor

15. Conclusions

There has been a significant loss of wetlands along the GBR coast and those that remain have varying values as fish habitats. The impact of this on fish stocks of the GBR lagoon is unknown but is considered to be substantial.

Our scientific understanding of the importance of freshwater wetlands is expanding rapidly and there are many research papers and technical reports that deal with the status of wetlands. In broad terms the use of wetlands by fish is accepted in terms of connectivity, water quality and habitat quality. The importance of wetlands to marine species is less well documented and the range of marine species using wetlands is likely to be greater than those 79 species identified in this report.

Land management practices that impact on wetlands have been slow to respond to the knowledge of the value of wetlands and many decision makers continue to compromise these values for short-term economic gain without factoring in the potential long-term economic losses to fishery productivity. As an example the issue of the effect of ponded pastures on fish was originally raised in 1991 but to date there is no effective policy on how to deal with this issue.

Catchment management policy and direction has traditionally come from government; however, with the establishment of regional strategy and catchment management groups there has been a gradual shift to a more community-based management approach. Many catchment management groups are developing regional strategies and catchment investment plans with clear targets for environmental improvement. Many groups have included the improvement of wetlands as part of their targets.

This report includes examples of many instances of community groups undertaking projects to improve wetlands, and of research and monitoring being undertaken or proposed, for continual improvement of our knowledge of wetland status and function in the GBR Catchment. That aside, there is an urgent need for holistic management of wetlands from a fishery perspective. Maintenance of fish stocks requires a combination of connectivity and access for the biota, habitat quality/diversity, a suitable food chain and suitable water quality. Remove any one of these factors and productivity is impacted or even completely stopped.

It is likely that, in some regions, the decline in wetland degradation is slowing and may have halted, while in other regions, wetland loss continues. Whilst some gains have been made on the Tully-Murray flood plain and the benefit to fisheries has been realised rapidly, these are isolated cases. There is little other evidence of wetlands where an improvement could be identified, especially in relation to wetlands for use by fish. Remedial action through aquatic weed harvesting in the Burdekin is improving wetlands but without action to improve connectivity to and from the marine environment through addressing both water quality and physical barriers, the benefits to marine fish will be limited.

16. Future Action

It is recommended that protection of remaining wetlands should be the first priority. There is a need to bring together catchment management groups, community leaders with a focus on changes to land management practices, government decision makers and those with knowledge and expertise of wetlands. At present most of these stakeholders are working in isolation and the benefit of their combined knowledge is compromised.

A more strategic targeted approach is required that includes priority setting based on wetland values, a thematic focus on specific threat types, protection ahead of restoration and specific restoration initiatives if there is to be a shift towards improvement in wetland management and protection. A Wetland Working Group comprising members of these groups should be established to provide guidance for future investment in wetlands.

It is considered that there is a sufficient knowledge base for investment in wetlands to shift from research to on-ground action aimed at protecting and improving high value wetlands. It is suggested that an investment ratio of 80% for on-ground action and 20% for further research and monitoring should be a target used in catchment management investment plans or when funding works on wetlands. Whilst additional research on wetlands values is important, we need to start using our existing knowledge to protect and rehabilitate wetlands and realise the benefits for the built and natural environment.

Monitoring needs to go beyond water quality parameters and address the food chain issues that are critical to fishery productivity. Use of biological monitoring will address both habitat issues and provide a better understanding of links to productivity. Regular population surveys should be introduced in all coastal waterways and used as an indicator for the health of wetlands.

Future research needs to focus on filling in the gaps in areas such as the relationship between habitat type and extent and the productivity of the fishery as identified in NSW in 1989. Other shortfalls include the impacts of sub-lethal effects of poor water quality in tropical wetlands and food chain relationships between freshwater and marine environments. Lack of research however, should not stop the restoration of catchments to start addressing obvious water quality and connectivity issues.

There is a need to establish an agreed list of assessment criteria of wetland values for fishery resources with an agreed rapid assessment procedure. Factors should include biological diversity of fish populations, adult/juvenile habitat, food chain/productivity contributions, water quality issues and hydrological functions as a minimum. An inventory of wetland resources needs to be established and maintained.

The high value wetlands identified in this report should be targeted and management strategies developed to maintain their values as a priority for future investment in wetlands. Future strategies should include maintenance and improvements to connectivity, water quality and habitat quality. These strategies should also include the use of these wetlands as demonstration and education sites and for communication of wetland values to the wider community. The strategy needs to be community driven rather than government or science driven.

