Department of National Parks,
Recreation, Sport and Racing

Fisheries Resources of Calliope River, Gladstone

Central Queensland

2014

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Contents

List of Acronyms and Abbreviations

CAMBA	China-Australia Migratory Bird Agreement
CHRIS	Coastal Habitat Resources Information System (formerly CFISH)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMP	Coastal Management Plan
CMS	Convention on Migratory Species
CQRP	Central Queensland Regional Plan
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry (Queensland - formerly DPI&F)
DERM	Department of Environment and Resource Management (Queensland)
DIWA	Directory of Important Wetlands in Australia
DNRM	Department of Natural Resources and Mines (Queensland)
DPI&F	Department of Primary Industries and Fisheries (Queensland)
DSDIP	Department of State Development, Infrastructure and Planning (Queensland)
EHP	Department of Environment and Heritage Protection
EIS	Environmental Impact Statement
EPBC	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
FHA	Fish Habitat Area
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
GPC	Gladstone Ports Corporation
GSDA	Gladstone State Development Area
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
LNG	Liquid Nitrogen Gas
LWM	Low water mark
NCA	Nature Conservation Act 1992 (Queensland)
NPRSR	Department of National Parks, Recreation, Sport and Racing (Queensland)
PPDA	Priority Port Development Area
QBFP	Queensland Boating and Fisheries Patrol
RGTCT	RG Tanna Coal Terminal
SPP	State Planning Policy
SPRP	Coastal Protection State Planning Regulatory Provision
WICET	Wiggins Island Coal Export Terminal

Executive summary

This fisheries resource assessment report provides an overview of the habitat and fisheries resources of the Calliope River study area. It also includes information relating to surrounding land uses, disturbances, administrative and legislative jurisdictions, as well as any other impacts and considerations for fisheries resource management in the area. It is a compilation of a substantial volume of information and data sourced from existing literature, reports and local knowledge. Due to the vast amount of available literature and data focused on the Calliope River, this report has been based primarily upon a desktop study. To supplement existing data, field assessments were conducted to identify any previously undocumented habitats and artificial structures. Personal communication with representatives of local fishing clubs complements published information and provided additional local knowledge of the system and its productivity.

Estuarine habitats are essential to the lifecycle of many recreational, indigenous and commercially targeted fish species. Declared Fish Habitat Areas (FHAs) play an important role in protecting these essential habitats from development activities, while still allowing community use for boating, fishing and recreational activities. One of the main purposes of this report is to assess the suitability of the study area to be included in the declared FHA network. This assessment of suitability is done by assessing the study area against a series of criteria under two categories - fisheries (four criteria) and fish habitat criteria (eight criteria). The presence of any regionally unique fish habitat features is also assessed.

The Calliope River, situated in Central Queensland, drains an area of 2236km² and its rarity of lacking an impoundment or major fish way barrier makes it of significant value to the region's fisheries. It flows from the Calliope Ranges to Port Curtis, adjacent to the industrial city of Gladstone and supports an extensive and highly productive estuarine and coastal system that includes mangrove communities, mangrove lined channels, seagrass meadows, intertidal flats and salt couch grasslands.

The Calliope River study area commences approximately 7km upstream of where the Bruce Highway crosses the river. It incorporates tidal, intertidal and freshwater areas to the river mouth, as well as tributaries and lower portions of Beecher and Double Creeks. The Gladstone Regional Council is the local government entity for the lands and waters of the area. Land use along the majority of the Calliope River is generally low impact (agriculture and grazing), with industrial development toward the mouth of the river causing the most significant changes and highest impacts.

The Calliope River study area supports a valuable commercial and recreational fishery. Its habitats are essential for the productive mud crab, inshore trawl and net fisheries operating adjacent to the river and significant to recreational fishers of the region due to accessibility to the river and high catch rates. The catch statistics documented in this report are a testament to the productivity of the river and its importance to the local economy.

Despite the extensive industrial development adjacent to and surrounding the Calliope River study area, water quality within the study area remains at a high level, well within the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines and the lack of an impoundment structure enables a sustained base flow and direct marine connectivity. Elevated levels of turbidity and some metals are attributable to natural causes and dredging nearby in the Gladstone harbour is monitored and regulated.

The fish habitats of the Calliope River study area were assessed against the above criteria and found to contain a significant area of complex, resilient and diverse fish habitats. Essential fish habitats identified include estuarine waters, mangrove communities, brackish, saline and freshwater lagoons, seagrass meadows, rocky outcrops and intertidal saltmarsh and saltpans. In addition to the considerable fisheries values of these habitats, they provide critical habitat for a range of other vertebrate species including internationally significant migratory birds and species listed as threatened under state and commonwealth legislation (dugongs and turtles for example).

The listing of the Calliope River and Port Curtis in the Directory of Important Wetlands of Australia (DIWA) is an indication of its substantial wetland values. As an unregulated system, the interconnectivity and availability of essential habitats provides niche habitats and unrestricted fish movement, making it significant to the maintenance of regional genetic diversity.

It is important to note that although this report includes all habitats of the Calliope River study area, a separate area of interest plan has been developed to define the area for public consultation should the Calliope River be considered suitable for progression toward declaration as an FHA. The downstream boundary of the area of interest plan is marked by the Calliope River railway bridge crossing (23°52'21S, 151°11'24E), approximately 13km upstream of the river mouth. This approach is to ensure that the valuable and productive habitats of the Calliope River outside of the area of interest plan (but within the study area) are recognised and acknowledged as interrelated and interconnected to those within the plan, but minimises conflict between the management intent of

declared FHAs and planned industrial expansion, which is important to the region's and State's economic growth.

In conclusion, the Calliope River represents a healthy, regionally unique, productive estuarine system that is making a valuable contribution to the region's ecology and fisheries sustainability. The size and composition of habitats, fish communities and other vertebrate species makes it a significant wetland both regionally and at a national level. The Calliope River study area fulfils all of the four fisheries criteria and eight habitat criteria. It is recommended the Calliope River area of interest be declared an FHA.

The following recommendations are the result of the findings of this report.

Recommendations

1. Proceed to public consultation with a view to declare the Calliope River, within the area of interest plan, as a management 'A' Fish Habitat Area under the *Fisheries Act 1994*. (Chapter 11 outlines the suitability of the Calliope River area of interest as compared to the declared FHA selection criteria).

2. Promote close consultation with Traditional Owners to encourage their support for and involvement in the declaration process and with the Department of State Development, Infrastructure and Planning (DSDIP), Gladstone Ports Corporation (GPC), Local Government and major industrial development corporations within and adjacent to the Calliope River study area to ensure acknowledgement of and provision for developments of State significance.

3. That the current status of riparian communities be maintained and enhanced where possible and adequate buffer strips be incorporated into future land use within and adjacent to the Calliope River study area. This is necessary to support and protect the area's substantial and valuable fisheries values.

4. Commence consultation with landholders adjacent to the freshwater lagoons known to be juvenile fish habitats with a view to enter into management agreements ensuring these valuable habitats are provided protection and enhancement.

5. Implement education and compliance activities in the Calliope River to alleviate fish habitat and marine plant damage through the construction of unlawful structures.

Chapter 1 Introduction

The Calliope River is an unregulated estuarine system within Central Queensland (CQ) that flows approximately 100 kilometres (km) from the Calliope Ranges to Port Curtis. The river floodplain and delta consists of four major tributaries, Larcom Creek, Oakey Creek, Paddock Creek and Double Creek, which drain a catchment area of approximately 2236km². The Calliope River lies within the Great Barrier Reef World Heritage Area (GBRWHA), is part of Rodd's Bay Dugong Sanctuary and is listed on the Directory of Significant Wetlands (DIWA), all of which highlight its significant ecological values.

The major industrial city of Gladstone lies on the southern bank of the lower reaches of the Calliope River and the Gladstone State Development Area adjoins the anabranch on the northern bank. Gladstone's population is approximately 61,000 and its growth is exceeding the State average, with opportunities for employment increasing in line with industrial development expansion. The river discharges into Port Curtis, Queensland's largest multi-commodity port and one of the top five coal export ports in the world, handling in excess of 500 million tonnes of coal per annum. The Gladstone region supports several major industries, including one of the world's largest alumina refineries (Queensland Alumina Limited), Queensland's largest coal fired power station, a major chemical plant producing bulk sodium cyanide and ammonium nitrate (Orica) and a shale oil plant (QER).

Major industrial developments are under construction on the land and water near the lower reaches of the Calliope River with one project planning the construction of infrastructure within the river mouth itself (Chapter 9.6). The remainder of the Calliope catchment is dominated by grazing land. Due to the vast extent of industrial activity within the Gladstone region, its waterways are the subject of a large volume of environmental research and monitoring. Regular reports delivered by the Government and stakeholders update the status of environmental impacts from port related activities.

Despite disturbances and reclamation for industrial use near its mouth, the Calliope River hosts a rich and diverse range of species and ecosystems. As one of the last remaining unregulated systems in Queensland, the Calliope River maintains a sustained base flow and direct marine connectivity, making it significant for contributing to the maintenance of regional genetic diversity (DERM 2011a) and it is considered alongside Baffle Creek as one of the only two major coastal streams in the region where the integrity of in-stream habitats remains high (DSDIP 2013).

1.1 Fisheries management, fish habitats and fisheries

Commercial and recreational fishing are important for the culture, economy and lifestyle of the region. Prior to recent port development activities inhibiting access to fishing areas and increasing living costs, Gladstone supported one of the largest commercial fishing fleets in Queensland (Hunt 2011). Despite industrialisation, the area is still heavily utilised for trawl and crab fishing and Gladstone's recreational fishing industry is continuously expanding, with a 30% increase in boat registrations between the years 2000 and 2012 and a 25% rise in fishing effort over the last six years (Sawynok et al. 2012).

Estuaries are considered to be among the most productive natural habitats in the world (McLusky and Elliott 2004) and coastal and estuarine habitats are integral to the reproduction and survival of many indigenous, recreational and commercially targeted fish species. Quinn (1992) estimated that more than 75% of species landed in Queensland's commercial fisheries rely on a variety of habitats found in healthy estuaries during some part of their lifecycle. The barramundi (*Lates calcarifer*) and mud crab (*Scylla serrata*) for example, two of Queensland's most iconic species and highly sought after within the Gladstone region, rely on habitats within estuarine systems for large proportions of their lifecycles.

As a result of human induced impacts such as clearing and land reclamation, mangrove and salt marsh estuarine habitats are amongst the most threatened ecological systems globally (Bridgewater and Cresswell 1999). The maintenance and appropriate management of these key habitats are vital to ensure future sustainability of Queensland's fish stocks. The Calliope River basin supports an extensive estuarine and coastal system that includes mangrove communities and mangrove lined channels, seagrass meadows, intertidal flats and salt couch grasslands of national and international significance (DNRM 2005a). Despite these diverse and productive habitats, the significant ecological value of the system and its importance to fisheries production, less than 0.3% of the catchment is within protected areas (WICET 2006).

High species richness and abundance of fish occur in the marine, coastal, estuarine and freshwater habitats of Port Curtis (Coffey Environments 2012). The size and composition of these communities reflects the availability of the aquatic habitats upon which the species depend during different phases of their life history, many having freshwater, estuarine and marine phases. For these species, declared Fish Habitat Areas (FHAs) and passageways are of particular importance in maintaining connectivity between different aquatic environments (Coffey Environments 2012).

1.2 Regional Fish Habitat focus

Commencing in the late 1960's, FHAs are declared under the *Fisheries Act 1994* and are fundamental to the protection of the state's critical fish habitats. The declared FHA network strategy recognises the complex and interrelated reliance of many species on multiple habitats during their lives and that protecting these habitats and their interconnectivity plays a crucial role in supporting fisheries. The declared FHA concept is to prevent physical damage from coastal development, whilst still allowing and encouraging community access and use. It has the added benefit of providing a safety net in protecting habitats that are presently poorly understood which may be found to have substantial fisheries values (Baker and Sheppard 2006).

The objective of the declared FHA concept is to foster a holistic approach to fisheries management by incorporating a wide range of essential habitats. This is considered a much more effective response to protecting fisheries resources than protecting or managing isolated habitats or species. Expansion of the declared FHA network is fundamental to ensuring a comprehensive, adequate and representative network of key fish habitats that are protected for future sustainability.

As part of a broader investigation program within Central Queensland, the Calliope River has come under consideration for declaration as an FHA. Presently the nearest declared FHAs to Port Curtis are the Fitzroy River declared FHA, to the north, and the Colosseum Inlet declared FHA, to the south. Given Central Queensland's high fish productivity, economic and social reliance on the fishing industry and its close proximity to the GBRWHA, there is a need to expand the network in this region. A previous proposal in 1997 to declare Calliope River as an FHA received strong community support however the Queensland government at the time, made the decision not to progress with the declaration due to concerns of incompatibility with future industrial development plans. To better accommodate for development infrastructure, should the Calliope River proceed to public consultation with a view to declaring it an FHA, a revised area of interest plan has been developed, with the downstream boundary moved to the railway bridge (23°52'21"S, 151°11'24"E). Given Gladstone's considerable industrial expansion in recent times and the corresponding increased pressure on the river's habitat values, it is timely that the Calliope River be reconsidered for FHA declaration to provide for a balance between development and fish habitat protection to support fisheries productivity.

1.3 Purpose of report

This report provides an overview of the Calliope River study area and its fish habitat values as they relate to the declared FHA selection criteria (NPRSR 2013). It provides a summary of available information relevant to these criteria, in addition to management issues, surrounding land uses and other impacts and considerations to the management of fisheries resources in the area. Throughout this report, unless otherwise stated, the term fish refers to finfish, crustaceans, molluscs, etc.

Chapter 2 Defining the Calliope River study area

2.1 Calliope River study area description

The Calliope River study area (Figure 2.1) covers approximately 3075ha of the tidal, intertidal and some fresh waters of the Calliope River from the river's mouth, to approximately 32km upstream. It includes small tributaries and the lower portion of Beecher and Double Creeks. Within the study area, the Calliope River area of interest is 408ha, with the downstream boundary defined by the rail bridge (23°52'21"S, 151°11'24"E) (Figure 2.1).

The larger study area has been included to ensure that the valuable and productive habitats of the Calliope River adjoining the area of interest are recognised and acknowledged as interrelated and interconnected, while minimising conflict between the management intent of declared FHAs and planned industrial expansion, which is important to the region's and State's economic growth.

2.2 Local Authority boundaries

The vast majority of the Calliope River and the entirety of the study area are located within the administrative boundaries of Gladstone Regional Council. Small tributaries in the upper reaches of the river are within Banana Shire.

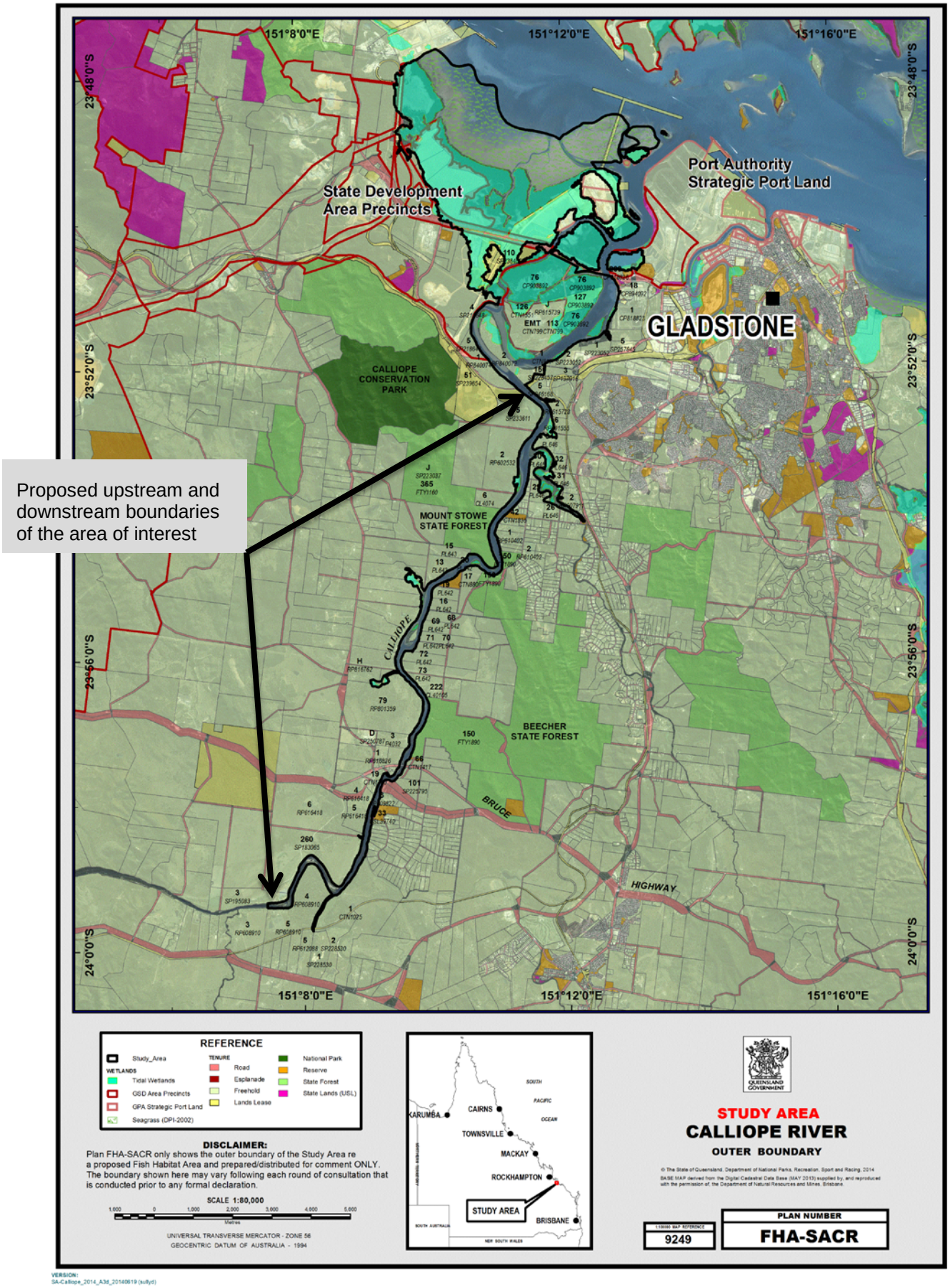


Figure 2.1: Map of Calliope River study area (also showing area of interest boundaries)

Chapter 3 Faunal Communities in the Calliope River and surrounding areas

Chapter Summary

More than 160 species of fish, crustacean and mollusc have been documented utilising the habitats of the Calliope River. Over 40% of those captured in fish surveys have direct economic significance, while others provide food sources and links within the food chain supporting these fisheries.

The abundance and diversity of identified fish and other vertebrate species within the Calliope River study area reflects the range and availability of essential habitats upon which these species depend. The identification of freshwater associated fish species within the study area demonstrates the river's interconnectivity and lack of fish way barriers.

3.1 Introduction

There is an impressive representation of essential fish habitats within the Calliope River and Port Curtis, which fosters a healthy variety of fish species, many of which are significant for their indigenous, recreational and commercial value. The abundance of shelter, feeding, breeding and nursery sites ensures a diverse range of fish species inhabit the river system, which also provides significant habitat for other vertebrate species.

Due to the rapid and intensive development of the Gladstone harbour and region, a large volume of literature has been compiled relating to the fisheries and habitats of Calliope River and Port Curtis. Many of these sources have studied the fauna of the Calliope River using a range of techniques and apparatus, including monofilament gill nets, hand line, bait seine net, cast nets, beam trawl and crab pots (McKinnon et al. 1995: Connolly et al. 2006; Wilson et al. 2012a). The following references to the estuarine section refers to the length of river from the Calliope Crossing (23°57'S, 151° 9'E) to the river's mouth, and the brackish section refers to the waters from the Calliope Crossing to approximately 6km upstream.

3.2 Data sources

Due to monitoring for industrial impact and the legislative requirement to complete a comprehensive environmental impact statement (EIS) as a part of the major development application process, the fauna of Port Curtis and the Calliope River, particularly toward the river's mouth, has been extensively surveyed. In addition to this, DPI&F conducted an intensive twelve month seasonal survey of the river's fisheries values in 1994, inclusive of the estuarine, brackish and freshwater reaches, resulting in the compilation of a species inventory list (McKinnon et al. 1995). The Department of Natural Resources and Mines (DNRM) compiled a further list of species in 2005 based upon existing data from McKinnon et al. (1995), the Queensland Museum and Gladstone Area Water Board (DNRM 2005a). Other information is sourced from Infofish Australia, Wilson et al. (2012a) and Connolly et al. (2006). Given the broad range of species that have been identified within the Calliope River, reinforced by the productivity of the local recreational and commercial fishing industries, it has not been considered necessary to complete a further survey of the local fauna for the completion of this report.

In addition to extensive fish studies, significant literature has been produced relating to other marine fauna of the area as a result of Port Curtis lying within the Rodd's Bay Dugong Sanctuary, internationally important migratory bird species habitat and turtle and dolphin feeding grounds.

3.3 Results

McKinnon et al. (1995) compiled a list of 91 fish, crustacean and mollusc species within the estuarine reaches. This list has been expanded through subsequent surveys to a total of 167 species. The full list of species can be found in Appendix A. A diverse range of recreational and commercially significant species were recorded in surveys, with 46% overall and more than 40% of the species in every section of the river sampled considered as being of economic importance (McKinnon et al. 1995, Appendix B). Many other species identified provide a valuable food source for these fish. High abundances of juvenile as well as adult fish were captured throughout the estuarine and brackish sections of the river.

Tagging studies show:

- higher growth rates for barramundi (*Lates calcarifer*), cod species (*Serranidae* spp.) and mangrove jack (*Lutjanus argentimaculatus*) in the Calliope River than the neighbouring Boyne River (Walker 1999, Sawynok et al. 2013)
- throughout the brackish section, McKinnon et al. (1995) found 90% of mullet species and barramundi caught exceeded the legal size limit
- fish move freely between the Fitzroy system, Gladstone Harbour and the Calliope and Boyne Rivers, particularly barramundi (*L. calcarifer*), cod species (*Serranidae* spp.), blue salmon (*Eleutheronerna tetradactylum*), flathead (*Platycephalidae* spp.) and mangrove jack (*L. argentimaculatus*) (Walker 1999). This freedom of movement is important for genetic integrity and diversity; and
- more freshwater associated species (e.g. barramundi (*L. calcarifer*), mangrove jack (*L. argentimaculatus*) and tarpon (*Megalops* spp.) are tagged in the Calliope River when compared to the neighbouring Boyne River.

McKinnon et al. (1995) found species diversity for both economic and non-economic fish showed similar trends throughout the year. Species diversity was also relatively even throughout the estuarine system and species that were dominant in the estuarine section were also dominant in the brackish section (e.g. sea mullet (*Mugil cephalus*), flat tailed mullet (*Liza argentea*) and barramundi (*L. calcarifer*)), however there was less species diversity in the brackish section (McKinnon et al. 1995). Wilson et al. (2012a) also found no significant statistical difference between species richness, evenness or diversity between catch sites within the Calliope River and Port Curtis harbour however the mouth of the river displayed the highest figures, with the largest and most diverse population of fish captured. The greenback mullet (*Liza subviridis*), giant leatherskin queen fish (*Scomberoides commersonianus*) and banana prawn (*Fenneropenaeus merguiensis*) were the most commonly recorded species by Wilson et al. (2012a), all of which are economically important.

Aside from fish species, the habitats of the Calliope River and Port Curtis are significant for a number of vulnerable marine megafauna and bird species. Rodd's Bay Dugong Protection Area encompasses the entire Port Curtis area and the areas around Wiggins Island and within the mouth of the Calliope River are known dugong (*Dugong dugon*) feeding sites, with regular sightings recorded. There has been significant decline in dugong numbers along the Queensland coast with Marsh et al. (2002) suggesting an estimated 97% reduction since the 1960's. Dugongs are listed:

- vulnerable to extinction under the International Union for Conservation of Nature (IUCN)
- on Appendix I (Species threatened with extinction) of Convention on International Trade in Endangered Species (CITES)
- on Appendix II (Migratory species that need or would significantly benefit from international cooperation) of the Convention on Migratory Species (CMS) (Australia is a signatory nation to CITES and CMS); and
- vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the Queensland *Nature Conservation Act 1992.*

Dugongs are also culturally significant to local Indigenous communities and traditional owners.

The seagrass meadows around the mouth of the Calliope River have been identified as an important turtle foraging area (DNRM 2005a), with the endangered Loggerhead (*Caretta caretta*) and Leatherback (*Dermochelys coriacea*) turtles and the vulnerable Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*) and Flatback (*Natator depressus*) turtles all known to frequent Port Curtis. Other species of conservation significance frequenting the Calliope River and adjacent areas include the Indopacific humpback dolphin (*Sousa chinensis*), listed as near threatened and estuarine crocodile (*Crocodylus porosus*), listed as vulnerable.

Port Curtis has been listed on DIWA due to the rich diversity of avian species frequenting the area, including a number of migratory and wader species protected under national and international agreements and legislation. Areas within Calliope River have been identified as important feeding and roosting sites for bird species listed under the Japan-Australia Migratory Bird Agreement (JAMBA) and China-Australia Migratory Bird Agreement (CAMBA), including the Whimbrel (*Numenius phaeopus*), Eastern Curlew (*Numenius madagascariensis*), Common Greenshank (*Tringa nebularia*) and the Bar-tailed godwit (*Limosa lapponica*). The Byellee Wetlands (Chapter 5.2.11) are known to provide habitat for bird species of conservation significance, for example the grey goshawk (*Accipiter novaehollandiae*) and black necked stork (*Ephippiorhynchus asiaticus*), both listed as near threatened and the powerful owl (*Ninox strenua*), listed as vulnerable.

3.4 Discussion

3.4.1 Species richness

The information provided in Appendix A indicates there is a high level of species richness and diversity in the Calliope River. The presence of freshwater species such as the blue catfish (*Arius graeffei*) and long-finned eel (*Anguilla reinhardtii*) demonstrates the Calliope River system's interconnectivity and is testament to the value of its lack of fish way barriers.

Contributing to the high species richness is that the Calliope River lies on a regional distribution overlap of southern and northern fish species; for example the diamond trevally (*Alectis indica*), sea mullet (*Mugil cephalus*) and the southern herring (*Herklotsichthys castelnaui*) are at their regional limits in Gladstone waters (CSIRO 2013). This overlap enables a wider variety of fish to utilise the habitats within the Calliope River.

3.4.2 Habitat values of Calliope River

The Calliope River is an unregulated waterway with relatively little impacts, which makes it of intrinsic value given the closest major estuaries, the Fitzroy River to the north and Boyne River to the south, contain major fish barriers. Weirs, barrages and impoundment structures have a major impact on some fish species by dividing fish populations, preventing fish migration and restricting recolonisation and movement for feeding and spawning purposes (McKinnon et al. 2004). McKinnon et al. (1995) found the greatest abundance of economically important fish were located in the upper estuarine section of the river. This area, directly below Calliope Crossing (Chapter 9.5.1), contains diverse habitat, as well as an aggregation point for many fish species. Fish species undertaking an upstream migration congregate in this area until the tides are high enough to allow unrestricted movement upstream. This aggregation is also likely to attract high order predatory species to the area (McKinnon et al. 1995).

The high species diversity within the catchment is likely due to the continued maintenance of good habitat diversity with sustained base flow, minimal fish passage barriers and proximity to the Fitzroy River catchment (DNRM 2005a). This provides niche habitats for a wide variety of species and facilitates access to available habitats. Many of the indigenous, commercial and recreationally targeted fish species recorded in the Calliope River rely on estuarine habitats for some or all of their lifecycle, for example barramundi (*Lates calcarifer*), mud crab (*Scylla serrata*) and flathead (*Platycelphalus* sp.). The high abundance of both juvenile and adult fish captured in the McKinnon et al. (1995) study indicates that the study area is providing essential habitat throughout the lifecycle of fish species. The importance of the Calliope River system to the region's fish stocks is reaffirmed by Wilson et al. (2012a), who found that 77% of total fish abundance caught in sampling were offshore spawners that used mangrove communities of the Calliope River as a nursery habitat.

3.4.3 Introduced marine species

In 2000, the Gladstone Port Corporation (GPC) funded a survey of Port Curtis to establish a baseline list of native and introduced species within the Port (Lewis et al. 2001). No pest species were detected during this survey however ten introduced species were identified (Appendix C). All of the introduced species identified are widespread in ports throughout Australia and internationally, and not considered a threat to native species (Lewis et al. 2001). No other introduced species were detected within the Calliope River in studies reviewed for this report.

3.5 Conclusion

The rich diversity of both fish and other vertebrate species recorded in the study area is testament to the health and range of available habitats within the Calliope River. These habitats are essential for supporting a large number and variety of indigenous, recreational and commercially targeted fish, some of which utilise the river system primarily as a nursery, whilst others use the extent of habitats throughout their lifecycle. The river's interconnectivity and lack of fishway barriers is highlighted by the range of freshwater associated fish species recorded.

Tagging studies showing higher growth rates for fish in the Calliope River indicate that an abundance of food is available for fish species utilising the river. This is also supported by the recording of high quantities of both juvenile and adult fish throughout the estuarine and brackish section of the river.

Chapter 4 Fisheries of Calliope River and surrounds

Chapter Summary

The Calliope River supports highly productive and valuable fisheries within and directly adjacent to it, as well as offshore in the Great Barrier Reef Marine Park (GBRMP). The recreational fishery and commercial net, trawl and crab fisheries are important to the economy of the region and fishing is considered one its four major industries. Estuarine habitats such as those found within the Calliope River study area are critical to the lifecycle of many of the fish species targeted by commercial, recreational and indigenous fishers.

The Calliope River is important to recreational fishers in the Gladstone region as it is accessible by vessel and from land and high catch rates are frequent. While commercial fishing effort is decreasing in the region, recreational fishing effort is increasing placing further pressures on existing stocks and reaffirming the need to protect essential fish habitats.

4.1 Introduction

The majority of Queensland's fisheries are estuarine-dependent, which means fish species spend part of their life in and rely upon, estuarine habitats (Walker 1997). The mangrove systems, saltpans and large areas of sheltered shorelines, creeks and intertidal wetlands of Port Curtis provide excellent habitats for estuarine fisheries and the region is recognised as one of the six principal mud crab harvest locations along the Queensland coast (DNRM 2005a). Gladstone Regional Council reaffirms the importance of its fishing industry by recognising fishing as one of the four major industries of the region, alongside manufacturing, processing and tourism (GRC 2012).

The Calliope River study area supports a range of indigenous, recreational and commercially important fish species such as barramundi (*Lates calcarifer*), threadfin salmon (*Polynemidae* spp.), penaeid prawns (Penaeidae spp.), mangrove jack (*Lutjanus argentimaculatus*) and sea mullet (*Mugil cephalus*). Its productivity and ease of access makes it a popular destination for recreational fishers and it supports a range of external commercial fisheries.

4.2 Fishery data sources

Data on fishing output levels has been sourced from the Department of Agriculture, Forestry and Fisheries (DAFF) Coastal Habitat Resources Information System (CHRIS; DAFF 2013d). Since 1988 Queensland's commercial fisheries catch statistics have been recorded on CHRIS, which includes a computer based compulsory commercial fisheries logbook program that stores catch and effort by location. Queensland is broken into 30 minute grids for the purposes of recording commercial catch and effort, with Calliope River and Port Curtis contained within grid S30 (Figure 4.1). This grid covers the length of the Calliope River and extends through the Narrows to the north, to Colosseum Inlet south and approximately 46km off shore from the Calliope River mouth.

Recreational fishing data was sourced from the CHRIS database (DAFF 2013d), which has been recording recreational data since 1997. Further sources of data include the 2010 statewide recreational fishing survey (Taylor et al. 2012), information provided by Infofish (Sawynock 2013) and a comprehensive report assessing trends in recreational fishing in Gladstone harbour and adjacent waterways (Sawynock et al. 2013).

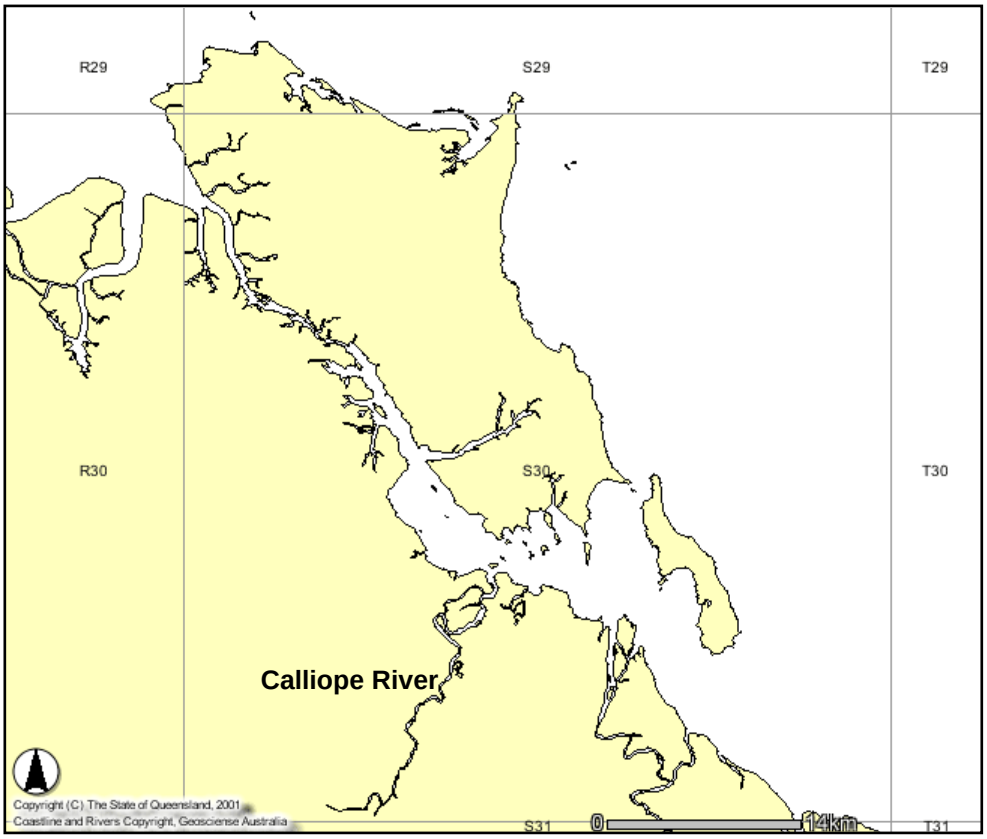


Figure 4.1: 30 minute commercial catch grids around Calliope River.

4.3 Commercial fishing

Inshore and offshore fisheries operate out of Gladstone harbour and it previously was one of Queensland's key ports for net, line, charter and crab fisheries (Fenton and Marshall 2001b), also hosting a large trawl fleet.

Catch statistics from the CHRIS database show that the combined commercial fishing industries (an average of 80 licences) harvested an average of 415.49t of fish species, to the value of almost $3.5 million annually from grid S30 between 2002 and 2012 (ranging from 150.95t in 2012 and 576.28t in 2011) (Figure 4.2).

Gladstone Harbour is closed to commercial fishers from Friday 6pm until Sunday 6pm to provide access for recreational fishers. Within the Calliope River there is minimal use by commercial fishers and the waters upstream of Farmer's Island are closed to commercial net fishing.

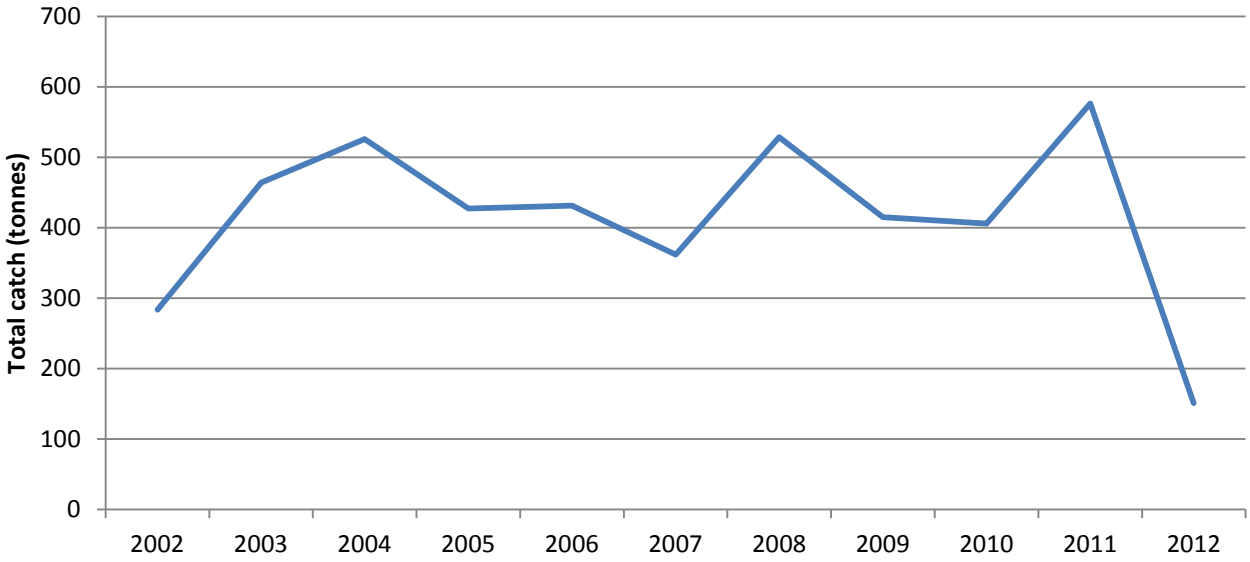


Figure 4.2: Total commercial catch (tonnes) of fish in the Gladstone area 2002-2012 (data sourced from DAFF 2013d)

Gladstone commercial fishing effort remained relatively stable between 2003 and 2011, but declined significantly in 2012. In 2000, the Gladstone region contained the third highest percentage of commercial net fishers in Queensland and the sixth highest percentage of trawl operators (Fenton and Marshall 2001a). The reduction of fishing effort is highlighted by figures that show 5233 days were fished in 2005, with 84 licences operating in the S30 grid, which has reduced to 2886 days fished and 69 licences operating in 2012. There have been various causes for this decline, including the Queensland Government's net buyback scheme, which has resulted in the surrender of 147 fishing symbols throughout the East Coast of Queensland. The most significant cause of decline in Port Curtis is related to intensive port development in the Gladstone harbour. A high volume of maritime traffic, dredging and closures of areas have reduced access to fishing areas; high remuneration offered by industrial companies for maritime skills has resulted in a scarcity of deck hands, skippers and engineering and maintenance personnel; and elevated living expenses in the Gladstone area has caused many residents to relocate (Hunt 2011). This reduction in catch and effort, particularly in 2012, is evident in the following graphs relating to the net and trawl fisheries (Figures 4.3 and 4.4).

4.3.1 Inshore trawl fisheries

The trawl fishery is Queensland's largest commercial fishery, with approximately 600 vessels harvesting up to 10,000t of product worth approximately $110 million annually (DAFF 2013c). Fishers licenced for the east coast otter trawl fishery and the river and inshore beam trawl fishery operate in the Gladstone region and banana prawns (*Fenneropenaeus merguiensis*) are their main target species.

Otter trawlers are larger vessels and generally work in deeper waters than beam trawlers, which operate in lower estuaries and shallow inshore waters (DAFF 2013c). The fishery is regulated by area closures and boat and net size restrictions.

Banana prawns utilise mangrove lined creeks as nursery habitats, moving into coastal waters as they mature. Therefore juvenile prawns are primarily caught in beam trawls, with otter trawlers more likely to take adult prawns (Kingston 2004). Other prawn species captured include coral, endeavour and tiger, however the catch totals are very low and these species have not been recorded since 2005. Between 2002 and 2011 the average annual banana prawn catch from trawl operators in grid S30 was 63.43t. Figure 4.3 shows the total catch and effort for banana prawns in grid S30 between 2002 and 2012.

Banana prawns are significantly influenced by summer flow and rainfall, with increased catch experienced with increased flow in the same year (Halliday and Robins 2007; Meynecke et al. 2006). This may be the cause of the obvious drop in catch rates in 2007, when there was a drought in Central Queensland at that time and the high catch compared to effort in 2011, when estuaries were flushed during the 2010-11 floods.

Figure 4.3: Banana prawn catch and effort in the Gladstone region 2002 - 12 (Grid S30). (data sourced from DAFF 2013d)

Figure 4.3 shows a significant decline in catch and effort in 2012 which illustrates the effect of the port development. Licence numbers dropped to 7, from a previous average of 16, and the total catch fell to 12.88t for the year, whereas the previous average was 68.48t. This can be attributed to area exclusions due to fishing closures, dredging and a high volume of vessel traffic in the Gladstone harbour as major infrastructure was being constructed for the Wiggins Island Coal Terminal (WICET) and Liquid Natural Gas (LNG) plants on Curtis Island (Chapter 9.3 and 9.6; 4.3.4).

4.3.2 Inshore net fisheries

The Gladstone region supports a successful net fishery, with commercial fishers targeting different fish species according to seasonal variations. As a part of Rodd's Bay Dugong Protection Area, various restrictions are placed upon commercial net fishers within Gladstone Harbour such as mesh size and how nets may be deployed. The waters upstream of Farmer's Island in the Calliope River are closed to commercial net fishing. A variety of mesh and seine nets are utilised within Gladstone Harbour with species commonly harvested including mullet (*Mugilidae* spp.), shark (*Carcharhinidae* spp.), blue threadfin salmon (*Eleutheronerna tetradactylum*), king salmon (*Polydactylus sheridani*), barramundi (*Lates calcarifer*) and whiting (*Sillaginidae* spp.) (DAFF 2013d). The annual average harvest for all species between 2002 and 2011 was 238.142t, with the highest catch rates for shark species.

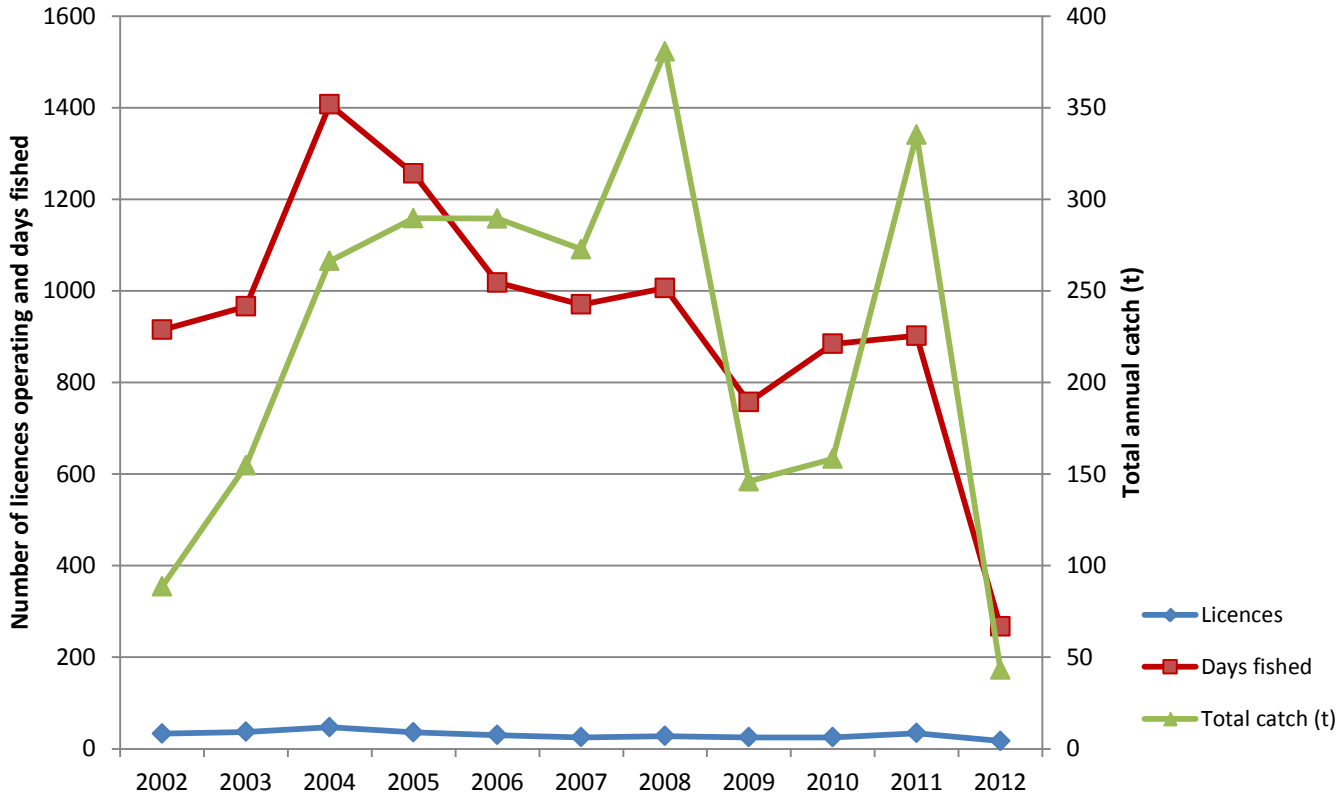


Figure 4.4: Total effort and catch in Gladstone's commercial net fishery 2002-12 (Grid S30). (data sourced from DAFF 2013d)

Figure 4.4 shows a peak in catch compared to effort in 2008 and 2011. This is due to an unusually high catch rate of mackerel in 2008 which increased from ranges between 1.27t in 2002 and 57.12t in 2006, to 123.36t in 2008. The 2011 peak is attributed to an extremely high barramundi catch in 2011.