Investment in improvement of wetlands is a key priority of the Reef Water Quality Protection Plan in terms of the future water quality of the water entering the GBR Lagoon. However, further encouragement is required to target wetlands protection that enhances the maintenance of fish stocks that use the GBR. It is recommended that priority investment for the GBR catchment area is targeted at wetlands assessed as having a high value from a fishery perspective.

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The Landsat TM Imagery displayed is held in the Great Barrier Reef Marine Park Geospatial Data Library.

18. References

Allen G. and Coates D., (1990). An Ichthyological survey of the Sepik River, Papua New Guinea. pp 31-116.

Allen G.R., Midgely S.H. and Allen M., (2002). Field Guide to the Freshwater Fishes of Australia. CSIRO Publishing, Collingwood, Vic.

Anon (1999a). Trinity Inlet Management Program Annual Report 1998/1999: http://www.timp.org.au .

Anon (1999b). Trinity Inlet Management Program: Trinity Inlet Management Plan October 1999: http://www.timp.org.au .

Anon (2000). The Report of the World Commission on Dams Released November 16 2000: http://www.dams.org/report/ .

Arthington A.H., Milton D.A. and McKay R. J., (1983). Effects of urban development and habitat alterations on the distribution and abundance of native and exotic freshwater fish in the Brisbane region, Queensland. Australian Journal of Ecology 8, 87-101.

Arthington A.H., McKay R.J., Russell D.J., and Milton, D.A., (1984). Occurrence of the introduced cichlid (*Oreochromis mossambicus*) in Queensland. Australian Journal of Marine and Freshwater Research 35, 267-272.

Berghuis A.P., Broadfoot C.D. and Heidenreich M.J., (2000). Assessment of the Walla Weir Fishlock, Burnett River. DPI&F, Brisbane, Qld.

Blackman J.G., Perry T.W., Ford G.I., Craven S.A., Gardiner S.J. and De Lai R.J., (1999). Characteristics of Important Wetlands of Queensland. EPA, Brisbane, Qld.

Broadfoot C.D., Berghuis A.P., Heidenreich M.J., (2000). Assessment of the Kolan River Barrage vertical slot fishway. DPI&F, Brisbane, Qld.

Bunn S.E., Davies P.M., and Kellaway D.M. (1997). Contributions of sugar cane and invasive pasture grass to the aquatic food web of a tropical lowland stream. Marine and Freshwater Research 48, 173-79.

Bunn S.E., Davies P.M., Kellaway D.M. and Prosser I.P. (1998). Influence of invasive macrophytes on channel morphology and hydrology in an open tropical lowland stream, and potential control by riparian shading. Freshwater Biology 39, 171-178.

Burrows D. (1998). FNQ 2010 Regional Environment Strategy – Key Waterways Report. ACTFR, Townsville, Qld.

Cappo M., Alongi D.M., Williams D.McB. and Duke N., (1998): Research Priorities for Fisheries Ecosystem Protection: Fisheries Research and Development Corporation and AIMS Report 95/055. AIMS, Townsville, Qld.

Clague C.I. (1991). The burst and sustained swimming speed of juvenile Barramundi (*Lates Calcarifer*) and Sooty Grunter (*Hephaestus Fuliginosus*). PhD Thesis, JCU, Townsville, Qld.

Congdon R.A. and Lukacs G.P. (1996). Water Quality Aspects of Irrigation Runoff from the Burdekin River Irrigation Area. JCU, Townsville, Qld.

Cotterell E. (1998). Fish Passage in Streams. Fisheries guidelines for design of stream crossings. DPI&F, Brisbane, Qld.

Digman R. (1996). Creation of lagoons or wetlands in a tropical agricultural setting. Tully, Qld.

Digman R. (1998). Stabilization & rehabilitation of eroding riverbanks in a tropical agricultural setting. Tully, Qld.

Digman R. (2000). A précis (in pictorial form) of the environmental impact of sugar growing on the wetlands and streams of the Tully-Murray catchment. Tully, Qld.

Digman R. (2001). Pictorial of flight over SIIP_WMS project area 23-1-99. Tully, Qld.

Dunstan D.J. (1959). The barramundi Lates calcarifer (Bloch) in Queensland waters: CSIRO Technical Paper no. 5. Division of Fisheries and Oceanography, CSIRO Australia, Cronulla, NSW.

EPA (formerly QDEH), (1998). Minutes of Proceedings FISHKILL FORUM - Ingham, 16 November 1998. EPA, Brisbane, Qld.

EPA, (1999). State of the environment Queensland 1999: EPA, Brisbane, Qld.

EPA, (2003). State of the environment Queensland 2003: EPA, Brisbane, Qld.