Awoonga Dam, a heavily stocked barramundi impoundment, overflowed in floods between December 2010 and March 2011 causing an estimated 30,000 large barramundi to be washed over the dam wall into the Boyne River (DAFF n.d.). Commercial catch statistics for this time show the monthly catch throughout 2011 to be equivalent to or exceed the previous six year's annual catch (DAFF n.d.). Between 2000 and 2010, commercial catch for barramundi ranged from 4t in 2009 up to 16.8t in 2005 however in 2011 it rose to 215.6t, to a value of $1.98m. This higher catch rate was also obvious in the species composition of commercial catch during 2011, where barramundi increased from less than 15% of total catch in previous years to approximately 75% in 2011 (DAFF n.d.).

Overall, catch and effort declined significantly in 2012, as it did with the trawl fishery (Chapter 4.3.1). It is most likely this decline can also be attributed to impacts and closures relating to the Gladstone Port developments that have excluded fishers from the area.

Appendix D contains catch and effort graphs for individual fish species most targeted by commercial net fishers.

4.3.3 Mud crab fishery

Juvenile and adult mud crabs (*Scylla serrata)* utilise sheltered estuaries, mangrove-lined channels, mud flats and mangrove forests (Ryan 2003). They are the principle target species for the Gladstone region and are caught using crab pots set in estuaries or near-shore areas. The fishery is managed by requirements to return females to the water and kept crabs must be a minimum size of 15cm across the crab's carapace. Most commercial crab fishers have multiple licences that allow them the additional flexibility of operating in net fisheries. The annual average harvest for mud crabs between 2002 and 2011 was 84.9t, with up to 40% of Queensland's mud crabs being taken from the Central Queensland coastline (WICET 2006, Ryan 2003).

A positive relationship exists between rainfall and catches for mud crab (Meynecke et al. 2006) which is demonstrated in Figure 4.5, where a peak in catch numbers is observed in the years 2003 and 2010. Heavy rains and flooding associated with ex-tropical cyclone Beni occurred in February 2003 and exceptionally high rain events occurred throughout 2010 (BOM 2013).

Mud crabs depend on appropriate and available near-shore habitat and are therefore vulnerable to impacts caused by degradation of estuarine habitats. The declared FHA network is an important component for the protection of these habitats and the future sustainability of the mud crab fishery.

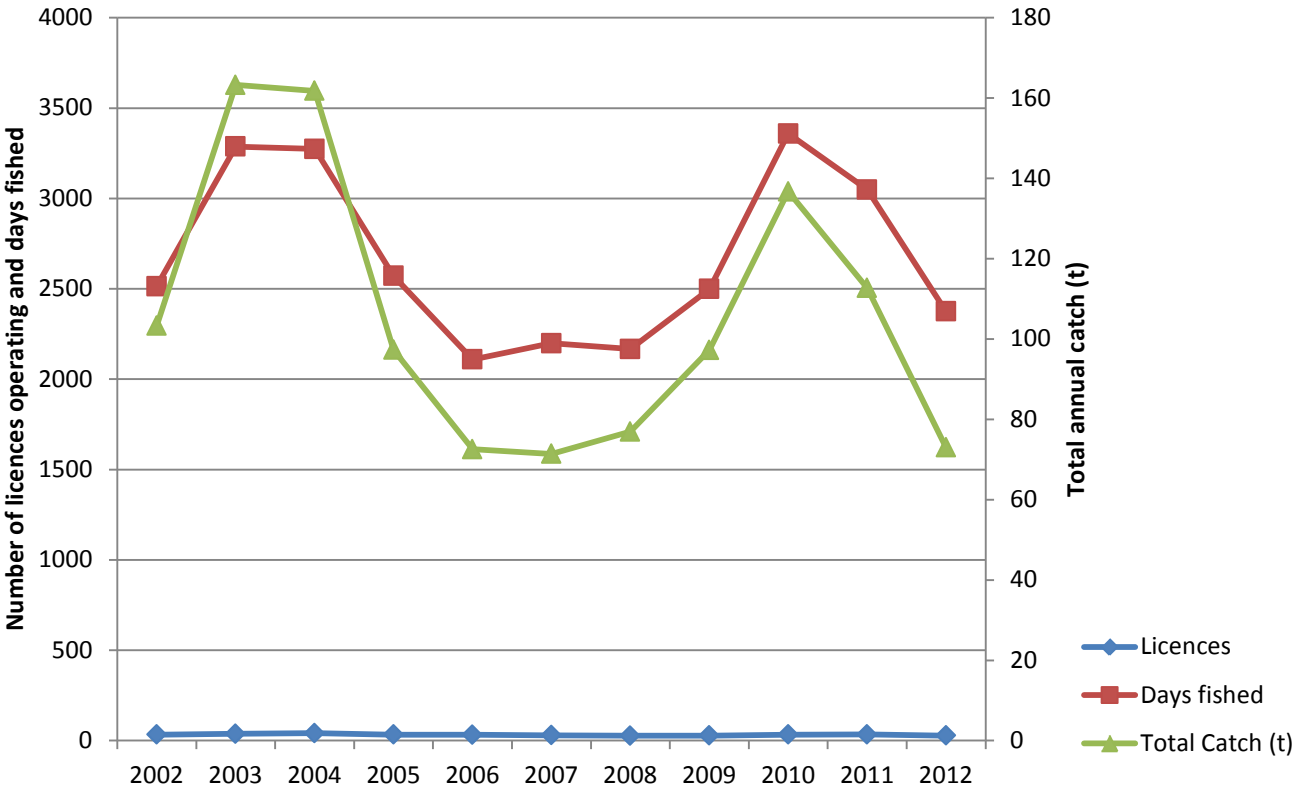


Figure 4.5: Total effort and catch in Gladstone's commercial mud crab fishery (Grid S30) 2002-11 (data sourced from DAFF 2013d)

4.3.4 Western Basin Dredging and Disposal Project Fisheries compensation program

In 2010, Queensland's Coordinator-General approved the Western Basin Dredging and Disposal Project (refer 8.3) within Gladstone harbour subject to a number of conditions. One of these conditions involved compensation for commercial fishing operators that suffered financially due to the loss of access to fishing areas (GPC 2013a). In order to be eligible for compensation, fishers must have owned or operated a commercial fishing operation which generated fishing income in the 2009/10 financial year with catch history recorded in catch sites 12, 13, 17 or 18 of Grid S30 (Figure 4.6). It was estimated six fishing enterprises would be directly affected by the dredging (GPC 2009a) however, an independent report estimated a more precise figure is 65 boats, with an economic loss of $37 million (Hunt 2011). Compensation amounts were to be calculated based upon catch history within the designated areas in the year 2009/10.

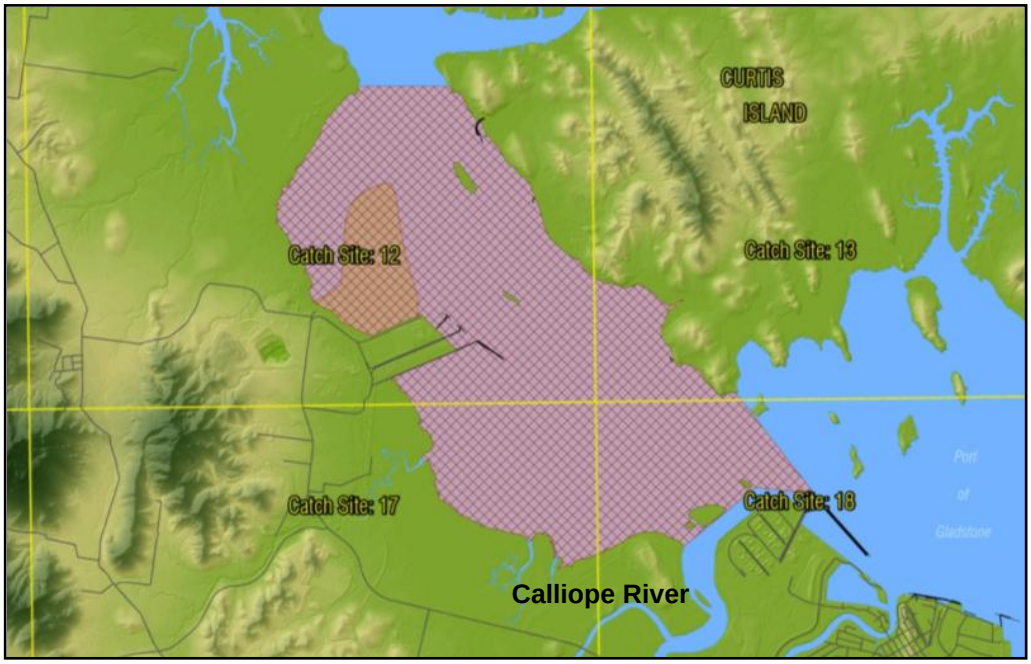


Figure 4.6: Fishing grounds (hatched area) affected by the Western Basin Dredging and Disposal Project (Source: GPC 2013c)

4.3.5 Commercial fishing charters

Extended reef fishing trips are the primary charters taken from Gladstone. The Gladstone fishing charter industry has historically been successful and thriving, with previous annual average numbers for this activity higher than Queensland's overall average by almost 20% (85.5% compared to 66.1%) (Fenton and Marshall 2001b). Presently there are 15 charter vessel licences registered to the Gladstone area. The Swains Reef and Capricorn Bunker Groups are the most targeted fishing areas, with peak months occurring from August to November (Fenton & Marshall 2001b).

Estuarine habitats are known to support offshore fish species and to protect marine environments through sediment filtration. Evidence suggests many coral reef species utilise mangrove and seagrass beds as nursery habitats (Mumby et al. 2004, as cited in Roushon et al. 2013, Nagelkerken, Grtol and Mumby 2012) and many offshore game fish rely on bait fish that spend a part of their lifecycle in coastal estuarine systems (QDEH 1994).

4.4 Indigenous fishing

Traditional fishing by indigenous people is not just considered a food source but is a valuable component of their connection with traditional responsibilities of land management and kinship and important for their cultural lifestyle, religion and ceremonial occasions (Henry and Lyle 2003).

In recognition of the rights of Indigenous people to continue their cultural practices and to encourage cooperative management within the GBRMP, Traditional Use of Marine Resources Agreements (TUMRA) have been implemented since 2005. A TUMRA describes how Traditional Owners intend to manage their natural resource take and activities within the GBRMP and outlines their chosen level of involvement in preserving the local fisheries and marine resources. The Port Curtis Coral Coast (PCCC) TUMRA area, accredited in August 2011, is the largest agreement of its kind (GBRMPA 2013) and represents the Gooreng Gooreng, Gurang, Bailai and Tarebilang Bunda Traditional Owners. Covering an area of 26, 386km², it extends from Burrum Heads, south of Bundaberg, to the northern end of Curtis Island and Fitzroy River mouth (Figure 4.7) and includes all tidal lands and waters below the line of the Highest Astronomical Tide, including the Calliope River. The PCCC TUMRA allows permits to be issued for the hunting of one green turtle (*Chelonia mydas*) per person and prohibits the hunting of dugong (*Dugong dug*on) (GDC 2013). Turtles are only taken for ceremonial occasions and there is no subsistence fishing in the Calliope River.

4.5 Recreational fishing

Recreational fishing is a major pastime industry within Queensland. During 2009, approximately 703,000 Queenslanders went recreational fishing within Queensland, which represents 17% of the population aged five years and older (Taylor et al. 2012). Recreational fishers account for a substantial proportion of the total annual catch of some fish species, with results of surveys showing that recreational catch may exceed commercial figures in some areas and species (SPCC 1984, Henry 1984; as cited in Henry and Lyle 2003).

Recreational fishing in the Gladstone region is a major contributor to the cultural, social and economic prosperity of the area. It supports a range of other outdoor activities including caravanning, camping and boating and the Calliope River has a direct impact on the region's recreation and tourism industries through recreational fishing and adjacent facilities (DNRM 2005b).

The Calliope River is in the Fitzroy statistical division, which includes the major urban centres of Gladstone and Rockhampton. Recreational fishing is popular within this division, with 20% of residents five years and older fishing, which is higher than the state average of 17% (Taylor et al. 2012). The most targeted species in 2010 for this division was mud crabs (*Scylla serrata*), followed by sand whiting (*Sillago ciliata*), pikey bream (*Acanthopagrus berda*) and cod (*Serranidae* spp.) (Taylor et al. 2012).

The entire length of the Calliope River's estuarine and brackish sections are utilised by recreational fishers. There are two ramps for launching vessels, one located at the power station and the other at the Calliope Crossing, which enables access to the brackish and freshwater sections of the river. Many locations along the river allow access without a vessel, including the popular hot water outlet at Gladstone Power Station (refer 9.2) and rocky outcrop section near the Bruce Highway (Figure 5.5). The Calliope River is well known for its angling opportunities and reputed to be one of the southern-most waterways where recreational fishers have an opportunity to catch a highly prized barramundi (DNRM 2005b).

The following information was obtained from Sawynock (2013), based on surveys conducted between March 2008 to January 2009 and September 2011 to July 2013.

The power station boat ramp has the highest usage for vessel access to Calliope River, with figures showing a steady increase from autumn 2008 to winter 2013. The estimated number of trailers utilising this ramp have increased to an average of approximately 2000 in each season in 2013, compared to less than 1500 in 2008. The average number of fishers per trip was 1.9, with trips lasting an average of 3.6 hours, to a total of 7 hours fishing effort.

Based upon surveys conducted from winter 2007 to winter 2013, the average overall catch rate was 6.4 fish caught and 1.5 fish kept per trip. The most prevalent species taken in the Calliope River by recreational fishers are bream (*Sparidae* spp.), barred javelin *(Amniataba percoides)*, mud crab (*Scylla serrata*), barramundi (*Lates calcarifer*) and cod (*Serranidae* spp.). Barramundi (*L. calcarifer)* catch has increased significantly since the flood events in 2011, 2012 and 2013, which caused many to spill from the Awoonga Dam and move into neighbouring estuaries (Chapter 4.3.2). Of all fish recorded, 18.1% were kept and 81.9% released. This is most likely due to size restrictions placed upon many targeted fish under the Fisheries Regulation 2008.

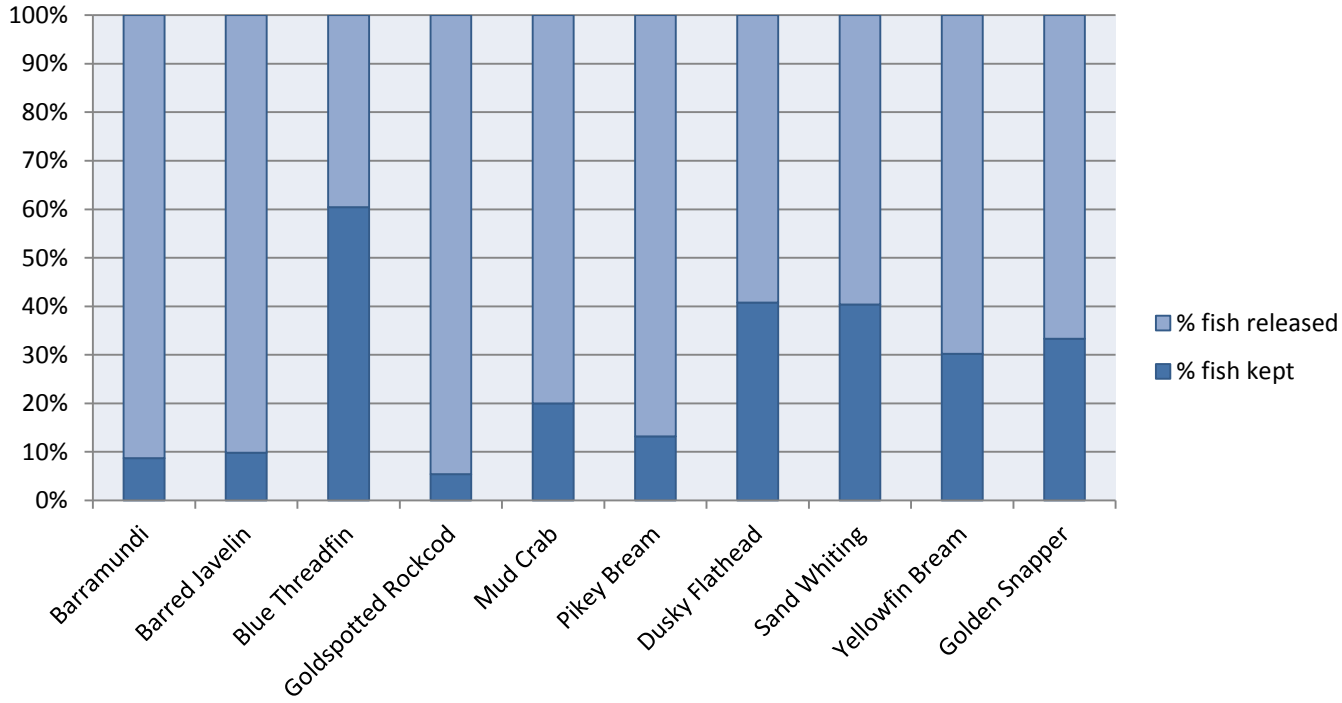


Figure 4.8: Summary of top 10 fish species caught compared to numbers kept in the Calliope River 2007 - 2013 (Data source: Sawynock 2013)

According to Sawynok et al. (2012), Gladstone region's fishing effort is steadily increasing whilst catch rates are declining. Boat registrations have risen to 7,000 in the Gladstone Regional Council area, an increase of 30% from 2000, and trailer surveys at local boat ramps indicate a rise in fishing effort of approximately 25% in the last 6 years (Sawynock et al. 2012).

With increasing growth forecast for the area, fishing effort and pressures on stocks are likely to increase. Within the Gladstone region, catch rates have steadily declined by around 35% based on fisher surveys, however the Wanderer's Fishing Club estimate a drop of 50-60% from 1985-2010 (Sawynok et al. 2011). These statistics reinforce the necessity to protect essential fish habitats in the Gladstone region to support the sustainability of fish stocks.

4.6 Boyne Tannum Hookup

The annual Boyne Tannum Hookup fishing competition, held over the first weekend in May, attracts over 3000 entrants from around the State with fishers targeting species at both inshore estuaries and offshore locations. The event has been held for 18 years and is one of Australia's largest family fishing events.

Fishing effort tends to be determined by weather conditions over the competition weekend, with higher numbers of anglers remaining inshore and fishing estuaries when the weather is inclement. Catch rates between 2007-12 for estuary/inshore trips over the Boyne Tannum Hookup weekend range between 4 to 12 fish caught and 0.5 to 2.5 fish kept per person (Sawynok et al. 2013).

4.7 Fishing closure 2011

In August 2011, the Queensland Government began receiving reports of barramundi (*Lates calcarifer*) and other fish species caught in the Boyne River and nearby waterways with skin discolouration, lesions, bulging/red eyes and blindness. The Government initiated an investigation in response to public concerns regarding fish health and claims by commercial fishers of health issues following contact with the water and sick fish. On 16 September 2011, the Gladstone harbour and surrounding areas, including the Calliope River, were closed to fishing by commercial and recreational fishers under section 46 of the *Fisheries Act 1994*.

Initial testing of the fish revealed two causes, red-spot disease (epizootic ulcerative syndrome [EUS]), which is a fungus endemic to fin fish species of mainland Australia (this condition was only confirmed in one fish from Port Alma) and an external parasitism due to the parasitic flatworm *Neobenedenia* spp, which was affecting the eye and skin particularly in barramundi in Gladstone Harbour (DAFF 2013e). This parasite has previously been found in

Queensland waters in Hinchinbrook Channel between Hinchinbrook Island and mainland Queensland where barramundi are in high densities (DAFF 2013e). Neither of these causes have been found to have a detrimental effect on humans and the harbour was re-opened to fishing on 7 October 2011.

Water quality testing was conducted and besides low salinity due to the flooding, results showed conditions across the region to be consistent with historical trends (EHP 2013a). The investigation could not find any extreme or unusual physio-chemical parameters that could directly link water quality parameters with poor fish health, and apart from one exception in South Trees Inlet, there was no evidence for industrial discharges causing increased concentrations of contaminants that could cause environmental harm (EHP 2013a). Findings revealed the likely cause of illness to be the result of stress and physical damage by large barramundi being washed over the Awoonga Dam wall during the 2011 floods (DAFF 2013e). The Awoonga Dam is a stocked impoundment and it is estimated approximately 30,000 barramundi were washed over the dam wall during the 2011 floods which caused the spillway to overtop for the first time since the 1990's. The large population of fish involved in forced relocation resulted in competition for food and this, combined with colder water temperature, caused the fish to become susceptible to disease and parasites. Flooding in 2013 also caused Awoonga Dam to overtop the spillway carrying (and damaging) more stocked fish into the Boyne estuary.

As a result of the fish health concerns that arose in August 2011, the Queensland Government setup an expanded water and sediment quality monitoring program in Gladstone harbour and associated waterways from September 2011 to September 2012 (EHP 2013a). Following flooding in January 2013, the water quality monitoring was continued between January and September 2013 (EHP 2013b). Visual assessments and laboratory tests were also carried on local fish, scallop and crustacean species (DAFF 2013e). The Queensland Government also established the Gladstone Healthy Harbour Partnership in February 2013 as a forum for bringing together 23 partners from community, government, industry, research and statutory bodies to maintain, and where necessary, improve the health of Gladstone Harbour.