Fitzpatrick R., Fox D. and Hicks W., (1999). Acid Sulfate Soils in East Trinity Inlet - A Summary of Presentations and Outcomes from a One-Day Workshop in Cairns, May 19, 1999. CSIRO, Wembley, WA.

Furnas M. (2003). Catchments and corals: Terrestrial runoff to the Great Barrier Reef. AIMS, Townsville, Qld.

Garrett R.N. (1991). Utilisation of Wetlands Habitats by Coastal Fisheries Resources in Northern Australia: Proceedings of the Probing Ponded Pastures Workshop: Rockhampton 16-18 July 1991: Volume 1, 94-114. University of Central Queensland, Rockhampton, Qld.

GBRMPA (2001). Great Barrier Reef Catchment Water Quality Action Plan. A Report to Ministerial Council on targets for pollution loads. GBRMPA, Townsville, 2001.

Grimes C.B. and Kingsford M.J. (1996). How do riverine plumes of different sizes influence fish larvae: Do they enhance recruitment? Marine and Freshwater Research 47(2), 191-208.

Halliday I.A. and Young W.R., (1996). Density, Biomass and Species Composition of Fish in a Subtropical *Rhizophera stylosa* Mangrove Forest. Marine and Freshwater Research 47, 609-615.

Hardy S. (2002). Industries in the Great Barrier Reef Catchment and measures to address declining water quality: September 2002. Whitsunday Rivers Integrated Catchment Management Association, Proserpine, Qld.

Helmke S., Peverell S., and Garrett R. (2000). Fisheries Resources: Trinity Inlet, north-east Queensland: DPI&F Report QI00093, DPI&F, Brisbane, Qld.

Herbert B. and Peeters .J., (1995). Freshwater fishes of Far North Queensland. DPI&F, Brisbane, Qld.

Hogan A. and Graham P., (1994a). Herbert River Floodplain Fish Distributions and Fish Habitat. Freshwater Fisheries and Aquaculture Centre, DPI&F, Walkamin, Qld.

Hogan A. and Graham P., (1994b). Tully-Murray Floodplain Fish Distributions and Fish Habitat. Freshwater Fisheries and Aquaculture Centre, DPI&F, Walkamin, Qld.

Hogan A., Graham P. and Malcolm H., (1995). Tully-Murray Floodplain Water Management Scheme Impact Assessment Study (Phase 2). Freshwater Fisheries and Aquaculture Centre, DPI&F, Walkamin, Qld.

Hogan A. and Vallance T., (1999). Water Quality Sampling in the Herbert River District (Unpublished). Fisheries and Aquaculture Centre, DPI&F, Walkamin, Qld.

Hogan A., (2000). Use of Lagoons on the Tully-Murray Floodplain by Native Fish (Unpublished). Freshwater Fisheries and Aquaculture Centre, DPI&F, Walkamin, Qld.

Humphries R., (1997). The Babinda Statement of Intent GBRMPA Cross-Sectoral Workshop on Wetlands and Water Quality Babinda Qld: 25-26 Sept 1997. GBRMPA, Townsville, Qld.

Hunt R.J. and Christiansen I.H., (2000): Dissolved Oxygen Information Kit: A CRC Sugar Technical Publication: November 2000. Cooperative Research Centre for Sustainable Sugar Production, JCU, Townsville, Qld.

Hyland S.J., (2002). An Investigation of the Impacts of Ponded Pastures on Barramundi and Other Finfish Populations in Tropical Coastal Wetlands: DPI&F Report QO03003. DPI&F, Brisbane, Qld.

Ivantsoff W. and Aarn, (1999). Detection of predation on Australian native fishes by *Gambusia holbrooki*. Marine and Freshwater Research 50, 467-468.

Johnson A.K.L., Ebert S.P. and Murray A.E., (1998). Spatial and temporal distribution of wetland and riparian zones and opportunities for their management in catchments adjacent to the Great Barrier Reef Marine Park. *Proceedings GBRMPA Cross-Sectoral Workshop on Wetlands and Water Quality*. Babinda, Queensland, 25-26 September, 1997.

Johnstone R.A., (1905). Spinifex and Wattle: Queenslander. Brisbane, Qld.

Kroon F.J., Bruce A.B., Housefield G.P., Creese R.G., (2004). Coastal floodplain management in eastern Australia: barriers to fish and invertebrate recruitment in acid sulphate soil catchments. Final report for the Fisheries Research and Development Corporation No 98/215, NSW Fisheries, Wollangbar, NSW.