Chapter 5 Habitat diversity

Chapter summary

Essential fish habitats within the Calliope River study area are well represented and include mangrove lined estuarine waterways, seagrass meadows, saltpan and saltmarsh, freshwater lagoons and rocky outcrops. These habitats foster a healthy variety of fish species, many of which are significant for their recreational and commercial value. The abundance of shelter, feeding, breeding and nursery sites ensures a diverse range of fish species inhabit the system, which also provides significant habitat for other vertebrate species. Although outside of the Calliope River area of interest, key fish habitats such as seagrass meadows and freshwater nursery habitats are interconnected and critical to the productivity of the system.

Fish species utilising the estuary rely on different habitats during daily tidal influences, seasonally and at different stages of their lifecycle. The declared FHA program recognises this complex and interrelated reliance and the importance of protecting the full suite and interconnectivity of habitats within an area for future fisheries resource sustainability. The protection of these areas is essential to adequately manage and maintain the productivity of local and regional fish stocks.

5.1 Introduction

Many recreational and commercially important fish species rely on estuarine habitats for some or all of their lifecycle, for example mud crabs (*Scylla serrata*), barramundi (*Lates calarifer*), flathead (*Platycephalus* spp.) and prawns (*Penaeidae* spp.) (Walker 1997). Within the Port Curtis area, species such as the sea mullet (*Mugil cephalus*) are known to utilise mangrove communities as juveniles, mudflats and seagrass meadows as large juveniles and all three habitats as mature fish (Small 1997).

The Calliope river basin supports an extensive estuarine and coastal system that includes mangrove communities, mangrove lined channels, seagrass meadows, intertidal flats and salt couch grasslands of national and international significance (DNRM 2005a). Mangrove, saltmarsh and seagrass communities directly support local inshore and offshore fisheries through their provision of food, shelter, breeding and nursery areas and sediment filtration. This is particularly important given the Calliope River's proximity within the GBRWHA and Great Barrier Reef (GBR) catchment area (Fig. 5.1). The health of the GBR relies on functioning estuarine systems to capture sediment and nutrients and support its fisheries values.

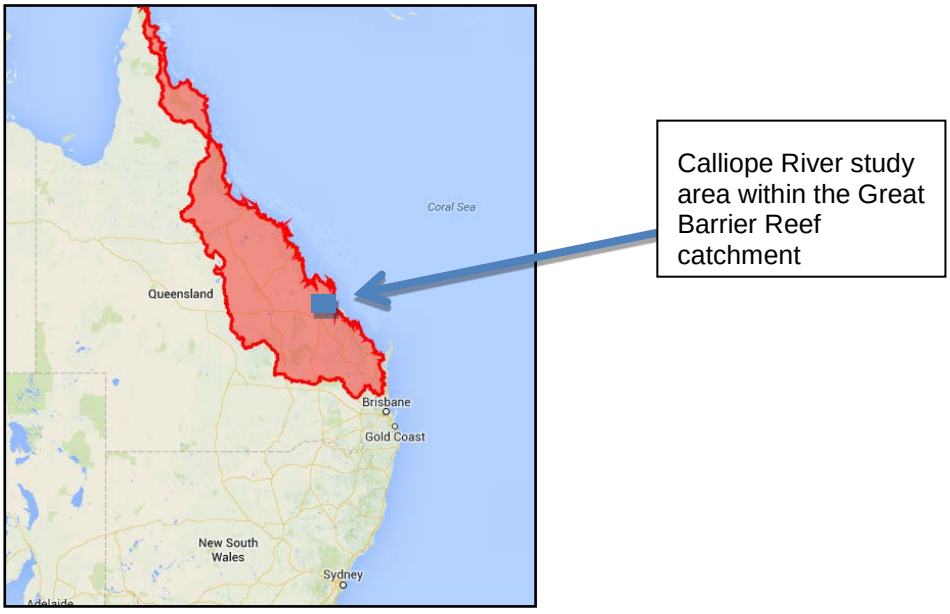


Figure 5.1: Queensland map showing the Great Barrier Reef catchment area

A recent study by Wilson et al. (2012a) found that 77% of the fish abundance caught in Calliope River were categorised as offshore spawners that use the mangrove communities of the Calliope River as a nursery habitat. This is supported by evidence that suggests many coral reef species utilise mangrove and seagrass beds as nursery habitats (Mumby et al. 2004, as cited in Roushon et al. 2013; Nagelkerken, Grol and Mumby 2012). Additionally, many offshore game fish rely on bait fish that spend a part of their lifecycle in coastal estuarine systems (QDEH 1994).

A large proportion of Gladstone's industrial land is reclaimed from the marine environment, in particular, salt flats, mangroves and shallow marine environments (Walker 1999). Since 1941 more than 16.5% of mangrove and 26% of coastal salt flat has been cleared for development within the Gladstone region, equating to more than 1600 hectares of tidal wetlands (Connolly et al. 2006). Industrial development and expansion from 2006 to 2013 has destroyed in excess of 680ha of fish habitat during construction activities and for reclamation (WICET 2006; GPC 2009b; QCG 2012; APLNG 2010; Santos 2012). This level of fish habitat destruction could be a significant contributor to declining catch rates in Gladstone's inshore recreational fishery as recorded over the last 20 years (Platten 2004).

The river's mouth and the adjacent Auckland Creek wetlands have been directly impacted upon by reclamation for industrial development, however the remainder of the Calliope River remains in a relatively undisturbed state (McKinnon et al. 2004).

Port Curtis is unusual in its habitat diversity and utilisation by fish species as diurnal exposure of mangrove forests and seagrass beds force fish species to utilise mudflats which are generally permanently submerged between tides (Small 1997). Small (1997) found high proportions of economically important fish species in mangroves (86%), seagrass (74%) and on mudflats (79%). Destruction of these important near-shore habitats through reclamation processes, combined with further increase in fishing pressure, may eventually lead to a decline of fin-fish in this area (Small 1997). Since it has been estimated that more than 75% of species landed in Queensland’s commercial fisheries rely on a variety of habitats found in healthy estuaries during some part of their lifecycle (Quinn 1992), it is vital that these important habitat areas are managed to ensure the region's future fisheries sustainability. The following descriptions outline the Calliope River's habitats as they relate to the declared FHA selection criteria (NPRSR 2013).

5.2 Habitats of the Calliope River

The Calliope River is unique in that it is one of the last remaining river systems in Queensland with close proximity to a major city that is not impeded by an artificial barrier. Weirs, barrages and impoundment structures have a major impact on some fish species, such as barramundi, freshwater eels and sea mullet, by dividing fish populations, preventing fish migration and restricting re-colonisation and movement for feeding and spawning purposes (McKinnon et al. 2004). Several perennial lower and upper catchment water bodies within the Calliope River system are known to support juvenile barramundi habitats (D. Sullivan, Gladstone Sportfishing Association, pers. comm.; DNRM 2005a), which highlights the importance of interconnectivity through a lack of major fish way barriers. These are valuable locations for sub-catchment aquatic productivity and connectivity for migratory aquatic species (DNRM 2005a).

The river's profile changes throughout its estuarine course, providing a diverse range of prime habitats. Several tributaries and branches feed into the mouth section, with a deep permanent channel, shallow intertidal mud banks and low open flat topography along the banks. The middle section is characterised by deep holes and mud bars, a lack of feed-in branches and is bounded by steep cliffs and banks. The upper estuarine section is dramatically different once again, dominated by shallow bars, wide mud banks, large rocky outcrops and a low level artificial causeway, separating the estuarine from brackish sections. This chapter outlines the individual habitat descriptions and values of Calliope River as defined in the declared FHA selection criteria (NPRSR 2013).

5.2.1 Marine waters >6 m or <6 m at low tide

The Calliope River study area boundary lies within the estuary, excluding inshore marine waters.

5.2.2 Aquatic beds

Seagrass communities are known to act as nursery grounds for juvenile fish targeted by commercial, indigenous and recreational fishers as well as being important food sources for other fish. These habitats are important to the sustainability of inshore and offshore prawn fisheries with juvenile tiger, endeavour and king prawns relying on seagrass communities for their survival (QDEH 1994). They are also recognised as important ecosystems for the maintenance of seabed stability, water quality and biodiversity.

Due to the high turbidity of the area, most seagrass beds in Port Curtis are intertidal, growing on either silty or sandy substrates (QDEH 1994). The seagrass meadows of Calliope River are concentrated around Wiggins Island, at the mouth of the river. In 2006, these seagrass meadows increased substantially in density and area from previous years with *Halopila ovalis*, *Zostera capricorni* and *Halophila decipiens* identified as the primary species (Taylor et al. 2006). Recent monitoring since the 2010-11 flood events has shown a significant decline, with less than 2% seagrass cover found in this area in September 2012 (Davies et al. 2012) and extremely low coverage was recorded for 2013. Seagrass beds naturally vary in area and biomass seasonally and between years (Danaher et al. 2005) however in addition to normal seasonal growth changes Aimes et al. (2013) has recorded a layer of sediment covering this area. This layer of sediment, most likely deposited during recent flood events, would be a major contributing factor restricting seagrass growth. Seagrasses are marine flowering plants, requiring sunlight to photosynthesise. Sediment loading smothers vegetation and reduces the amount of light that can penetrate to the seagrass, diminishing its ability to grow and respire (Kirkman 1997).

In addition to their fisheries values, these meadows are important dugong and turtle feeding areas and have been listed in DIWA (DNRM 2005a). Due to their location, these meadows are particularly vulnerable to impacts from adjacent port facilities, dredging activities and industrial expansion activities (Danaher et al. 2005).

5.2.3 Coral reef

There are no coral reefs in or around the Calliope River study area as its turbid waters are not conducive to the growth of reef forming corals.

5.2.4 Sand, shingle or pebble beaches

Pebble and sandy beaches stretch along the shores of the Calliope estuary particularly from the mid to upper estuarine sections and upper reaches of the study area (Figures 5.2 and 5.3).

These habitats support communities of algae which provide food sources for zooplankton and filter feeding invertebrates (Zeller 1998). Insects and burrowing animals, such as small crustaceans, worms and molluscs are common to these areas and attract indigenous, recreational and commercially targeted fish species such as whiting, bream, flathead and mullet.

Figure 5.2 Beaches along the mid-section of the Calliope River.

Figure 5.3: Gravel beach at the upper boundary of the study area.

5.2.5 Estuarine waters

An estuary is a partially enclosed body of water where freshwater from rivers and streams meet and mix with saltwater from the ocean. The estuarine waters of the Calliope River extend from its mouth to the artificial causeway approximately 26km upstream, with numerous smaller tributaries branching off from the main waterway (Figure 5.4). Permanent water depths range from over 11m deep to shallows of less than a metre at low water mark (LWM) (Patrick 2003).

The Gladstone region's significant mud crab and prawn fisheries rely on estuarine waters and their habitats for periods of their lifecycle as do many other economically significant species (Zeller 1998). It has been estimated that more than 75% of species landed in Queensland's commercial fisheries rely on a variety of habitats found in healthy estuaries during some part of their lifecycle (Quinn 1992). The largest percentage of recreational fishing effort in Queensland occurs in estuarine systems (45% state wide), with yellow fin bream (*Acanthopagrus australis*), whiting (*Sillaginidae* spp.) and flathead (*Platycephalidae* spp.) the most common species caught in this environment (Taylor et al. 2012).

Figure: 5.4: Shallow permanent estuarine waters in the Calliope River

5.2.6 Intertidal flats

Exposed mud and sand banks are the most common intertidal habitat within Port Curtis. These habitats develop in sheltered places where the water velocity slows and are important sedimentation areas, with high productivity and nutrient value. Intertidal flats support a diversity of burrowing and surface fauna and interstitial algae provide a direct food source for fish species (Long and McKinnon 2002). Small (1997) found that the Port Curtis sub-tidal flats are particularly important for juvenile fish species in providing alternative habitat at low tide when adjacent seagrass meadows and mangroves become fully drained, recording that 79% of species caught in these habitats were of direct economic significance.

Throughout the Calliope River, there are extensive intertidal flats, making sections of the river difficult to traverse at low tide. The substrates of these flats vary from coarse sand with a surface layer of large shell fragments and rubble at the mouth, to fine soft clays and dense clays throughout the remainder of the study area (WICET 2006; Small 1997). Algal and seagrass communities are prevalent on the intertidal flats between Fisherman's Landing (to the north of the river) and the Calliope River mouth. In addition to the fisheries values, this area is recognised as important feeding habitat for shorebirds, dugongs and turtles, including a number of species listed as Migratory under the EPBCA, such as the Whimbrel (*Numenius phaeopus*), Eastern Curlew (*Numenius madagascariensis*), Common Greenshank (*Tringa nebularia*) and the Bar-tailed godwit (*Limosa lapponica*) (WICET 2006).

5.2.7 Intertidal saltmarshes and saltpans

Despite their relatively low duration of inundation, intertidal saltmarshes and saltpan habitats have been found to have significant habitat values for many species of fish, including those of economic importance such as bream, whiting and mullet (Thomas and Connolly 2001; Mazumder et al. 2006). Mazumder et al. (2006) found a direct link between intertidal saltmarsh inundation and crab larvae recruitment to coastal waters, which also contributed significantly to the diet of itinerant fish species utilising the saltmarsh. It appears there is no substantial difference between the fish species richness captured in vegetated and un-vegetated saltmarsh and saltpan habitats, with a high number and diversity of estuarine resident and estuarine/marine fish species utilising the entirety of these habitats, travelling more than 400m from sub-tidal water (Thomas and Connolly 2001).

On the terrestrial side of many of the mangrove communities lining the lower Calliope River is a mix of intertidal wetlands dominated by saltpans. Salt couch (*Sporobolus virginicus*) is represented throughout the estuarine section of the river, with its distribution and abundance dependent upon the riverbank profile and size of salt flats at the rear margin of the mangroves (McKinnon et al. 1995). At a number of locations it is the dominant intertidal vegetation, with intertidal succulent species, sea purselane (*Sesuvium portulacastrum*) and samphire (*Sarcocornia quinpueflora*) occurring in small numbers dispersed within the salt couch or bare substrate (McKinnon et al. 1995). Large areas of Calliope River's saltmarsh and saltpan (approximately 180ha) have recently been reclaimed for WICET (WICET 2006).

5.2.8 Mangrove communities

Mangrove forests consist of distinct communities growing within the intertidal zone of estuaries, coastal rivers and bays. They are among the most productive and biologically diverse ecosystems in the world and are crucial to the biological productivity and food webs of coastal waters, providing critical nursery areas for many indigenous, commercial and recreationally important fish species (Goudcamp and Chin 2006). Within Port Curtis, Small (1997) found the most abundant numbers of juvenile fish were found in mangrove communities. This is due to the use of prop-roots and overhanging branches by juvenile fish as refuge from predatory fish and food provision through the abundant source of plankton, algae and detritus.

Mangrove communities play a vital role in preventing coastal erosion, trapping sediment and filtering land run-off (Lovelock 1999) and as such, are integral to the health of the GBR ecosystem through their role in sediment and nutrient capture (Hogarth 1999; Goudcamp and Chin 2006). Despite the biological and economical importance of mangrove communities, more than 35% have been removed globally (WWF 2013) and 16.5% have been destroyed within the Gladstone region (Connolly et al. 2006).

Mangrove species are variable in their tolerance to local environmental factors such as salinity, levels of inundation, soil types and wave action (Danaher et al. 2005) and this causes the density and diversity of mangrove communities in the Calliope River to vary throughout the study area. In addition to this, Port Curtis contains an unusual mix of mangrove species, with the region marking an overlap between the southern-most reaches of tropical mangrove species and a diverse range of sub-tropical species (Small 1997). Port Curtis marks the most southern occurrence of Cedar mangrove (*Xylocarpus moluccensis*), Holy mangrove (*Acanthus ilicifolius*) and Rib fruited orange mangrove (*Bruguiera exaristata*) (Danaher et al. 2005).

Twelve species of mangrove have been recorded in the Calliope River (Saenger 1996; McKinnon et al. 1995 Appendix E). Mangrove forests close to the mouth of the river contain a range of mangrove species with no individual species dominating, however species diversity reduces with distance from the mouth (McKinnon et al. 1995). In areas regularly inundated at high tide, red mangroves (*Rhizophora stylosa*) are the most commonly occurring species due to its high tolerance of regular inundation. The most abundant adult trees in sites sampled are river mangroves (*Aegiceras corniculatum,* 67%; Figure 5.5) with red mangrove (*Rhizophora stylosa,* 17%), grey mangrove (*Avicennia marina,* 10%) and yellow mangrove (*Ceriops tagal,* 6%) well represented throughout the river (Wilson et al. 2012a; McKinnon et al. 1995). The least represented species is black mangrove (*Lumnitzera racemosa*), representing less than 1% of adult mangrove trees (Wilson et al. 2012a).

Figure 5.5: Closed *Avicennia* mangrove communities in the lower Calliope River

5.2.9 Marine swamps/lagoons

Many of the creeks feeding into Calliope River contain small perennial lagoons and pools that only become tidal during certain high tides, for example Beecher Creek (Figure 5.6). These pools provide interconnectivity with freshwater lagoons further upstream that have the capacity to support a range of fish species including juvenile barramundi (Baker and Sheppard 2006; Chapter 5.2.11). Larval and juvenile fish species such as barramundi and mullet move to these protected brackish food rich habitats whilst they mature, returning to the estuarine habitats as adults (Long and McKinnon 2002).

Figure 5.6: Beecher Creek

5.2.10 Freshwater/brackish swamps and lagoons

The Byellee Wetlands (23°53'S, 151°11'E) is a locally significant wetland area located on the southern bank of the Calliope River approximately 14km upstream of the river mouth. This wetland encompasses an area of approximately 350ha of freshwater and saltwater interface from the Calliope River mangroves and saltpan to a permanent freshwater wetland lagoon and diverse open bushland. A man-made freshwater lake with three bird hides located at various points around the lake is used by bird watchers and for other low key recreational purposes such as bush walking. This is an important part of the local and regional network of green corridors containing habitats such as riverine blue gum (*Eucalyptus tereticornis*), riparian rainforest and paperbark teatree (*Melaleuca fluviatilis*). In addition to providing essential habitat for juvenile fish species, powerful owls (*Ninox strenua*), listed as vulnerable under the NCA and migratory bird species are known to utilise this habitat, along with many other fauna (FBA 2006).

Extending beyond the Calliope River study area, are significant freshwater lagoons within the Beecher, Gravel and Double Creeks that provide habitats for juvenile barramundi (D. Sullivan, Gladstone Sportfishing Club, pers. comm.). Barramundi is an important target species for indigenous, recreational and commercial fisheries. Its lifecycle includes freshwater, estuarine and marine phases. Barramundi rely on estuarine systems for spawning and larval stages and then juveniles migrate to brackish and freshwater (where available) habitats, remaining in these sheltered protective environments for approximately 3 to 4 years whilst they mature. Other species captured in these lagoons include bream, mullet, milkfish, sleepy cod and tarpon (D. Sullivan, Gladstone Sportfishing Club, pers. comm.). These lagoons provide habitat for juvenile fish, contribute to the future sustainability of fish stocks and support the fish productivity of the Calliope River (refer to section 5.3). Figure 5.7 shows locations where juvenile barramundi have been tagged in the Calliope River. The majority of fish were tagged in the upper Calliope River, Beecher Creek, Leixlip Creek and Double Creek.

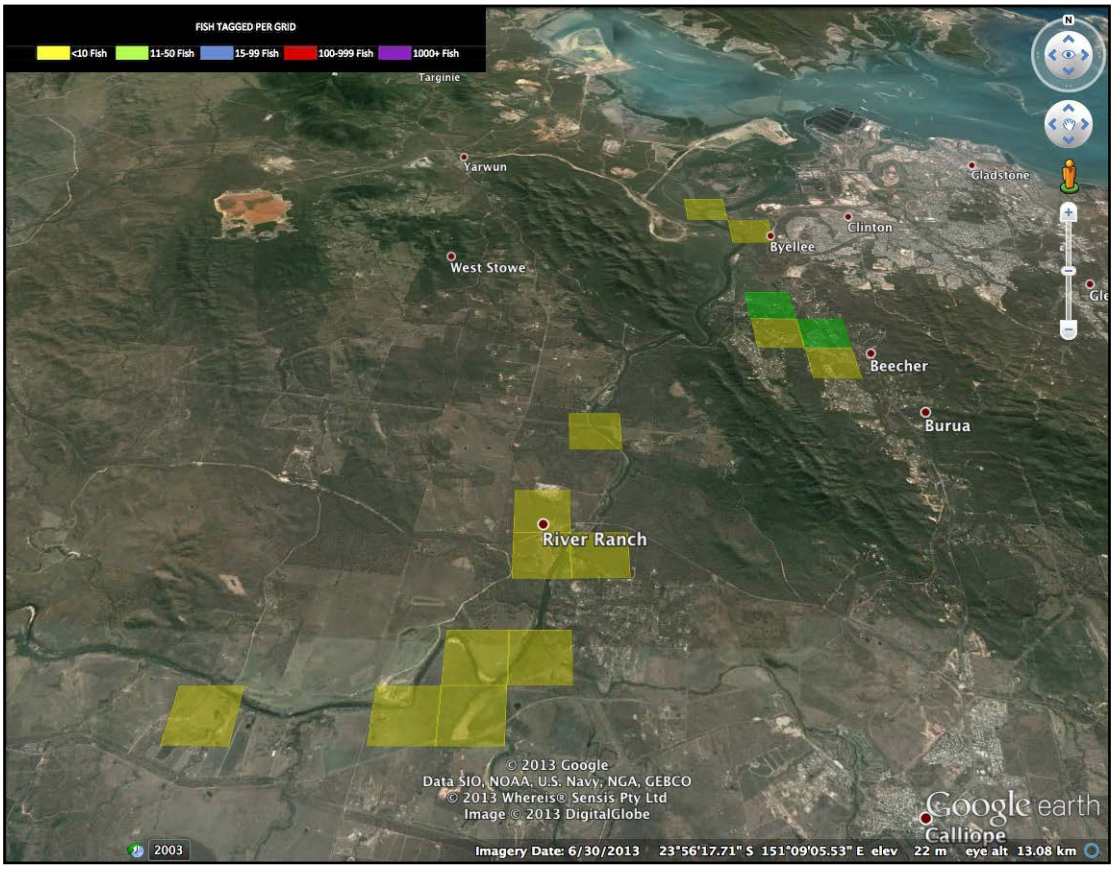


Figure 5.7: Estuarine and freshwater locations where juvenile barramundi (<300mm and 300- 600mm) have been tagged. (Sawynock 2013)

5.2.11 Rocky structures

Large rocky outcrops and gravel bars are a common feature of the Calliope River, providing an abundance of food and shelter for pelagic fish. Rocky structures provide a hard substrate for the attachment of rich algal flora (which contributes to the river's primary production) and immobile invertebrates (barnacles, oysters and tube worms) (Zeller 1998).