Laxton J.H., Hansen M.M. and Duell J.D., (1995). Ecology of creeks in Sarina and Broadsound Shires, Central Queensland (1989-1993) - Part 3 - Fish: Private Research Paper by JH & ES Lakton - Environmental Consultants Pty Ltd, 59 pp. Sydney, NSW.

Long P.E., McKinnon S.G. and Lupton C.J., (1995). A Fisheries Resource Assessment of the Calliope River System in Central Queensland 1994: DPI&F Report: QI95001. DPI&F, Brisbane, Qld.

Lukacs G., (1996). Final Report to the Townsville City Council - Wetlands of the Townsville Area. ACTFR, JCU, Townsville, Qld.

Lukacs G.P., (1997). Coastal Freshwater Wetlands of North Queensland - Imperatives for their Conservation: *Proceedings GBRMPA Cross-Sectoral Workshop on Wetlands and Water Quality*. Babinda, Queensland, 25-26 September, 1997.

Lukacs G.P., (2003). Presentation to GBRMPA Water Quality and Coastal Development RAC, 26-27 Nov 2003. ACTFR, JCU, Townsville, Qld.

Lunow C.P., (1998). Preliminary List of Fish Species from the Pioneer River, Murray Creek and St Helens Creek in the Mackay Region, North Queensland: DPI&F Leaflet QL98040: 8 pp. DPI&F, Brisbane, Qld.

Lupton C.J. and Heidenreich M.J., (1996). A Fisheries Resources Assessment of the Baffle Creek System in the Wide Bay-Burnett Region of Queensland: DPI&F Report QI96055(a). DPI&F, Brisbane, Qld.

Manly Hydraulics Laboratory (MHL), (2002). Lake Conjola Entrance Management Plan, Newsletter No. 2. NSW Department of Public Works and Services, Manly Hydraulics Laboratory, Manly, NSW. http://www.mhl.nsw.gov.au (avail).

Marsden T., Thorncroft G. and Woods K., (2003a). Rehabilitation of Freshwater Drains Project. DPI&F, Brisbane, Qld.

Marsden T., Thorncroft G. and Woods K., (2003b). Reconstruction of Culverts and Causeways to Assist Migration of Adult and Juvenile Fish Project. DPI&F, Brisbane, Qld.

Marsden T., Thorncroft G., and McGill D., (2003c). Gooseponds Creek Fish Passage Project. DPI&F, Brisbane, Qld.

NSW Agriculture and Fisheries, (1989). 'Review of land and water management on fisheries and agricultural resources in the lower Macleay. Working Party Report, December 1989'. New South Wales Department of Agriculture and Fisheries: Wollangbar, NSW. 18pp.

Pearson R.G. and Connolly N., (2004). Biological Processing of Materials in Tropical Freshwater Ecosystems *in* Dawson N., Brodie J., Rayment G. and Porter C. (eds) Protecting the values of Rivers, Wetlands and the Reef. CD ROM ISBN 0 7345 24633.

Pease B.C., Reynolds D.P. and Walsh C.T., (2003). Validation of otolith age determination in Australian longfinned river eels, *Anguilla reinhardtii*. Marine and Freshwater Research, 54, 995-1004.

Perna C. (1998). Fish Assemblage in Stuart Creek (Unpublished). ACTFR, JCU, Townsville, Qld.

Perna C. (2003). Management and rehabilitation of fish habitat in Burdekin delta distributary streams. ACTFR, JCU, Townsville, Qld.

Pusey B.J., (2001). Current Environmental Conditions and Impacts of Existing Water Resource Development: Fish: Pioneer Valley Water Resource Plan, Appendix H. Dept Natural Resources and Mines, Brisbane, Qld.

Pusey B.J. and Kennard M.J., (1994). The freshwater fish fauna of the Wet Tropics Region of northern Australia: Report to the Wet Tropics Management Authority, 100pp.

Pusey B.J., Arthington A.H. and Read M.G., (1995). Species richness and spatial variation in fish assemblage structure in two rivers of the wet tropics (World Heritage Area) of northern Queensland, Australia. Environmental Biology of Fishes 42, 181-199.

Pusey B.J. and Kennard M.J., (1996). Species richness and geographical variation in assemblage structure of the freshwater fish fauna of the Wet Tropics region of northern Queensland. Marine and Freshwater Research 47, 563

Rayment G.E. and Bohl H.P., (2002). Dissolved oxygen in waterways of sugar catchments. In: *Managing Soils, Nutrients and the Environment for Sustainable Sugar Production Short Course*: (Ed Bruce RC) pp. 15-23: Cooperative Research Centre for Sustainable Sugar Production. JCU, Townsville, Qld.