The subtidal rubble areas of the mouth's deep channel and shallow river channel contain a relatively rich and abundant epibenthic community typically seen in much deeper waters. These include solitary (non-reef building) corals, stinging hydroids, sea pens, barnacles, scallops, feather stars and encrusting sponges (WICET 2006).

The upper estuarine section of the Calliope River is characterised by large rocky outcrops that dominate for several hundred metres (Figure 5.8), providing prime fish habitat (McKinnon et al. 1995). McKinnon et al. (1995) found the greatest abundance of economically important fish were located in this area, presumably due to migratory fish species congregating in this area until the tides are high enough to allow unrestricted movement upstream. This is a popular recreational fishing destination with accessibility by land.

Figure 5.8: Rocky outcrops in the upper section of the Calliope River

5.2.12 Surf bars

Due to the sheltered waters of Port Curtis and the protection availed by Curtis Island there are no surf bars within the Calliope River study area.

5.2.13 Overhanging/Undercut waterway banks

Overhanging and undercut waterway banks provide shelter and protection for juvenile fish species and predatory species. They are popular fishing locations for anglers due to the larger predatory species that utilise the shelter for ambushing prey, for example mangrove jack and barramundi. These banks normally form as a result of natural erosion processes however this can be accelerated by wash resulting from significant boat activity (Baker and Sheppard 2006).

Many of the waterway banks along the Calliope River and its tributaries contain overhanging and undercut banks (Figure 5.9).

Figure 5.9: Eroded and undercut banks in the Calliope River

5.3 Unique habitat features

The lack of fish way barriers within the Calliope River makes it one of the last remaining major river systems in Queensland that is not impeded by an artificial barrier and a unique and valuable system for the region's fisheries. Species abundance at juvenile fish nursery sites in Central Queensland is directly related to the frequency and duration of connectivity to the marine system (Infofish 2002). Weirs, barrages and impoundment structures, such as those in estuarine systems adjacent to the Calliope River, have a major impact on some fish species, such as barramundi, freshwater eels and sea mullet, by dividing fish populations, preventing fish migration and restricting re-colonisation and movement for feeding and spawning purposes (McKinnon et al. 2004). The Calliope River's connectivity and availability of upstream habitats contributes significantly to the maintenance of genetic diversity within the region's fisheries (DERM 2011a). These important upstream habitats include significant large rocky outcrops.

Freshwater habitats upstream in Beecher, Leixlip and Double Creeks (Chapter 5.2.11) are known to support juvenile fish from a range of species, including barramundi (D. Sullivan, Gladstone Sport fishing Association, pers. comm.; DNRM 2005a). The extent to which fish access to off-stream creeks and wetlands has been reduced by barriers in other estuarine systems has resulted in barramundi relying heavily on in-stream habitat and brackish tidal areas for nursery sites, making them vulnerable to predation, waterway modification and overcrowding (Infofish 2002). For this reason, juvenile habitats such as those found in the Calliope River are critical to future fish stock sustainability. Barramundi is an iconic species in Queensland and highly sought after by anglers. To maintain commercial and recreational stocks at a sustainable level, it is important to recognise and protect not only the fish habitats of the Calliope River but also their accessibility and connectivity to adjoining fish habitats. As these adjoining fish habitats are outside of the Calliope River area of interest, alternate management and protection strategies should be employed, such as cooperative management arrangements with adjacent landholders.

5.4 Conclusions

The Calliope River is host to a range of diverse, interconnected and highly productive fish habitats. These habitats support a variety of fisheries that are important to the indigenous, commercial and recreational fishing sectors. The maintenance and protection of these key habitats is integral to the sustainability of the region's fish stocks and a key component of the FHA concept. Habitat interconnectivity and effective functioning is a fundamental requirement for productive and sustainable fisheries and the importance of protecting all available habitats within an area is a central focus of the declared FHA concept (NPRSR 2013, Baker and Sheppard 2006). With rapid urban and industrial growth in the region the Calliope River is likely to experience increased pressures on its fish habitat values in the future. High priority should be placed on the protection and maintenance of the full range of fish habitats and their connectivity as an important component to the management of the region's fisheries.

Chapter 6 Riparian zone

Chapter summary

The riparian communities within the Calliope River catchment are relatively intact and represent significant habitat areas for native flora and fauna. A narrow semi-continuous riparian corridor remains, with a continued dominance of native vegetation from its source to the tidal limit.

Large proportions of the vegetation of the Calliope River catchment are mapped as remnant vegetation, containing 'of concern' or 'endangered' regional ecosystems, interspersed with high value regrowth vegetation.

6.1 Introduction

Riparian zones, terrestrial vegetation growing along a watercourse, provide significant ecological value and biological functions and are critical to the protection and maintenance of fisheries resources. Benefits derived from a healthy and functioning riparian buffer zone include:

- flood control
- improvement of water quality through sediment and chemical capture and filtering
- stabilisation of shorelines
- shading
- a buffer from adjacent land uses
- physical habitat
- erosion control through improved bank stability
- protection of fish and wildlife habitats (Bavins et al. 2000; Baker and Sheppard 2006).

Waterways bordered with well-developed, healthy and intact riparian vegetation generally support higher levels of productivity than those lacking a vegetative buffer zone (Bavins et al. 2000). The presence and health of riparian vegetation provides a good indication of the impact of surrounding land uses on a waterway and its resilience to these impacts.

6.2 Riparian zones within the Calliope River

The riparian ecosystems within the Calliope River catchment are relatively intact and represent significant habitat areas for native flora and fauna (WICET 2006). Although the basin has experienced significant clearing for agricultural and pastoral use, a narrow semi-continuous riparian corridor remains with a continued dominance of native vegetation, from its source to the tidal limit (DNRM 2005a). Much of the riparian zone is a mix of vegetation communities, including Melaleuca and Eucalypt woodlands, located in the upper reaches of watercourses, or on the landward side of intertidal wetlands (Figure 6.1). The lower reaches are predominately intertidal wetlands (WICET 2006).

A large majority of the riparian corridor along the lower half of the Calliope River is mapped as remnant vegetation and considered of state and regional significance. Large proportions of the vegetation communities of the Calliope River catchment contain 'of concern' or 'endangered' regional ecosystems, interspersed with high value regrowth vegetation (DEHP 2013, Appendix F).

Figure 6.1: Eucalypt woodland along the upper estuarine section of river

6.3 Conclusion

Despite disturbance and clearing within the Calliope catchment, a narrow semi-continuous riparian zone remains. This riparian zone provides protection for the waterway from surrounding land uses and impacts and enhances productivity. It is essential these important terrestrial habitats are protected to support waterway productivity through such measures as clearing restrictions and appropriate Council planning and management in relation to urban development.

Chapter 7 Climate, catchment flows and impoundment structures

Chapter summary

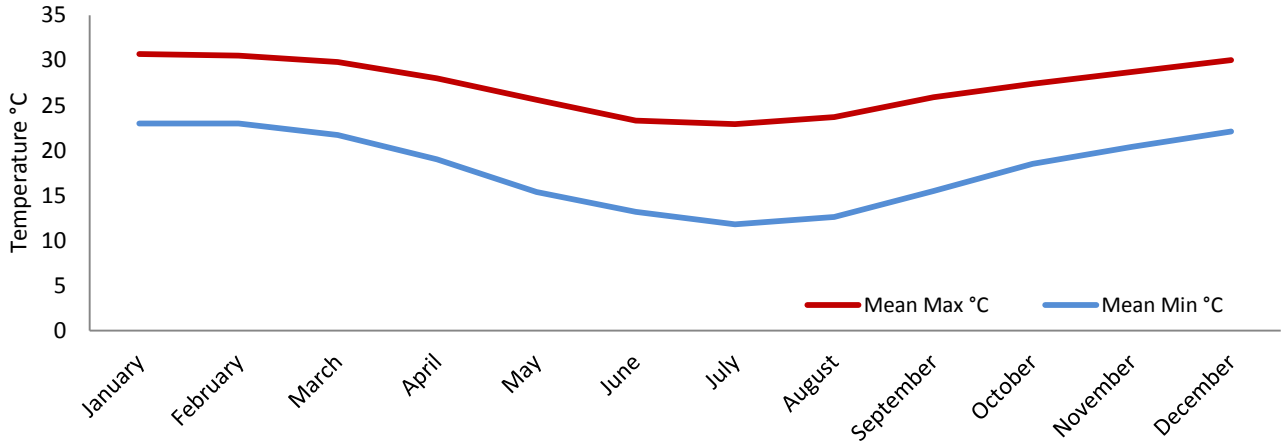
The Calliope River catchment covers an area of 2236km². It has a subtropical climate with an average annual rainfall above 800mm. A limited licencing system is in place for the management of water extraction and there are no major water impoundments within the catchment. This allows full waterway connectivity and the free movement of fish between a range of habitats.

The Gladstone region has a sub-tropical climate with an average rainfall of 853mm. The highest rainfall occurs between December and February (figure 7.1 c). Temperatures range from 22.1°C to 30.7°C in the summer months and 11.8°C to 23.7°C in winter (figure7.1a). Tropical cyclones occur approximately every seven years.

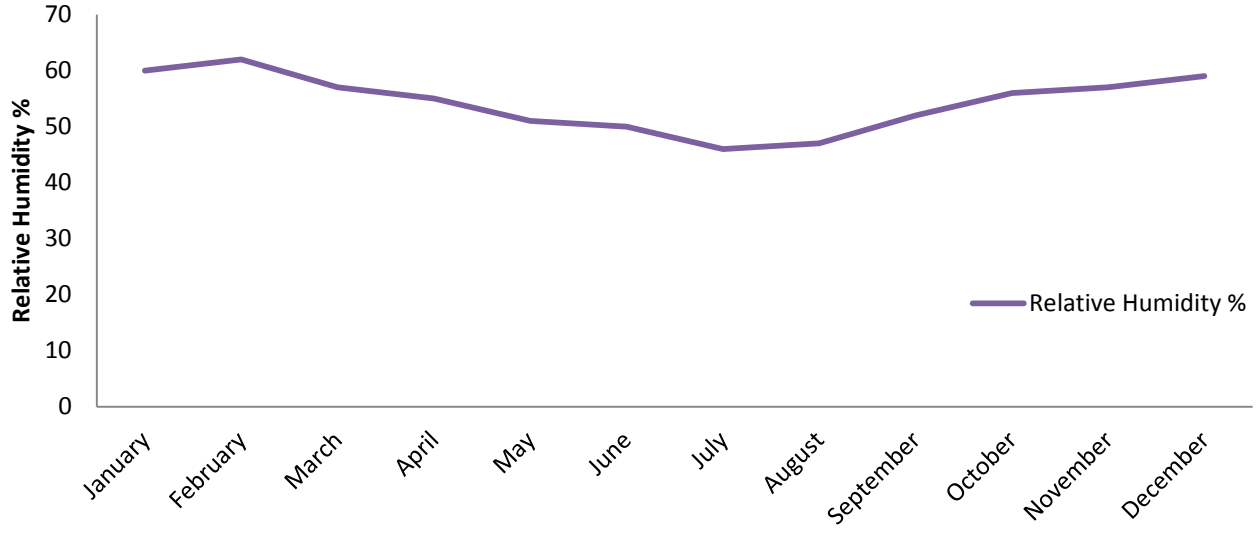
The Calliope River catchment encompasses an area of 2236km², is not impeded by an artificial barrier and is one of the few remaining rivers in the region with a near natural flow regime. Weirs, barrages and impoundment structures have a major impact on some fish species, such as barramundi, freshwater eels and sea mullet, by dividing fish populations, preventing fish migration and restricting re-colonisation and movement for feeding and spawning purposes (McKinnon et al. 1995).

The *Water Resource (Calliope River Basin) Plan 2006* limits water extraction for consumptive use to less than 7% of the overall mean annual discharge (153,000 megalitres) (DNRM 2007). Consumptive use relates primarily to small scale irrigation such as cattle feed production, with some horticulture and aquaculture production. Surface water extraction is managed through a licencing system with 59 licences extracting approximately 1500 - 4500 megalitres per annum (DNRM 2007). Most urban residential and industrial water supply for the Gladstone area is sourced from the Awoonga Dam, on the adjacent Boyne River.

Graph a



Graph b



Graph c

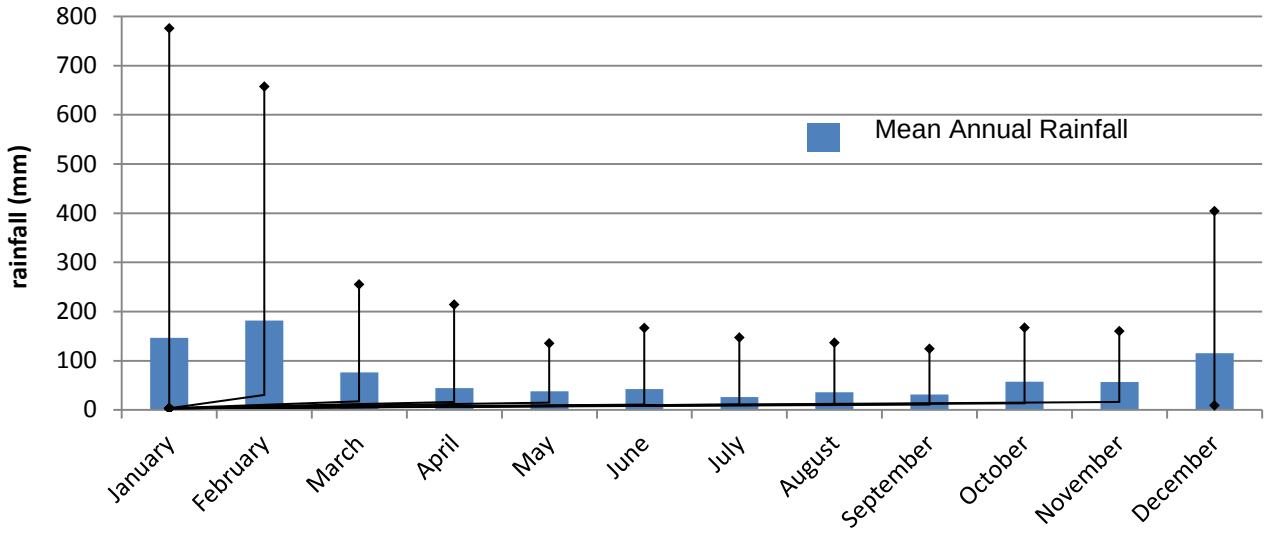


Figure 7.1: Gladstone monthly climate averages measured by the Bureau of Meteorology (BoM 2013). (a) Maximum and minimum temperatures (between 1993 and 2013); (b) 3pm relative humidity (between 1993 and 2010); and (c) rainfall. Lines show range (between 1994 and 2013).

Chapter 8 Water quality

Chapter summary

The water quality of Calliope River has been monitored routinely since 1994 and recent nearby development activities have caused an increase in testing schedules and comparisons. Available data shows the water quality to be of high standard and well within ANZECC guidelines. Increased turbidity levels and elevated metals have been attributed to natural causes and some increase in temperature may be caused by the NRG power station thermal outlet. Regular assessments of dredging activities have shown no evidence of harmful impacts from water quality and contaminant concentrations.

8.1 Introduction

Water quality is fundamental to the maintenance and value of a healthy waterway. It sustains ecological processes that support fish populations, vegetation, wetlands and birdlife. Water quality is closely linked to the surrounding environment and land use and can decline through processes such as land clearing, industrial and urban development, pollution and stream modification (Baker and Sheppard 2006). The impact of these processes diminishes the environmental health of the river as well as its commercial and recreational value. Poor water quality can cause fisheries values to decline from introduced disease, degraded habitat values and poor fish health (Baker and Sheppard 2006).

ANZECC developed the National Water Quality Management Strategy (ANZECC 2000) which provides water quality guidelines to ensure that environmental values of waters are protected. The presence of contaminants and the characteristics of water are used to indicate the quality of water and trigger values (TVs) are calculated based on toxicity testing of a range of species. Trigger values provide a measure of the biological significance of the metal concentration through indicating the likelihood of organisms being impacted. Exceeding a TV does not necessarily signify that the water is harmful, but rather it indicates the need for further investigation or action.

8.2 Water quality

Following the 2011 Gladstone fishing closure (Chapter 4.7), extensive water quality testing and historical comparisons were undertaken by DERM to determine if there had been any obvious or unusual deterioration in water quality in the Port Curtis area (DERM 2011b, EHP 2013a, b). It was originally suggested that an outbreak of fish disease was caused by decline in water quality through harbour dredging and the 2010-11 floods. Analysis for the Calliope and Boyne estuaries and the Gladstone harbour showed natural variation in water quality due to seasons, flooding, rains and drought. Water quality parameters in the estuaries were consistent with historical levels, apart from salinity, which was low for an extended period due to the extensive flooding in the area in 2010-11 (DERM 2011b, EHP 2013a).

Since 1994 monthly monitoring data has been collected from the Calliope River with samples taken on the surface of the water, and then every two metres to the estuary substrate (DERM 2011b). Tests show water quality is of a high standard in Calliope River. Elevated levels of turbidity, phosphorous, copper, manganese and zinc have been detected however all metals are below recommended guidelines (Vision Environment Queensland 2011).

8.2.1 pH

pH is the measure of acidity or alkalinity of a waterway. It ranges from 0 (strongly acidic) to 14 (strongly alkaline), with a pH of 7 being neutral. Acidic water can damage the skin and gills of fish, leading to increased susceptibility to fungal and bacterial infection. ANZECC guidelines recommend a pH level of between 7 and 9 for estuarine systems. Recordings of pH in the Calliope River have ranged between 7.1 in 2004 and 8.7 in 1994 (DERM 2011b).

8.2.2 Dissolved oxygen concentration

Dissolved oxygen (DO) is an important measure of the health of a waterway for fish survival, as it is an indication of the available oxygen for fish to respire (DERM 2011b). Fish kills can occur in waterways with persistent low oxygen concentrations (<50% saturation), whereas algal blooms can initiate supersaturated levels of oxygen above 100%. DO within the Calliope River is highly variable with ranges between 54% and 162% saturation. These figures reflect flood events in the Calliope River which can drastically alter DO levels with low concentrations being due to the aerobic decomposition of high levels of organic matter by microbes in the estuary and high concentrations due to phytoplankton blooms (DERM 2011b).

8.2.3 Water temperature

Water temperature has an impact on fish health and sudden changes to temperature or an extended cold winter can impact fish immunity functions (DERM 2011b). The temperature range within Calliope River is quite variable, ranging from 16.8°C to 36.4°C. A possible cause for this could be the proximity of temperature sampling sites to the NRG Power station's thermal outlet, which can increase water temperature of between 2°C and 5°C in the waters immediately adjacent to the outlet (Ross et al. 1986). There are no trigger values for temperature.

8.2.4 Metals

Metals and metalloids can be present in either the dissolved form or associated with suspended particles. They occur naturally in all waterways within Australia and levels tend to peak after heavy rains (DERM 2011b). Metals and metalloids are toxicants and can harm aquatic organisms, with the dissolved fraction considered to be the most bioavailable form. Within the Calliope River natural elevations of manganese and iron are detectable as are copper and zinc. However all metals are consistently below ANZECC guidelines (Vision Environment Qld 2011).

8.2.5 Turbidity

Turbidity provides a measure of sediment in the water column. High levels can stress fish through clogged gills and reduced ability to absorb oxygen. The Calliope River, particularly within the anabranch, is generally considered a turbid system compared to the Port Curtis harbour and adjacent Boyne River, however data showed few exceedences of guideline values (Wilson et al. 2012b).

8.3 Sediment quality

Levels of contaminants such as metals and polycyclic aromatic hydrocarbons (PAHs) measured in sediment layers can harm fisheries resources. PAHs can be naturally synthesised by bacteria, plants and fungi, but also originate from human activity and can cause harm through toxicity, accumulation in animal tissue, habitat alteration and chemical and physical changes to the sediment medium (Storey et al. 2007).

Dissolved contaminants in waterways bind with suspended sediment particles, which coagulate and sink into the sediment layer. Although these contaminants are generally stable and sediment bound, activities such as dredging, burrowing organisms and natural flood events can destabilise these toxins and have the capacity to adversely affect the surrounding environment and harm fisheries resources. Mangrove sediments tend to contain higher concentrations of contaminants than other shoreline sediment due to aerial roots trapping tidal waters and allowing suspended particles to settle (Vision Environment Queensland 2011).

All metals in sediment samples within the Calliope River are below recommended guidelines and PAH's are of low concentration (Storey et al. 2007). Analysis of metals, metalloids, pesticides, petroleum hydrocarbons (including PAHs), polychlorinated biphenyls, dioxins and dioxin-like chemicals from Port Curtis sediments found only low, negligible or undetectable concentrations (EHP 2013a).

8.4 Dredging operations

Over 21 000 000m³ of material was dredged and removed from the Gladstone harbour, in the vicinity of the Calliope River mouth, from May 2011 to September 2013 (GPC 2013b; DERM 2011b; GPC 2013d). This was to accommodate various new industrial infrastructures and shipping channels. Dredging activities are closely monitored and several water quality tests conducted by GPC, the Department of Environment and Heritage Protection (EHP) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) have shown no evidence of harmful water quality within the harbour or the Calliope River and that metal concentrations generally remain below ANZECC guidelines (GPC 2013b, EHP 2013a, EHP 2013b).

8.5 Conclusions

The Calliope River is a healthy system with water quality parameters well within acceptable limits. Historical data shows that variations occur and water quality diminishes at various times however this is most likely due to flooding events which contain high sediment loadings, low DO levels and elevated metal and metalloid levels. Dredging activities are outside of the extent of the Calliope River and closely monitored.