Roth C.R., Lawson G. and Cavanagh D., (2003). Overview of Key Natural Resource Management Issues in the Burdekin Catchment, with particular reference to Water Quality and Salinity Burdekin Catchment Condition Study Phase I. CSIRO Townsville Qld

Russell D.J. and Garrett R.N., (1983). Use by juvenile barramundi, *Lates calcarifer* (Bloch), and other Fishes of Temporary Supralittoral Habitats in a Tropical Estuary in Northern Australia. Aust Journal of Marine and Freshwater Research, 34, 805-811.

Russell D.J. and Garrett R.N., (1985). Early Life History of Barramundi, *Lates calcarifer* (Bloch), in North-eastern Queensland. Aust Journal of Marine and Freshwater Research, 36, 191-201.

Russell D.J. and Garrett R.N., (1988). Movements of juvenile barramundi, Lates calcarifer (Bloch), in North-eastern Queensland. Aust Journal of Marine and Freshwater Research, 39, 317-329 .

Russell D.J. and Hales P.W., (1993). Stream Habitat and Fisheries Resources in the Johnstone River Catchment. DPI&F Report QI93056 60pp. DPI&F, Brisbane, Qld.

Russell D.J., Hales P.W. and Helmke S.A., (1996a). Fish Resources and Stream Habitat in the Moresby River Catchment. DPI&F Report QI9606 150pp. DPI&F, Brisbane, Qld.

Russell D.J., Hales P.W. and Helmke S.A. (1996b). Stream Habitat and Fish Resources in the Russell and Mulgrave Rivers Catchment. DPI&F Report QI96008 58pp. DPI&F, Brisbane, Qld.

Russell D.J. and Hales P.W., (1997). Fish Resources and Stream Habitat of the Liverpool, Maria and Hull Catchments. DPI&F Report QI97039. DPI&F, Brisbane, Qld.

Russell D.J., Mc Dougall A.J. and Kistle S.E. (1998). Fish Resources and Stream Habitat of the Daintree, Saltwater, Mossman and Mowbray Catchments. DPI&F Report QI98062. DPI&F, Brisbane, Qld.

Russell D.J., McDougall A.J., Ryan T.J., Kistle S.E., Aland G., Cogle A.L. and Langford P.A., (2000). Natural Resources of the Barron River Catchment 1 - Stream habitat, fisheries resources and biological indicators. DPI&F Report QI00032. DPI&F, Brisbane, Qld.

Russell D.J., McDougall A.J., Flectcher A.S., Overden J.R. and Street R., (2003). Biology, management and genetic stock structure of mangrove jack (Lutjanus argentimaculatus). DPI&F Report QO02005. DPI&F, Brisbane, Qld.

Sammut J., White I. and Melville M.D., (1994). Stratification in acidified coastal floodplain drains. Wetlands (Australia), 13, 49-64.

Sammut J., White I. and Melville M.D., (1996). Acidification of an estuarine tributary in eastern Australia due to drainage of acid sulfate soils. Marine and Freshwater Research, 47, 669-684.

Sawynok W., (1998). Fitzroy River - Effects of Freshwater Flows on Fish - Impact on Barramundi Recruitment, Movement and Growth. National Fishcare report 97/003753. Rockhampton, Qld.

Sawynok W., (2001). Revegetation of 12 Mile Creek at Marmor: Capricorn Sunfish report. NHT project 972218. Rockhampton, Qld.

Sawynok W., (2002). Barramundi Nursery Areas in Central Queensland. Natural Heritage Trust projects reports 982209 and 2012207. Rockhampton, Qld.

Sawynok W., (2003). Barramundi Nursery Areas in Central Queensland - 2002/03: Capricorn Sunfish report CS200308. Rockhampton, Qld.

Shiao J., Tzeng W., Collins A. and Izuka Y., (2002). Role of marine larval duration and growth rate of glass eels in determining the distribution of *Anguilla reinhardtii* and *A. australis* on Australian eastern coasts. Marine and Freshwater Research, 53, 687-695.

Skells P.K., (2000). Case Study: Earl Hil Project, North Queensland. In K.M. Watling, K.M. Hey, V.J. Eldershaw, C.R. Ahern and J.M. Anorov (Eds) *Acid Sulfate Soils Technical and Short Course and Wet Tropics Issues, Cairns*. DNR&M, Brisbane, Qld.

Stuart Ivor, (1997). Assessment of a Modified Vertical-Slot Fishway, Fitzroy River Queensland. DPI&F report QO97023. DPI&F, Brisbane, Qld.