Considering the level of industrial development and activity surrounding the Calliope River, the results from water quality monitoring show it to be a highly resilient and robust estuarine system.

Chapter 9 Land use within and adjacent to the Calliope River

Chapter summary

The Calliope River drains into Queensland's largest multi-commodity port and is adjacent to the major industrialised city of Gladstone. Intensive industrial operations and developments exist on and adjacent to the lower reaches of the Calliope River. Grazing is the primary land use in the upper catchment.

Limited artificial structures have been constructed along Calliope River's waterways. The Calliope Crossing creates a distinct boundary between the estuarine and brackish sections of the river however it allows fish migration during higher tides. Despite the surrounding land uses, the Calliope River sustains a wide range of productive and healthy fish habitats.

9.1 Introduction

The Calliope River basin is surrounded by a variety of land uses. Grazing is the dominant land use on a large proportion of the more fertile lands, particularly on the floodplain and alluvial frontage areas in the upper reaches of the catchment. These areas have been cleared for increased pasture production for cattle grazing, as well as limited areas of ponded pasture development (DNRM 2005a). The highly industrialised nature of the Gladstone region and its multi-commodity port means that intensive industrial and urban development exists on the north eastern margin of the basin, toward the mouth of the river.

As of June 2011, the resident population of Gladstone Regional Council was 62,319 persons (Qld Treasury and Trade 2013). The presence of the Gladstone State Development Area and Gladstone Port facilities has attracted many large industrial corporations to the region.

Existing major industries in the region include:

- Aluminium production - Boyne Smelters Ltd
- Cement production - Cement Australia
- Alumina production - Rio Tinto Alcan, Queensland Alumina Ltd
- Gladstone Ports Corporation
- NRG Power Station
- Chemical production - Orica Australia Pty Ltd
- Shale Oil fuel production - QER Pty Ltd.

Proposed projects and those in development include:

- Four LNG extraction plants, Curtis Island
- Expansion of the Fisherman's Landing Port Facility
- Wiggins Island Coal Export Terminal
- Gladstone Steel Making Facility
- Yarwun Coal terminal.

9.2 NRG Power Station

The NRG Power Station covers 80ha along the Calliope River, approximately 8km upstream from its mouth (Figure 9.1). Built in 1976, it is Queensland's largest coal fired power station generating 1680 megawatts of electricity to the State grid, 60% of which is consumed by the Boyne Smelters.

The station requires 245 million litres of saltwater for cooling every hour which is pumped from Auckland Inlet, passes through the station’s condensers to revert steam back to water for repeat use in the boilers and then the cooling water is discharged into the Calliope River (NRG 2013). This discharge causes an increase in water temperature of between 2 °C and 5 °C in the waters immediately adjacent to the outlet (Ross et al. 1986).

Studies suggest that thermal discharge outlets have a negative effect on benthic fauna and fish assemblages (Saenger et al. 1982; Teixeira et al. 2009). Fish are known to aggregate in thermal discharges, particularly in winter months, however the cause of this is unclear (Williams and Waldman 2010). This aggregation is likely to affect fish

migration within the river, however it also provides angling opportunities that may otherwise not exist. Public access is allowed into this area and it is a popular fishing spot for local residents (Figure 9.2), with barramundi, queenfish and trevally regularly caught in the immediate waters (GAPDL 2013).

Figure 9.1: NRG Power

Figure 9.2: NRG Power Station hot water outlet

9.3 Wiggins Island Coal Export Terminal

The Wiggins Island Coal Export Terminal (WICET), comprising six berths, is currently under development at the mouth of the Calliope River (Figure 9.3). It runs to the north and west of the River's mouth and adjacent to the anabranch. Queensland's Bowen Basin produces high quality coal that is exported to Japan, Korea, Taiwan, China, India, Europe and Brazil and the increasing demand for this supply has surpassed the capacity of the existing RG Tanna and Barney Point Coal Terminals situated in Gladstone harbour. Upon completion, WICET will have a nominal export capacity of 70 million tonnes of coal per annum and contribute an additional $6.4 to $8.3 billion in economic activity to the State annually (WICET 2006).

Initial dredging for this project excavated approximately 3.2 million m^3 of sediment with subsequent dredging campaigns planned to excavate a further 3.1 million m^3 of the seabed. The spoil is being disposed of in reclamation areas approximately 4km from the site (WICET 2006). The terminal infrastructure placement and design was specifically tailored to minimise damage to marine plants, however the construction of infrastructure required the destruction of 183ha of marine plants, including mangroves, seagrass, saltmarsh and salt couch, and reclamation

of a further 290ha of intertidal habitats.

Figure 9.3: Wiggins Island Coal Export Terminal construction

9.4 RG Tanna Coal Terminal

RG Tanna Coal Terminal (RGTCT) is adjacent to the mouth of the Calliope River, on the southern side to WICET (Figure 9.4). It was built in the late 1970s to transport coking coal to Japan and is now the fifth largest coal export terminal in the world, exporting over 45M t of coal per annum. It consists of a 4-berth wharf with a total length of 1.95km. Historical records indicate that approximately 2000 - 3000m^3 of sediment is dredged from each berth at the RGTCT each year (WICET 2006). The dredge spoil has historically been dumped in designated offshore spoil grounds or onshore (WBPD 2013).

Figure 9.4: RG Tanna Coal Terminal

9.5 Other land uses

Beef cattle grazing is the dominant land use of the catchment occupying approximately 66% of the catchment area. Of cattle grazing holdings, 25% have adopted riparian management practices, with 12% ensuring riparian areas are fully fenced and providing alternative water points (ABS 2010). In the lower reaches of the river, some clearing and weed infestations are evident.

Adjacent to the Calliope Crossing, a 48 hour campsite exists on the riverbank which is popular as a stop-over for tourists. This area suffered significant damage and erosion in the 2010-11 floods and is currently closed for rehabilitation.

9.6 Artificial Structures

Apart from the major developments in the lower sections of the river (chapters 9.2, 9.3, 9.4), the most prominent structure is an artificial causeway at the upper limits of the estuarine section, approximately 26km from the River's mouth (chapter 9.6.1). There are several boat ramps and access points obvious along the banks (Figures 9.5-9.7), most likely built for private access by landholders however this only constitutes a very small area of disturbance along the River's banks.

Figure 9.5: Example of artificial structure in the Calliope River study area - boat access point

Figure 9.6: Example of artificial structure in the Calliope River study area - boat access point

Figure 9.7: Example of artificial structure in the Calliope River study area - backyard boat access point

9.6.1 Calliope crossing

The Calliope crossing (23°57'39S, 151°9'18E) is a small bridge across Calliope River which was previously part of the Bruce Highway and is now closed to traffic. The land along the water's edge is a popular camping spot for travellers and locals. The structure of the bridge creates an artificial causeway (Figure 9.8) which delineates a distinctive barrier between estuarine and brackish waters. Large tides push water over this causeway and it does not provide a barrier to fish movement.

Brackish waters occur upstream of the causeway (Figures 9.9 and 9.10) then the waterway gradually narrows, turning to fresh approximately 6km upstream from the causeway. Throughout the brackish section, McKinnon et al. (1995) found 90% of mullet species and barramundi caught exceeded the legal size limit under the *Fisheries Act 1994*. Abundant fish activity in this area was obvious during field assessments.

Figure 9.8: Artificial causeway at the Calliope crossing

Figure 9.9: Brackish section upstream of the causeway at Calliope crossing

Figure 9.10: Double Creek at the upper limit of the study area

9.7 Future development proposals

On Curtis Island, 3.5km across the harbour from the mouth of Calliope River, three liquefied natural gas (LNG) plants are currently being constructed. At present these plants have no direct impact on the estuary, however a landing facility at the mouth of the river is proposed for a fourth LNG plant approved for Curtis Island. This project, known as the Arrow LNG plant, will have a nominal capacity of 16 million tonnes per annum (Mtpa) of LNG, with the potential of up to 18 Mtpa. Works at the tunnel launch site in Calliope River will disturb approximately 58ha of saltmarsh and require extensive ongoing dredging of the river mouth for both the construction and operation of the site, with disposal of the spoil planned for existing approved onshore and offshore disposal sites (Coffey Environments 2012). The Calliope River area of interest plan begins upstream of this proposal.

Other proposals in the area include the Yarwun Coal Terminal Project which will construct a stockyard on saltpans approximately 4km north of the Calliope River mouth and utilise two berths currently in construction as part of WICET. An extension to the Fisherman's Landing Port Facility, 6km north of Calliope River has been approved, which will develop infrastructure on reclaimed land, utilising dredge spoils as fill.

9.8 Conclusion

The primary land use for the Calliope catchment is grazing, which has had some impact on the riparian zone through clearing and weed infestations. Outside of the area of interest, toward the lower reaches of the river industrial developments have had an impact on the river system through clearing and reclamation of marine habitats.

The Calliope Crossing is the most significant barrier within the Calliope River study area, however it still allows for fish migration on certain tides. Minimal damage has occurred from landholder access to the waterways however FHA declaration would increase protection from the construction of unlawful structures along the riverbank.

Chapter 10 State and regional planning and management

Chapter summary

The Calliope River maintains a rich and diverse ecosystem that supports a range of important fisheries. Balancing these values with increasing development and industrial growth is a challenge facing state, regional and local planners. A range of planning mechanisms, including the State Planning Policy, the Gladstone Regional Council and Calliope Shire Planning Schemes, the Central Queensland Regional Plan and Gladstone State Development Area policies are in place to meet this challenge and assist in prioritising matters of state interest and significance to guide decision making processes.

10.1 Introduction

The Calliope River lies within the largest industrial region in Queensland and the Gladstone area is host to a wide range of industries that have a significant impact on the region and state's economy. Balancing a need for economic growth with the management of important environmental resources is a challenge for state, regional and local planners. Various planning and management policies and legislation are under development or in place to assist with the process of assessing developmental needs and guiding future growth decisions. The following provides a brief outline of some of these guidelines specific to the Gladstone area.

10.2.1 State Planning Policy

The State Planning Policy (SPP) came into effect on 2 December 2013. This new approach aims to clarify the planning policies previously in place by revoking multiple policies based upon social, economic, environmental and health priorities and replacing them with a consolidated and comprehensive 'one state' planning policy. The SPP outlines matters considered to be of state significance, which include coastal environments, water quality and biodiversity. Local government planning and assessment processes are required to reflect these state interests through appropriate consideration and protection of such things as:

- matters of national and state environmental significance (including declared FHAs)
- strategic offset areas
- protecting species and species habitat, ecosystems and ecosystem services and other natural values to the greatest extent practicable; and
- maintaining or enhancing ecological connectivity.

10.2.2 Coastal Management Plan

Released on 18th March 2014, the Coastal Management Plan (CMP) provides direction and guidance about the management of coastal land in Queensland to achieve the objectives of the *Coastal Protection and Management Act 1995*. The CMP applies to management planning, activities, decision and works that are not assessable development under the *Sustainable Planning Act 2009* and therefore not subject to the SPP. It is primarily aimed at local government who are responsible for managing areas of public coastal land and beaches however other specialist coastal managers will benefit from the policies and information contained within the plan. The plan provides guidance and direction to achieve the objectives of:

- providing for the protection, conservation, rehabilitation and management of the coastal zone, including its resources and biological diversity
- having regard to the goal, core objectives and guiding principles of the National Strategy for Ecologically Sustainable Development in the use of the coastal zone
- ensuring decisions about land use and development safeguard life and property from the threat of coastal hazards; and
- encouraging the enhancement of knowledge of coastal resources and the effect of human activities on the coastal zone.

10.2.3 Gladstone State Development Area

Located to the northwest of the Calliope River, encompassing areas of Yarwun, Targinnie, Aldoga and Curtis Island, is the Gladstone State Development Area (GSDA). The GSDA is a 29 000ha land bank established by the Queensland Government to secure and protect suitable land for large scale industrial development over a 30-50 year timeframe. Its proximity to a national highway, rail and a deep water port makes it ideal for industrial development (Figure 10.1).

Land use and infrastructure planning and development within the GSDA are controlled by a development scheme and supported by specific policies. Activities considered appropriate for the GSDA includes:

- large-scale, large-footprint industrial development
- industrial development requiring access to strategic port logistics and maritime facilities
- port-related activities and industries necessary to support major industrial development
- liquefied natural gas processing, storage and export facilities
- materials transportation infrastructure and utility and service infrastructure; and
- gas transportation infrastructure and other compatible infrastructure.

Approximately 4590ha of the GSDA has been set aside as an environmental management precinct. This area, on Curtis Island, was created to recognise, protect and maintain significant ecological, environmental and heritage areas in the southern part of the island.

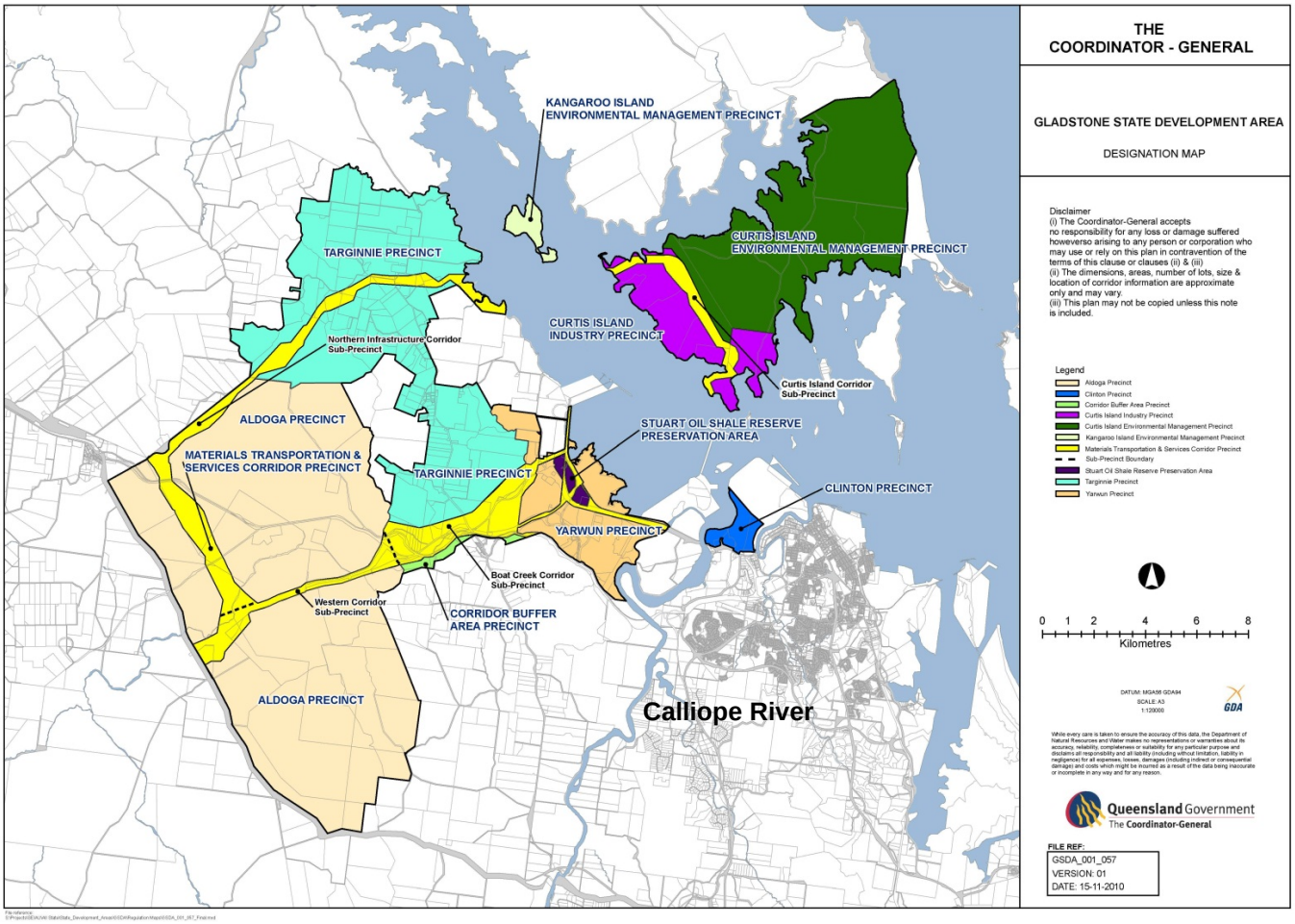


Figure 10.1: Gladstone State Development Area

10.2.4 Port management

There are a range of planning mechanisms in place to direct future expansion of the Port of Gladstone, including the Queensland Ports Strategy (DSDIP 2014), the Great Barrier Reef Ports Strategy (DSDIP 2012) and the GPC's 50 year strategic plan (GPC 2012).

The GBR Ports Strategy aims to balance building an efficient port network within Queensland to support economic growth, with the minimisation of environmental impacts to the GBR. It incorporates strategies such as restrictions to port development in and adjoining the GBR World Heritage Area to within port limits until 2022, rigorous analysis of port decisions and impacts to the GBR and environmental assessments of the cumulative impacts of port activities.

The Queensland Ports Strategy builds on the GBR Ports Strategy and is the Queensland Government's blueprint for managing the state's port network until 2024. Key actions in the strategy include the establishment of five Priority Port Development Areas (PPDAs) and introduction of a statutory guideline for port master planning. The five PPDAs are Gladstone, Brisbane, Abbott Point, Townsville and Hay Point and Mackay. The aim of focusing on five PPDAs is to restrict port development and prohibit capital dredging and expansion of additional port facilities outside of these areas (until 2024).

The GPC's 50 year strategic plan, first published in 1992 and updated in 2012, supports the management, development and operation of port facilities and services within the Port of Gladstone. Future expansion plans for the port do not include Calliope River, with the closest development planned being a fifth berth at R.G. Tanna Coal Terminal (chapter 9.4) and two additional berths alongside WICET (chapter 9.3).

10.2.5 Great Barrier Reef World Heritage Area

The GBRWHA encompasses an area of approximately 348,000km^2 from Baffle Creek (north of Bundaberg) to Cape York and is the world's most extensive coral reef system, with some of the richest biological diversity on Earth.

The Australian and Queensland Governments have a cooperative and integrated approach to managing the GBR. The Great Barrier Reef Marine Park Authority (GBRMPA) is the Australian Government entity responsible for the overall management of the GBR, and the Queensland Government's Department of National Parks, Recreation, Sport and Racing (NPRSR) oversees the day to day management. In inshore and intertidal areas, the Great Barrier Reef Coast Marine Park has been declared by the Queensland Government to complement the protection provided by the GBRMP. The marine parks are zoned to define activities that are allowed in each area and separate potentially conflicting activities.

Port Curtis and the Calliope River are within the GBRWHA but outside of the State and Commonwealth Marine Parks, so these areas are not subject to marine parks legislation. To the north of the Calliope River, the waterway separating Curtis Island from the mainland, known as The Narrows, is the closest component of the marine park system and zoned Habitat Protection under the Great Barrier Reef Coast Marine Park zoning plan. Habitat Protection Zones aim to manage and protect sensitive habitats through preventing potentially damaging activities such as trawling.

10.2.6 Port of Gladstone-Rodds Bay Dugong Protection Area

Port Curtis and the Calliope River are within the Port of Gladstone-Rodds Bay Dugong Protection Area (also referred to as the 'Rodds Bay Dugong Sanctuary'), a special management area declared as regulated waters under the Fisheries Regulation 2008 and recognised by both state and commonwealth marine park legislation (Figure 10.2). The declaration of Dugong Protection Areas provides a certain level of protection for dugongs (*Dugong dugon*) and is considered a key strategy to help recover declining dugong numbers in the GBR. Areas are selected by significant habitat and feeding grounds of dugong populations and aim to protect dugongs through managing fish netting activities.

The Calliope River study area is within a Zone B Dugong protection area. Netting is restricted by attendance requirements, mesh size and where and how nets may be deployed.

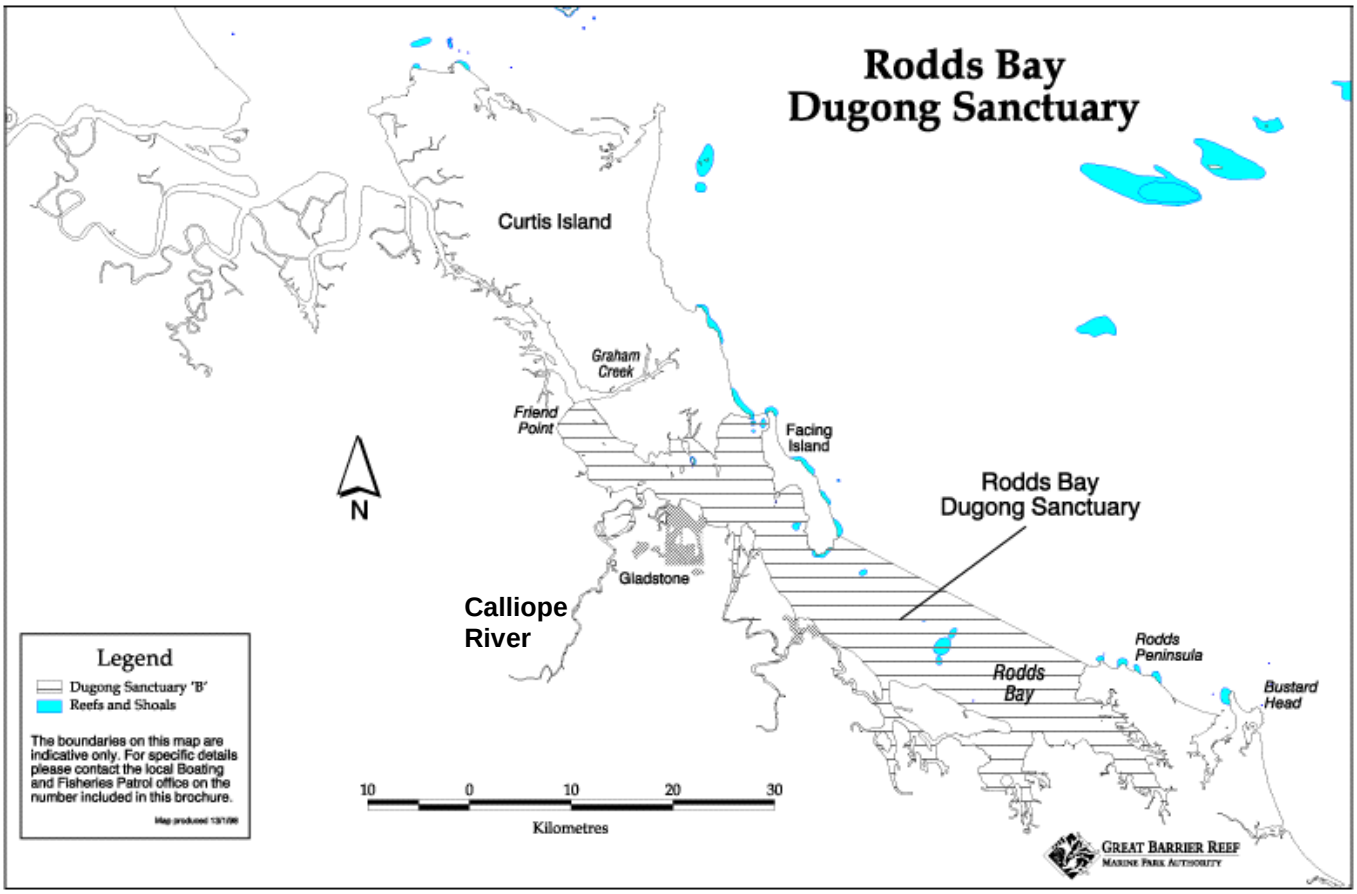


Figure 10.2: Port of Gladstone-Rodds Bay Dugong Protection Area (Source: GBRMPA)

10.2.7 Significant wetlands

DIWA is a cooperative project involving Australian, state and territory governments. First published in 1993, the Directory identifies nationally important wetlands and provides information on wetlands, their ecology and social and cultural values. It does not uphold any legislative jurisdiction.