Stuart I.G. and Berghuis A.P., (1999). Passage of Native fish in a vertical-slot fishway on the Burnett River barrage, South-eastern Queensland. DPI&F report QO99007. DPI&F, Brisbane, Qld.

Suntag, (2004). Data extracted from the Suntag database. Australian National Sportfishing Association Qld Branch, Rockhampton, Qld.

Tait J., (1994). Lowland Habitat Mapping & Management Recommendations, Tully-Murray Catchments. Cardwell Shire Catchment Coordinating Committee, Tully, Qld.

Tait J., (2003). Presentation to GBRMPA Water Quality and Coastal Development RAC, 26-27 Nov 2003. Wetlandcare Australia, Ballina, NSW.

Trenerry M., (1991). A report on the intertidal fauna of the Daintree, Endeavour and Russell/Mulgrave Rivers. Internal report - EPA, Brisbane, Qld.

Veitch V., (1999). The Fish Kill Report. Sunfish Queensland Inc., Margate, Qld.

Wannamaker C.M. and Rice J.A. (2000). Effects of hypoxia on movements and behavior of selected estuarine organisms from the southeastern United States. Journal of Experimental Marine Biology and Ecology, 249(2), 145-163.

Webb A., (2004). The ecology of invasions of non-indigenous fishes in North Queensland (In review). JCU, Townsville, Qld.

White I., Melville M.D., Sammut J., Wilson B.P. and Bowman G., (1996). Downstream impacts from acid sulfate soils. In H.M. Hunter and G.E. Rayment (Eds) *The Downstream Effects of Landuse*, Proceedings of a Conference at Rockhampton, 26-28 April 1995, Queensland, 165-172.

White L.J. and O'Brien T. (1999). Fishways - An element of stream rehabilitation: some issues, recent successes and research needs. Proceedings of the Second Australian Stream Management Conference Adelaide SA. Feb 1999: pp 691-695.

19. Appendix 1 – Species List

List of species recorded from both freshwater and saltwater in the past 15 years. More species are likely to be identified as monitoring continues in the GBR region.

Common Name	Scientific Name	WT	TV	MK	CQ	BB
ANCHOVY – HAMILTON	*Thryssa hamiltoni*				Y	
ARCHERFISH	*Toxotes chatareus*	Y	Y			
BARRAMUNDI	*Lates calcarifer*	Y	Y	Y	Y	Y
BASS –AUSTRALIAN	*Macquaria novemaculatus*					Y
BLUE EYE – PACIFIC	*Pseudomugil signifer*	Y		Y	Y	
BONY BREAM – FRESHWATER	*Nematalosa erebi*	Y	Y	Y	Y	Y
BONY BREAM – SALTWATER	*Nematalosa come*				Y	
BREAM – BUTTER	*Monodactylus argenteus*				Y	
BREAM – PIKEY	*Acanthopagrus berda*	Y				
BREAM – YELLOWFIN	*Acanthopagrus australis*				Y	Y
BULLROUT	*Notesthes robusta*	Y		Y	Y	Y
BUTTERFISH – SPOTTED	*Scatophagus argus*	Y	Y		Y	Y
BUTTERFISH – STRIPED	*Selenotoca multifasciata*	Y			Y	Y
CARDINALFISH – HUMPBACK	*Apogon hyalosoma*	Y				
CATFISH – BLACK	*Neosilurus ater*			Y		
CATFISH – FORKTAIL	*Arius graffei*		Y	Y	Y	Y
CATFISH – HYRTL	*Neosilurus hyrtlii*				Y	Y
CATFISH – TRIANGULAR SHIELD	*Arius leptaspis*			Y		
EEL – LONGFINNED	*Anguilla reinhardtii*	Y	Y	Y	Y	Y
EEL – LONGFIN SNAKE	*Pisodonophis cancrivorus*	Y				
EEL – PACIFIC	*Anguilla obscura*	Y				
EEL – SHORTFINNED	*Anguilla australis*					Y
EEL – SWAMP	*Ophisternon gutterale*	Y				
FLATHEAD – BARTAIL	*Platycephalus indicus*	Y				
FLATHEAD – DUSKY	*Platycephalus fuscus*				Y	
GARFISH – EASTERN RIVER	*Hemiramphus regularis ardelio*	Y				
GARFISH – SNUBNOSE	*Arrhamphus sclerolepis*	Y	Y	Y	Y	Y
GLASS PERCHLET	*Ambassis agassizi*	Y		Y	Y	Y
GLASS PERCHLET	*Ambassis gymnocephalus*	Y				
GLASS PERCHLET – ESTUARY	*Ambassis marianus*					Y
GLASS PERCHLET – FLAGTAIL	*Ambassis miops*	Y				
GLASS PERCHLET – LONG SPINED	*Ambassis interruptus*	Y				
GLASS PERCHLET – VACHELLI	*Ambassis vachellii*	Y			Y	
GOBY – CELEBES	*Glossogobius celebius*	Y				
GOBY – ROMAN NOSE	*Awaous acritosus*	Y				
GOBY – SLEEPY	*Glossogobius biocellatus*	Y				
GOBY – SPECKLED	*Redigobius bikolanus*	Y	Y			
GRUNTER – BANDED	*Amniataba percoides*		Y	Y	Y	Y