To be considered nationally important, a wetland must meet at least one of the six criteria:

- biogeographic representativeness
- important ecological or hydrological functions
- provision of animal habitat during times of vulnerability or adverse conditions
- support for more than 1% of the national population of any taxa
- support for threatened taxa or communities
- historical or cultural significance.

The most recent edition of the Directory listed 904 nationally important wetland sites across the nation, covering an area of 57,904 254ha. Port Curtis and the Calliope River are listed under DIWA. The inclusion of this area is in recognition of its notable flora and fauna and cultural and socio-economic diversity and highlights the ecological significance of the area.

10.2.8 Declared Fish Habitat Areas

FHAs are declared under the *Fisheries Act 1994* and are fundamental to the protection of the state's critical fish habitats. The declared FHA network strategy recognises the reliance of many species on multiple habitats during their lives and that protecting these habitats and their interconnectivity plays a crucial role in supporting fisheries. Management of declared FHAs enables the protection of essential fish habitats from physical disturbance caused by development, whilst still allowing community access for such activities as boating and legal fishing.

Presently the nearest declared FHAs to Port Curtis are the Fitzroy River declared FHA and Colossuem Inlet declared FHA. Given Central Queensland's high fish productivity, economic and social reliance on the fishing industry and its close proximity to the GBRMP, there is a need to expand the network in this area. A previous proposal in 1997 to declare Calliope River as an FHA received strong community support however the Queensland

government made the decision not to progress with the declaration due to concerns at that time of incompatibility with future industrial development plans.

10.2.9 Regional and Local Government plans

Local Councils are required to prepare planning schemes under the *Sustainable Planning Act 2009*. Planning schemes assist the local government in assessing development applications and identifying future land uses through providing a detailed direction for the area, focusing on community planning whilst incorporating the needs of state and regional interests. Gladstone Regional Council is preparing a planning scheme but until it is finalised the planning schemes of the former Gladstone City, Calliope and Miriam Vale Shire Councils remain in effect. Both the Gladstone City and Calliope Shire Planning Schemes cover the study area. Although planning schemes enable local governments to manage land use within the region, the Gladstone area encompasses Strategic Port Land and the Gladstone State Development Area, so development may also be managed by the Gladstone Ports Corporation and Queensland's Coordinator-General.

To assist and provide guidance to Local Councils in their planning and policy making, the Central Queensland Regional Plan (CQRP), has been developed. The CQRP aims to effectively manage the high level of growth in the Central Queensland area, by incorporating the key state interest matters addressed in the SPP with a regional focus. The focus of the plan is to:

- protect the region's priority agricultural land uses from incompatible resource development by mapping priority agricultural areas and identifying assessment criteria that will apply to resource activities undertaken within these areas
- protect the future of towns in the region by mapping priority living areas and initiating legislative amendments that will allow local governments to determine whether or not resource activities can be located within a priority living area
- identify infrastructure opportunities for the region and
- provide regional direction in relation to other state interests.

The Gladstone Regional Council acknowledges the importance of maintaining the health of the Calliope River and its riparian communities and has incorporated the need to ensure the integrity of its waterways through protection from inappropriate land uses into its planning schemes (GRC 2012).

10.3 Conclusion

Despite the Gladstone region being host to extensive industrial production, the Calliope River has managed to retain much of its natural condition and diverse fish habitats. Appropriate planning and management of encroaching development proposals is a crucial factor in balancing the economic growth of the region with the environmental values and resources that are important to the local community. A range of planning mechanisms are in place to meet this challenge.

Chapter 11 Suitability of Calliope River for FHA declaration

Chapter summary

The Calliope River study area and area of interest meets all of the four fisheries criteria and the eight habitat criteria. It also satisfies the regionally unique feature criteria. Given the developments toward the mouth of the river, their ongoing maintenance and expansion requirements and the conflict this may cause with the management intentions of declared FHAs, the boundary for the Calliope River area of interest begins at the rail bridge, approximately 13km upstream of the river mouth. Although the minimum size criteria for declared FHAs outline suggested management levels, the lack of a waterway barrier and the uniqueness of the rocky structures and juvenile barramundi habitats within the Calliope River area of interest have the potential to outweigh this recommendation. It is therefore recommended the Calliope River area of interest is progressed to consultation with the view to declare it a management 'A' FHA.

11.1 Introduction

Fish Habitat Areas are declared under the *Fisheries Act 1994* and are fundamental to the protection of the state's essential fish habitats. The declared FHA concept recognises the complex and interrelated reliance of many species on multiple habitats during their lives and aims to protect these habitats and their interconnectivity by restricting development and physical alteration, whilst still allowing for public access and legal fishing activities. The overriding Government entity responsible for the declaration and management of FHAs, NPRSR, also recognises the importance of regional and State economic growth and the requirement for industrial development and expansion. To minimise possible conflicting resource management objectives, should the Calliope River proceed to public consultation with the view to declaring it an FHA, the Calliope River area of interest boundary excludes the section of study area downstream of the rail bridge (23°52'21"S, 151°11'24"E).

The FHA selection, assessment, declaration and review (NPRSR 2013) has been developed as a guideline and provides a set of criteria to determine an area's suitability for declaration as an FHA (Appendix G). This chapter provides the findings of this report in relation to the FHA selection criteria.

Although the FHA selection criteria is a vital component to the eventual declaration of an FHA, it is only the first step in the process. The long term integrity of declared FHAs is dependent upon community support and as such, candidate areas that are assessed as meeting the requirements of the FHA selection criteria are subject to extensive public consultation to gauge community and stakeholder support.

11.2 Assessment of Calliope River in relation to the declared FHA selection criteria

The aim of this Fisheries Resource Assessment is to assess the suitability of the Calliope River area of interest for declaration as an FHA. The findings from this report will be used to assess the Calliope River area of interest against each of the criteria (Appendix G) in a brief description below.

Fisheries Criteria

1. High fish species richness

The Calliope River Fisheries Resource Assessment (McKinnon et al. 1995) recorded 91 fish species in the Calliope River, which has been increased in subsequent literature to document 167 fish species. This compares favourably with the Fitzroy River as a regional benchmark, which has recorded 109 species (Long and McKinnon 2002). Given the proximity of the Fitzroy River to Calliope River, the freedom of movement of fish species and that full fish sampling was not completed by Long and McKinnon (2002), it is more likely however that similar species occur in both rivers.

- *The fish species richness of Calliope River is equivalent to other regional waterways (Chapter 3)* - **compatible with FHA.**

2. High diversity and abundance of regionally targeted fish species

The Calliope River study area supports a diverse and abundant range of species that are important to indigenous, recreational and commercial fisheries. Iconic species targeted include barramundi (*Lates calcarifer*) and mudcrab (*Scylla serrata*). Other economically important species targeted within and surrounding the Calliope River include mullet (*Mugilidae* - 7 spp.), salmon (*Polynemidae* - 2 spp.), flathead (*Platycephalidae* - 4 spp.), whiting (*Sillaginida*e - 3 spp.), mangrove jack (*Lutjanus argentimaculatus*) and penaeid prawns (*Penaeidae* - 5 spp.). Appendix B contains the full list of economically important fish species found in the Calliope River.

- *>15 regionally targeted species in high abundance (Chapters 3 & 4)* **- compatible with management 'A' area.**

3. Supports existing fisheries

The Calliope River has a direct impact on the local recreational and tourism economies through recreational fishing activities. It is a popular destination for recreational fishers and the entire length is utilised by anglers. It is particularly favoured by anglers due to accessibility without a vessel and the angling opportunities available. Many iconic species can be targeted in the Calliope River, such as mud crabs, mangrove jack and barramundi.

- *Major recreational fishery within the area (Chapter 4.5)* - **compatible with management 'A' area.**

4. Supports external/regional fisheries

Port Curtis is host to highly productive and valuable commercial and recreational fisheries. Although commercial effort has declined, coastal net, trawl and crab fisheries still occur, with the mud crab fishery the 6th largest in the state. The average commercial harvest in the Gladstone region was 438.12t between 2002 and 2011. Recreational fishing numbers are increasing in the Gladstone region, with an estimated 25% rise in the recreational fishing effort.

The Calliope River supports these fisheries through the provision of shelter, feeding, breeding and nursery sites at various lifecycle stages of fish species. 40% of all species sampled in the Calliope River were found to be of economic significance.

- *Major commercial and recreational fishing occurs adjoining the area and in adjacent offshore waters, targeting species that are directly linked to the area (Chapter 4, 5)* - **compatible with management 'A' area.**

Fish Habitat criteria

1. Large in size

The Calliope River area of interest covers approximately 408ha.

- *>100ha (Chapter 2)* - **compatible with management 'B' area.**

2. Diverse habitat types

There is an impressive representation of essential fish habitats in the Calliope River area of interest. It contains nine of the 14 habitat types outlined in the NPRSR FHA selection criteria (NPRSR 2013).

- *>7 habitat types represented (Chapter 5)* **- compatible with management 'A' area.**

3. Presence of a functioning riparian buffer zone

Although clearing for grazing and industrial development has impacted upon the riparian zone of the Calliope River, a narrow semi-continuous corridor remains. Throughout the Calliope River area of interest large portions of the riparian zone are relatively undisturbed.

- *>50% of the length of the riparian zone is adequately vegetated and functioning effectively (Chapter 6)* - **compatible with management 'B' area.**

4. Limited disturbance from artificial in-stream structures

Apart from the Calliope Crossing, there are very few in-stream structures along the waterway. The remaining structures are small scale, private access points for landholders.

- *Minimal disturbances from artificial structures >400m and <5% of the riverbank altered by artificial structures (Chapter 9)* - **compatible with management 'A' area.**

5. Good water quality

The water quality of the Calliope River has been monitored routinely since 1994. Available data shows the quality to be of a high standard and well within ANZECC guidelines.

- *Water quality is of a high standard and within ANZECC guidelines (Chapter 8)* - **compatible with FHA.**

6. Limited disturbance from, or ongoing reduction of impacts from, water impoundment structures

The Calliope River is unique in its lack of waterway barriers and one the few remaining rivers in the region with a near natural flow regime.

- *No water impoundment structures are present on the main stream or any major tributary of the main stream (Chapter 7)* - **compatible with FHA.**

7. Limited interaction with development of major significance to the state

The Wiggins Island Coal terminal, NRG power station and RG Tanna Coal terminals are of major significance to the State, all of which lie on the banks of the Calliope River mouth. Excluding this area from the area of interest plan minimises interaction and provides a buffer from these activities.

- *Any adjoining land developments of major significance to the state are in a location and can be appropriately buffered to ensure that they will have no existing or future impacts on the area (Chapter 9)* - **compatible with FHA.**

8. Compatible with adjacent land and aquatic planning

The land adjacent to the Calliope River area of interest is designated rural land with a small section of rural residential land and pockets of conservation, public use and forestry land. The local Council planning scheme recognises the importance of the Calliope River and its riparian vegetation to the ecology of the region and as a community resource and manages accordingly.

- *Adjacent land and aquatic planning compatible with intent of the strict management 'A' area (Chapter 9)* **- compatible with management 'A' area**

Regionally unique features

Presence of regionally unique natural fish habitat features

The Calliope River area of interest contains a diverse range of essential fish habitats that support an abundant range of fish species. It is regionally unique in that it does not contain any major water impoundments or fish way barriers. This is an important benefit to the fisheries of the region, allowing access to the full suite of available fish habitats (including the upstream large rocky outcrops) and contributing to genetic diversity.

The existence of juvenile barramundi habitats is a significant feature of the Calliope River and its adjoining fish habitats. These habitats are known to support a range of juvenile fish species important to the region's fisheries and it is important to maintain habitat accessibility and connectivity.

- *Contains one or more regionally unique features, e.g. habitat type, spawning ground, nursery location or habitat assemblage (Chapter 5)* - **compatible with FHA.**

11.3 Conclusion

The Calliope River is a significant waterway to the local and regional fisheries. It provides a suite of healthy, interconnected and productive habitats that support diverse and abundant fish species. The Calliope River area of interest contains unique features, satisfies all four fisheries criteria and the eight habitat criteria. It is timely that the Calliope River be afforded a level of protection given the social, economic and ecological values of the river, combined with Gladstone's considerable industrial expansion and the corresponding increased pressure on the river's habitat values.

The Calliope River area of interest clearly meets all requirements to be suitable for declaration as an FHA. In addition to the fisheries benefits of the lack of a waterway barrier, the large rock structures near the Bruce Highway bridge that act as a congregation area for fish and the juvenile barramundi habitats off stream provide regionally unique fish habitats. The presence of these unique features within the study area have the capacity to outweigh the management level suggested by the minimum size criteria as they provide essential fish habitat and warrant a high level of protection. Fish surveys to be conducted within the juvenile habitat areas are expected to confirm the quality and importance of these areas and inform the consultation process. It is therefore recommended that the Calliope River area of interest progress to the consultation process with the view to declaring it a management 'A' FHA.

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Appendix A: Species of Fishes, Crustaceans and Molluscs from the Calliope River

List source:

C and R Consulting 2005; Connolly et al. 2006; McKinnon et al. 1995; Wilson et al. 2012a; anecdotal evidence from fishing surveys conducted by Infofish Australia.

Family Species	Common Name
Fish	
Carcharhinidae (Requim Sharks)	
Carcharhinus obscurus	Black Whaler Shark
Carcharhinus leucas	Bull Shark
Rhizoprionodon acutus	White-eyed Shark
C. fitzroyensis	Creek Whaler Shark
Myliobatidae (Eagle Rays)	
Aetobatus narinari	White spotted eagle ray
Dasyatidae (Stingrays)	
Himantura uarnak	Long-tailed Ray
Dasyatis fluviorum	Brown Stingray
D. kuhlii	Bluespot Stingray
Gymnuridae (Butterfly Rays)	
Gymnura australis	Rat-tailed Ray
Rhinobatidae (Guitarfish)	
Aptychotrema rostrata	Eastern Shovelnose Ray
Chanidae (Milkfishes)	
Chanos chanos	Milkfish
Elopidae (Giant Herring)	
Elops hawaiensis	Giant Herring
Megalopidae (Tarpon)	
Megalops cyprinoides	Tarpon / Ox Eye Herring
Muraenesocidae (Pike Congers)	
Muraenesox cinereus	Pike Eel

Anguillidae (Freshwater Eels)

Anguilla reinhardtii	Long-finned Eel

Clupeidae (Herring)

Herklotsichthys castelnaui	Southern Herring
H. koningsbergeri	Spotted Herring
Nematalosa come	Hairback Herring
N. erebi	Bony Bream
Hyperolophus translucidus	Glassy Sprat

Engraulidae (Anchovies)

Stephorus sp.	Anchovy
Thryssa hamiltoni	Hamilton's Anchovy
T. setirostris	Longjaw Glassnose
T. aestuaria	Estuary Anchovy

Chirocentridae (Wolf Herrings)

Chirocentrus dorab	Wolf Herring

Ariidae (Sea Catfishes)

Arius graeffei	Blue Catfish
A. thalassina	Salmon Catfish

Belonidae (Longtoms)

Strongylura strongylura	Black Spot Longtom
Tylosurus crocodilus	Crocodile long-tom

Hemiramphidae (Garfishes or Halfbeaks)

Arrhamphus sclerolpis	Snub-nose Garfish
Hemirhamphus robustus	Three By Two Garfish
Hyporhamphus regularis	River Garfish
H. quoyi	Short-nosed garfish
H. australis	Sea garfish
Zenarchapterus biffonis	Buffon's River Garfish

Syngnathidae (Seahorses)

Sygnathidae sp. 1	Pipefish
Hippocampus sp. 1	Seahorse

Scorpaenidae (Scorpionfish)

Notesthes robusta	Bullrout
Scorpaenidae sp.	Scorpion Fish
Paracentropogon vespa	Spot fin Waspfish
Scorpaenopsis sp.	Scorpionfish

Platycephalidae (Flathead)

Platycephalus fuscus	Dusky Flathead
P. indicus	Bar-tailed flathead
Suggrundus sp.	Flathead
P. arenius	Sand flathead

Ambassidae (Glassperch)

Ambassis marianus	Estuary Perchlet
A. vachelli	Perchlet

Serranidae (Cods and Groupers)

Ephinephelus coioides	Estuary Cod
E. malabaricus	Malabar Cod
E. quoyanus	Longfin RockCod
E. lanceolatus	Queensland Groper
Cephalopholis cyanostigma	Blue Spotted Rock Cod

Terapontidae (Grunters)

Pelates quadrilineatus	Trumpeter
P. sexlineatus	Eastern Striped Grunter
Amniataba percoides	Barred Grunter
Terapon jarbua	Crescent perch

Apogonidae (Cardinalfishes)

Siphamia roseigaster	Pinkbreast Siphonfish
Ostorhinchus fasciatus	Striped Cardinalfish
Apogon sp. 1	Cardinalfish

Ephippidae (Spadefish)

Zabidius nevemaculeatus	Short-Finned Batfish

Haemulidae (Grunts)

Pomadasys argenteus	Small spotted Javelin fish
P. kaakan	Spotted Javelin fish
Plectorhynchus gibbosus	Brown Morwong
Diagramma pictum	Painted Sweetlip

Centropomidae (Sea Perches)

Lates calcarifer	Barramundi

Rachycentridae (Cobia)

Rachycentron canadum	Cobia

Lutjanidae (Tropical snappers)

Lutjanus argentimaculatus	Mangrove Jack
L. johni	Golden Snapper
L. russelli	Moses Snapper

Sparidae (Porgies)

Acanthopagrus australis	Yellowfin Bream
A. berda	Black/Pikey Bream
Acanthopagrus sp. 2	Bream
Lethrinus laticaudis	Grass Emporer

Nemipteridae (Threadfin Breams)

Nemipterus theodorei	Yellow-lip butterfly Bream
Pentapodus paradiseus	Blue-faced whiptail

Monodactylidae (Moonyfishes)

Monodactylus argenteus	Diamond Fish

Leptobramidae (Beach salmon)

Leptobrama muelleri	Beach salmon

Gerreidae (Mojarras)

Gerres subfasciatus	Silver Biddy
G. filamentosus	Threadfin Silver-belly
G. oyena	Common silver-biddy

Drepanidae (Sicklefish)

Drepane punctata	Spotted Sickle Fish

Sillaginidae (Whiting)

Sillago analis	Golden-lined Whiting
S. maculata	Winter Whiting
S. ciliata	Sand Whiting

Sciaenidae (Drums or Croakers)

Argyrosomus japonicus	Jewfish/Mulloway
Protonibea diacanthus	Black jewfish

Chaetodontidae (Butterfly fishes)

Scatophagus argus	Spotted Scat
Selenotoca multifasciata	Butter-fish
Chaetodon tricinctus	Three-band coralfish
Parachaetodon ocellatus	Ocellate coralfish

Leiognathidae (Ponyfishes)

Leiognathus equulus	Common Ponyfish
L. sp.	Ponyfish
L. sp.	Ponyfish

Carangidae (Jacks and Trevallys)

Alectis indica	Diamond Trevally
Caranx melampygus	Spotted Trevally
Gnathanodon speciosus	Golden Trevally
Caranx ignobilis	Giant Trevally
Parastromateus niger	Black Pomfret
Scomberoides commersonianus	Giant Leatherskin Queenfish
Megalaspis cordyla	Finny Scad
Selaroides leptolepis	Smooth-tailed Trevally
Pentolabus radiatus	Fringe-finned Trevally
Carangoides caeruleopinnatus	Onion-ring Trevally
Ulua mentalis	Cale Trevally

Paralichthyidae (Sand Flounders)

Pseudorhombus arsius	Large-toothed flounder
Pseudorhombus argent	Flounder

Mugilidae (Mullet)

Liza subviridis	Greenback mullet
L. argentea	Flat-tail Mullet
L. vaigiensis	Diamond scale Mullet
Mugil cephalus	Sea Mullet
Paramugil georgii	Fantail Mullet
Myxus elongatus	Sand Mullet
Valamugil seheli	Blue-tailed Mullet

Polynemidae (Threadfin Salmon)

Eleutheronerna tetradactylum	Blue Threadfin Salmon
Polydactylus sheridani	King Salmon
Polydactylus macrochir	King Threadfin Salmon

Sphyraenidae (Barracudas)

Sphyraena barracuda	Great Barracuda
S. jello	Pickhandle Barracuda

Synodontidae (Lizardfishes)

Saurida undosquamis	Large-scaled grinner

Gobiidae (Gobies)

Arenigobius frenatus	Goby
Glossogobius biocellatus	Sleepy Goby
Leme sp.	Burrowing Goby
Periopthalmus koelreuteri	Mud-skipper
Goby species	Juvenile too small to identify species

Diodontidae (Porcupine fishes or Burfishes)

Diodon nichthemerus	Porcupine fish

Atherinidae (Silversides or hardyheads)

Atherinomorus vaigiensis	Common Hardyhead

Lapridae (Wrasses)

Choerodon cephalotes	Purple tuskfish

Gerreidae (Silver biddies)

Gerres subfasciatus	Common Silverbiddy

Siganidae (Rabbitfishes)

Siganus guttatus	Golden-lined Spinefoot
Siganus rivulatus	Happy Moments/Marbled Spinefoot

Scombridae (Mackerels, Tuna, Bonitos)

Scomberomorus semifasciatus	Broad-barred Mackerel
S. queenslandicus	School mackerel
Auxis thazard	Frigate mackerel

Soleidae (Sole)

Phylichthys sclerolepsis	Sharp-headed Sole
Achlyopa nigra	Black Sole

Mullidae (Goatfishes)

Upeneus tragula	Bar-tailed Goatfish

Monacanthidae (Filefishes, Leatherjackets)

Paramonacanthus sp.	Filefish
Meuschenia sp. 1	Leatherjacket
Meuschenia sp. 2	Leatherjacket
Meuschenia sp. 3	Leatherjacket
Meuschenia sp. 4	Leatherjacket

Triacanthodidae (Triplespines)

Tripodichthys angustifrons	Yellow-fin Tripod fish
Triacanthus biaculeatus	Short-nosed Tripod-fish

Tetraodontidae (Toadfishes, puffers)

Marilyna pleurostictus	Banded Toadfish
Chelonodon patoca	Milk-spotted Puffer
Torquigener sp.	Toadfish
Tetractenos hamiltoni	Common Toadfish
Arothron manilensis	Narrow-lined Toadfish

Synanceiidae (Ray-finned fish)

Synanceia horrida	Estuarine stonefish

Scatophagidae (Scat fishes)

Selenotoca multifasciata	Striped Butterfish

Amblyopidae (Cavefishes and Swampfishes)

Brachyamblyopus sp.	Worm Goby

Echeneididae (Suckerfishes)

Remora remora	Remora Suckerfish

Crustaceans

Penaeidae (Penaeid Prawns)

Melicertus plebejus	Eastern King Prawn
Fenneropenaeus merguiensis	Banana Prawn
Metapenaeus ensis	Greasyback Prawn
M. bennettae	Bay Prawn
Trachypenaeus fulvus	Hardback Prawn

Sergestidae (Prawns)

Acetes sp.	Shrimp

Alpheidae (Snapping Shrimps)

Apheus sp.	Clicker Prawn

Palaemonidae (Shrimps)

Macrobrachium sp.	Machrobrachium

Squillidae (Mantis Shrimps)

Squilla sp.	Mantis Shrimp

Callianassidae (Ghost Shrimps)

Trypaea australiensis	Yabby

Portunidae (Crabs)

Portunus pelagicus	Blue Swimmer Crab
Scylla serrata	Mud Crab

Molluscs

Sepiolidae (Bobtail Squids)

Euprymna sp.	Mickey Mouse Squid
Idiosepius sp.	Seagrass Squid

Loliginidae (Pencil Squids)

Loliolus sp.	Bay Squid

Batillariidae (Mudcreepers)

Telescopium telescopium	Mud Whelks

Appendix B: Economically important species identified in the Calliope River

Source: McKinnon et al. 1995; Grant 1999, DAFF 2013a.