GRUNTER – SILVER	*Mesopristes argenteus*	Y				
GRUNTER – SOOTY	*Hephaestus fuliginosus*			Y		
GUDGEON – BROWN	*Eleotris fusca*	Y				
GUDGEON – EBONY	*Eleotris melanosoma*	Y				
GUDGEON – EMPIRE	*Hypseleotris compressa*	Y		Y	Y	Y
GUDGEON – FLATHEAD	*Philypnodon grandiceps*					Y
GUDGEON – PURPLE SPOTTED	*Mogurnda adspersa*		Y	Y	Y	
GUDGEON – SNAKEHEAD	*Ophieleotris aporos*	Y				
GUDGEON – SPANGLED	*Ophiocara porocephala*				Y	
GUPPY *	*Poecilia reticulata*	Y				
HARDYHEAD – FLY SPECKLED	*Craterocephalus stercusmuscarum*			Y	Y	Y
HERRING – GIANT	*Elops hawaiensis*			Y	Y	
HERRING – SOUTHERN	*Herklotsichthys castelnaui*				Y	
LONGTOM – FRESHWATER	*Strongylura kreffti*			Y	Y	
MANGROVE JACK	*Lutjanus argentimaculatus*	Y	Y	Y	Y	Y
MILKFISH	*Chanos chanos*	Y			Y	Y
MOSQUITO FISH *	*Gambusia holbrooki*		Y		Y	Y
MOUTH ALMIGHTY	*Glossamia aprion*	Y		Y	Y	
MULLET – BLUESPOT	*Valamugil sehili*	Y				
MULLET – FANTAIL	*Liza subviridus*	Y			Y	
MULLET – SEA	*Mugil cephalus*	Y		Y	Y	Y
MULLET – SILVER	*Mugil georgii*	Y				
MULLET – SQUARETAIL	*Liza vaigiensis*	Y				
PERCH – JUNGLE	*Kuhlia rupestris*	Y		Y		Y
PERCH – SPANGLED	*Leiopotherapon unicolor*			Y	Y	Y
PONYFISH – COMMON	*Leignathus equulus*	Y			Y	
RAINBOWFISH – EASTERN	*Melanotaenia splendida splendida*	Y		Y	Y	
REMORA – BROWN	*Remora remora*				Y	
SHARK – BULL	*Carcharhinus leucas*				Y	
SILVERBELLY – COMMON	*Gerres subfasciatus*				Y	
SILVERBELLY – THREADFIN	*Gerres filamentosus*	Y	Y		Y	Y
SLEEPER – DUCKBILL	*Butis butis*	Y				
SLEEPY COD	*Oxeleotris lineolatus*	Y		Y		
SLEEPY COD – COASTAL	*Oxeleotris gyrindoides*				Y	
SOLE – DAPPLED	*Aseraggodes spp*					Y
TARPON	*Megalops ciprinoides*	Y	Y	Y	Y	Y
TERAPON – JARBUA	*Terapon jabbua*	Y				
TERAPON – SMALLSCALE	*Terapon puta*	Y				
TILAPIA *	*Tilapia mariae*	Y				
TREVALLY – BIGEYE	*Caranx sexfasciatus*	Y				
TREVALLY – GIANT	*Caranx ignobilis*	Y				

Regions are WT = Wet Tropics TV = Townsville MK = Mackay CQ = Central Queensland BB = Bundaberg

* species are not native

20. Appendix 2 – Tagged Fish Summary

Barramundi tagged in freshwater and brackish wetlands from the Suntag database 1984-2004.

LOCATION	TAGGED	WHEN	RECAPTURES	HABITAT	STOCKED
LAKE CALLEMONDAH	372	2000-2003	Y	F	S
12 MILE CK	4658	1984-2004	Y	B	
BLACKS HOLE	563	1989-2003	Y	F	
8 MILE CK	2	1999	N	F	
WOOLWASH LAGOON	365	1989-2003	Y	F	S
FROGMORE LAGOON	865	1985-2003	Y		
BATES LAGOON	18	1989-1997	Y	F	
YEPPEN LAGOON	1	1998	N	F	
HEDLOW CK	242	2001-2003	Y	F	S
SERPENTINE LAGOON	84	2002-2004	Y	F	S
CORIO WETLAND	185	1991	Y	F	
BOUNDARY LAGOONS	18	1993-1996	Y	F	
SHOALWATER CK	21	2002-2003	N	B	
POTTY LAGOON	42	1993	N	F	
HERBERT CK	476	1989-2001	Y	F	
WUMALGI LAGOON	6	1992-1998	Y	F	
GRANITE CK	43	1990-1994	Y	F	
HEIFER CK	21	1995-1997	N	F	
ANDERGROVE LAGOON	55	1987-2002	Y	F	
INVESTIGATOR SWAMP	46	2002	Y	F	
GOOSEPONDS CK	172	1989-2001	Y	F	
MURRAY CK	22	1999-2001	Y	F	
THOMPSON CK	150	1988-2001	Y	F	
LAGUNA LAKES	13	2000-2001	N	F	
GOORGANGA CK	79	1990-2002	N	F	
CLAY HOLE	27	2000-2002	Y	F	
REED BEDS LAGOON	95	1985-1992	Y	F	
HODEL LAGOON	27	1990-2000	Y	F	
CROOKED WATERHOLE	3	1998	N	F	
CROMARTY LAGOON	13	2000	N	F	
JERONA LAGOON	10	1994-1999	Y	F	
WEST BARRATTA CK	115	2001-2003	Y	F	
GORIZIA LAGOON	4	2003	N	F	
BARRATTA CK RAILWAY	77	1990-2000	Y	F	
CLEVEDON CAUSEWAY	21	1991-2000	Y	B	
GOOSE LAGOON	6	1994	Y	F	
CATTLE CK	64	1988-1997	Y	F	
RIPPLE CK LAGOON	14	1999	Y	F	
BARRETTS LAGOON	47	1995-2000	Y	F	
WRECK LAGOON	5	1992-1996	N	B	
LANDCARE LAGOON	6	2000-2002	N	F	
DIGMAN LAGOONS	26	2000-2002	Y	F	

BOONGURAY LAGOON	16	2002	N	F	
KYAMBOL LAGOON	4	2003	N	F	
HASSELL LAGOON	11	1994	Y	F	
FLEGLER LAGOON	1	2003	N	F	
WARRINA LAKES	33	1998-2001	Y	F	

21. Appendix 3 – Recaptured Fish Summary

Barramundi recaptures for fish tagged in freshwater and brackish wetlands from the Suntag database 1984-2004.

LOCATION	TOTAL RECAPS	NO MOVEMENT	IN	OUT	UNKNOWN
LAKE CALLEMONDAH	57	28	0	29	
12 MILE CREEK	1113	1058	1	54	
BLACKS HOLE	35	13	2	20	
WOOLWASH LAGOON	73	5	13	55	
FROGMORE LAGOON	114	9	8	97	
BATES LAGOON	11	0	5	6	
FRENCHMAN CK	1	0	0	1	
HEDLOW CK	2	2	0	0	
SERPENTINE LAGOON	4	0	0	4	
CORIO WETLAND	15	1	0	14	
BOUNDARY LAGOONS	1	0	0	1	
HERBERT CK	23	13	0	10	
WUMALGI LAGOON	1	1	0	0	
GRANITE CK	1	0	0	1	
ANDERGROVE LAGOON	3	0	0	3	
INVESTIGATOR SWAMP	1	0	0	1	
GOOSEPONDS	35	23	1	11	
MURRAY CK	3	1	0	2	
THOMPSON CK	8	1	0	7	
JERONA LAGOON	1	0	0	0	1
WEST BARRATTA CK	6	4	0	1	1
BARRATA CK RAILWAY	4	2	0	1	1
CLAY HOLE	1	1	0	0	
REED BEDS LAGOON	9	0	0	9	
HODEL CK	4	0	0	4	
CLEVEDON CAUSEWAY	6	0	0	6	
CATTLE CK	1	0	0	1	
RIPPLE CK LAGOON	1	0	0	1	
BARRETTS LAGOON	6	2	0	4	
DIGMAN LAGOONS	1	1	0	0	
HASSELL LAGOON	1	0	0	1	
WARRINA LAKES	1	0	0	1	
			30	345	