Species	Common Name
Lates calcarifer	Barramundi
Leptobrama muelleri	Beach salmon
Aptychotrema rostrata	Easter shovel nosed ray
Lutjanidae 3 spp.	Tropical snappers
Polynemidae 3 spp.	Threadfin salmons
Mugilidae - 7spp.	Mullet
Scombridae 3 spp.	Mackerel
Scomberoides commersonianus	Giant leatherskin queenfish
Selenotoca multifasciata	Butterfish
Anguilla reinhardtii	Long-finned eel
Argyrosomus japonicus	Jewfish/Mulloway
Protonibea diacanthus	Black jewfish
Sillaginidae 3 spp.	Whiting
Rachycentron canadum	Cobia
Carangidae 4 spp.	Trevally
Haemulidae 4 spp.	Javelin fish
Platycephalidae 4 spp.	Flathead
Zenarchapterus biffonis	Buffon's garfish
Strongylura strongylura	Black spot iongtom
Monodactylus argenteus	Diamond fish
Ariidae 2 spp.	Catfish
Megalops cyprinoides	Oxeye herring
Chirocentrus dorab	Wolf Herring
Strongylura strongylura	Black spot longtom
Choerodon cephalotes	Purple tuskfish
Aetobatus narinari	White spotted eagle ray
Serranidae 5 spp.	Gropers and cods

Sparidae 4 spp.	Breams
Scatophagus argus	Spotted scat
Drepane punctata	Spotted sickle fish
Hemiramphidae 6 spp.	Garfish
Portunus pelagicus	Blue swimmer crab
Scylla serrata	Mud crab
Panaeidae 5 spp.	Prawns

Appendix C: Introduced marine species identified in Port Curtis

Source: Lewis et al. 2001

Name	Distribution
Botrylloides leachi	Auckland Point; South Trees Wharf
Styela plicata	Wharf pylons throughout Port Curtis
Amathia distans	Wharf pylons throughout Port Curtis
Bugula neritina	Gladstone marina, Wharf pylons throughout Port Curtis
Cryptosula pallasiana	Wharf pylons throughout Port Curtis
Watersipora subtorquata/acuata	Wharf pylons throughout Port Curtis
Zoobotryon verticillatum	Gladstone marina; Wharf pylons throughout Port Curtis
Obelia longissima	Wharf pylons throughout Port Curtis
Paracerceis sculpta	South Trees Wharf
Alexandrium sp.	Auckland Point; Channel marker S19

Appendix D: Catch and effort for the Gladstone commercial net fishery (Grid S30)

(most targeted species 2002 - 2011) (Data sourced from DAFF 2013d)

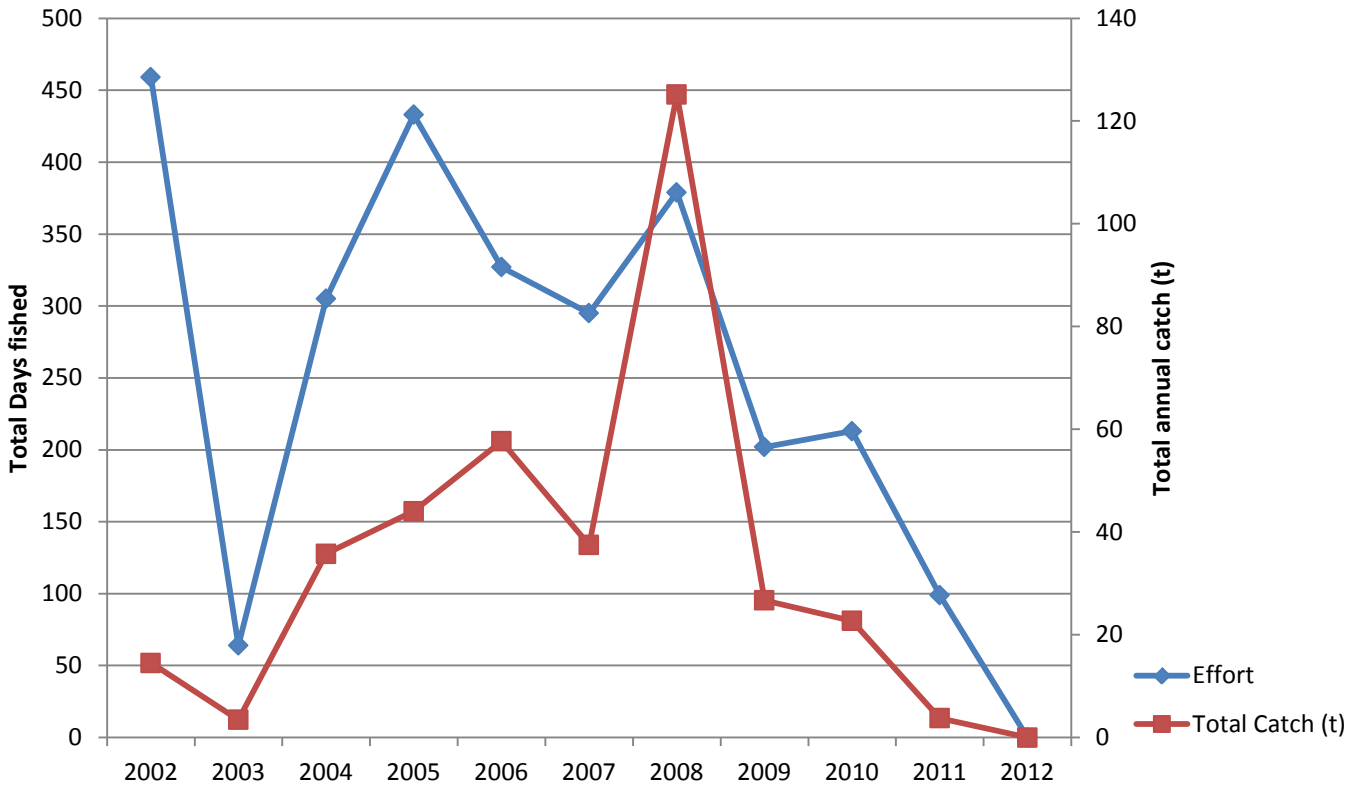

Figure C1: Catch and effort for threadfin salmon in Gladstone's commercial net fishery 2002-12 (Grid S30)

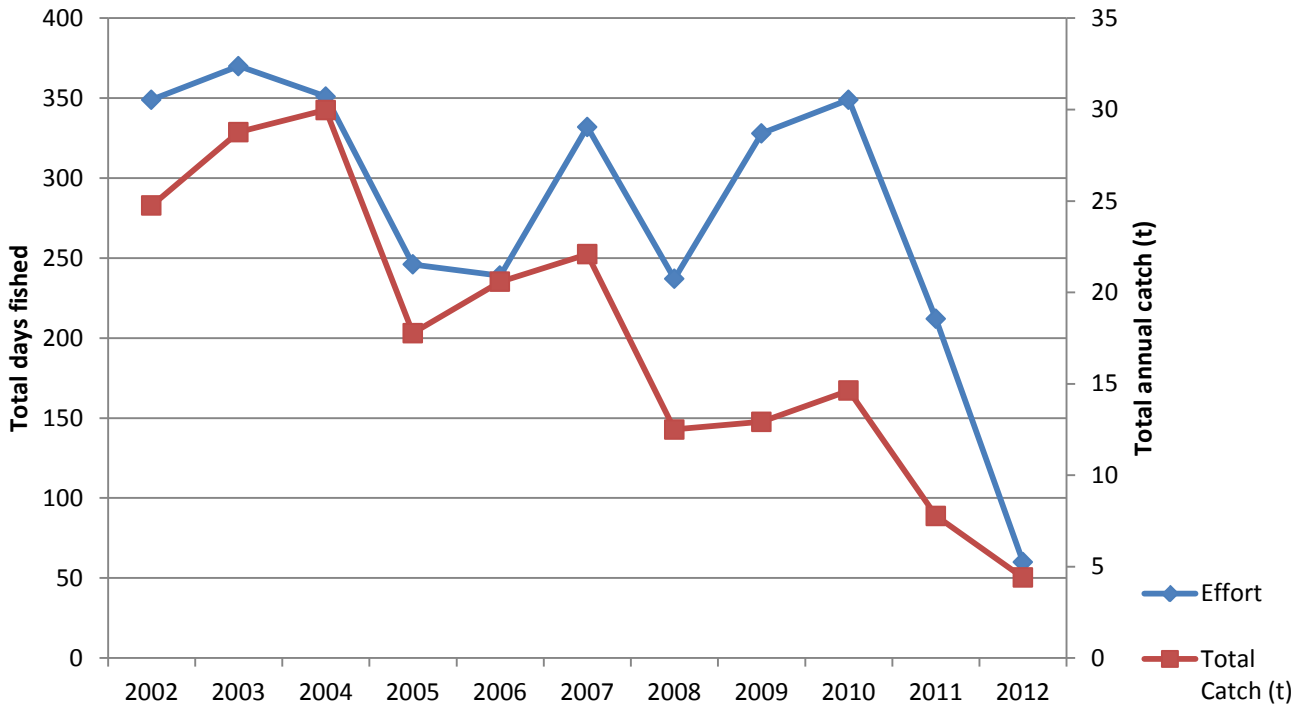

Figure C2: Catch and effort for mullet in Gladstone's commercial net fishery 2002-12 (Grid S30)

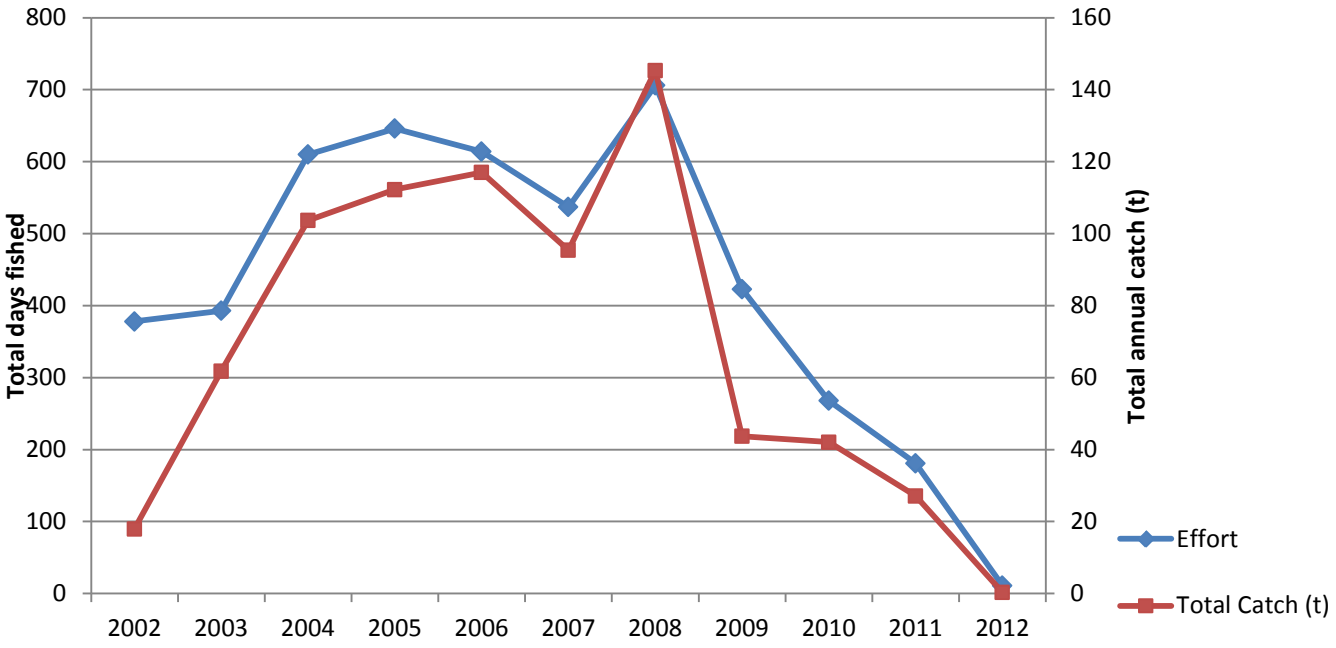

Figure C3: Catch and effort for shark species in Gladstone's commercial net fishery 2002-12 (Grid S30). (Note: shark catch for 2011 showed a similar pattern to previous years in both catch and effort until July, after which there was no fishing for shark recorded (DAFF 2012)

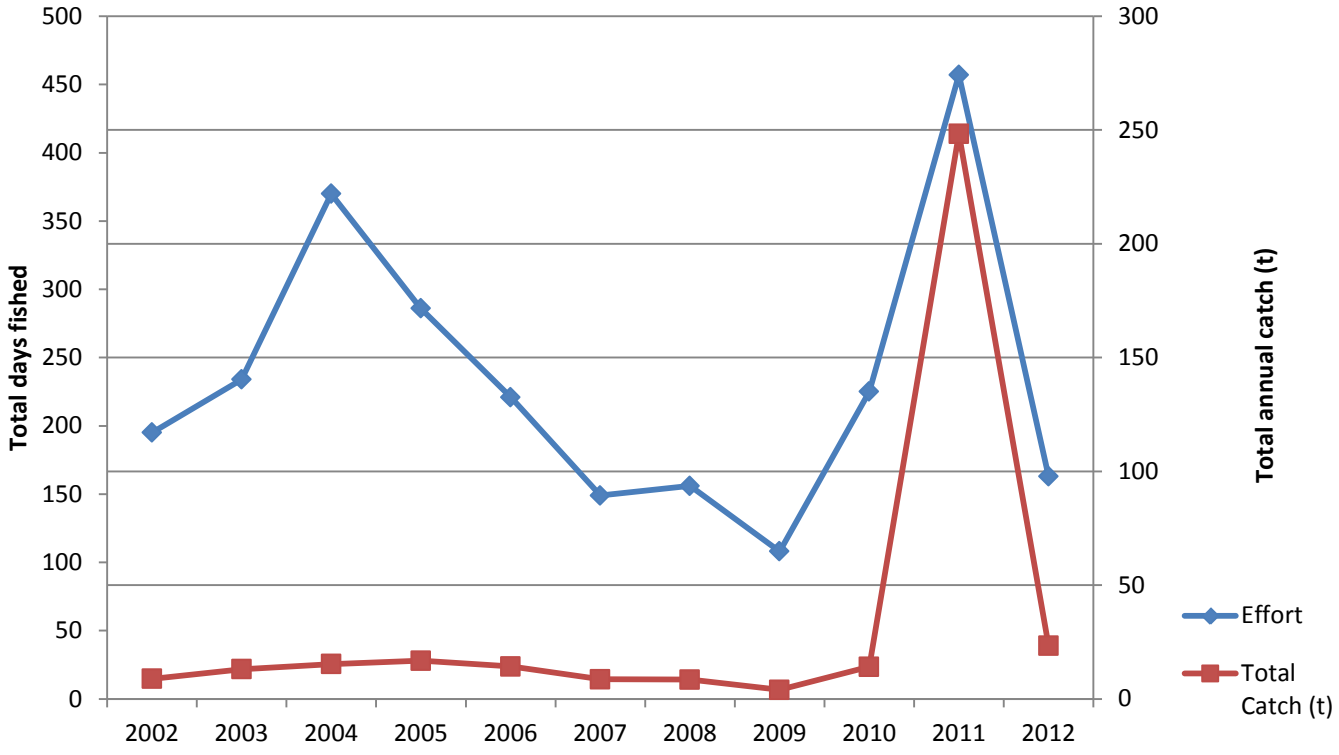

Figure C4: Catch and effort for barramundi in Gladstone's commercial net fishery 2002-12 (Grid S30)

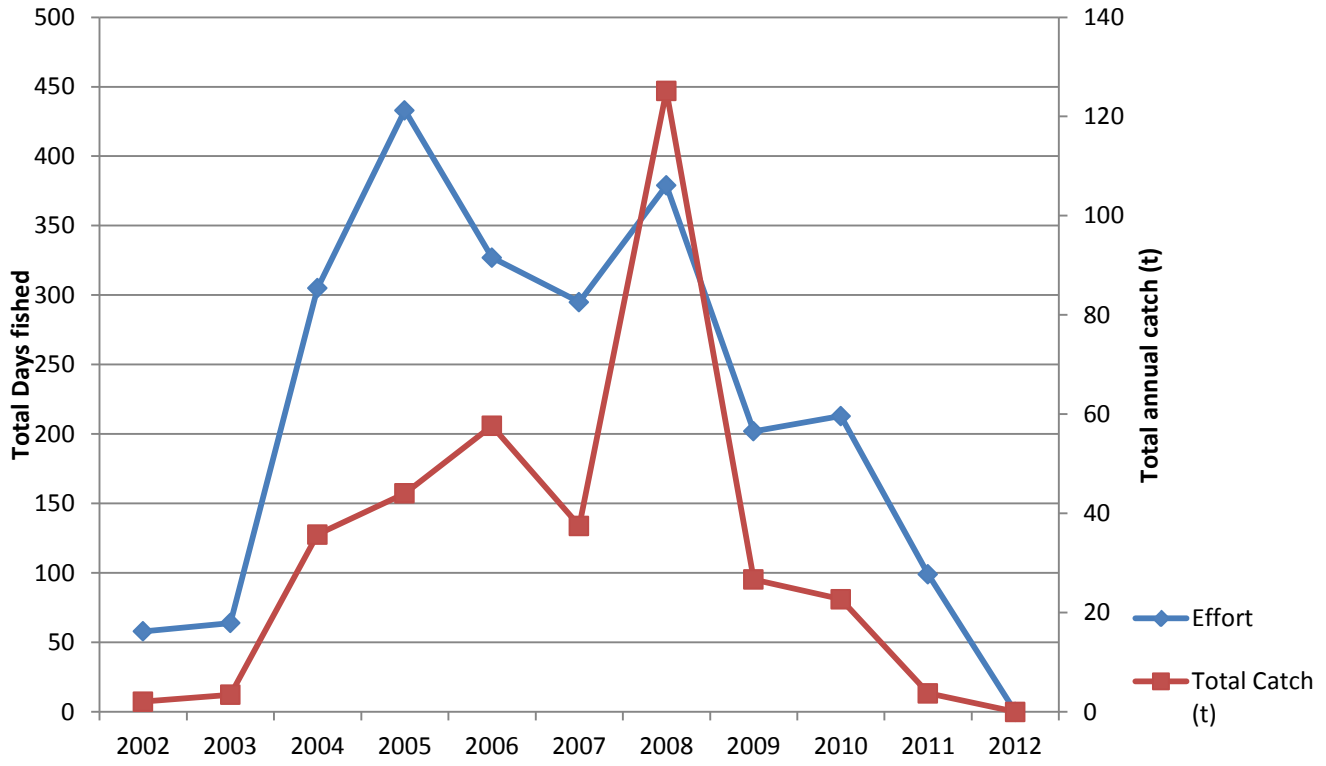

Figure C5: Catch and effort for mackerel species in Gladstone's commercial net fishery 2002-12 (Grid S30)
Note: No catch was recorded for 2012, possibly due to fishers targeting barramundi (DAFF 2012)

Appendix E: Mangrove species of the Calliope River

Source: McKinnon et al. 1995.

Scientific Name	Common Name
Aegialitis annulata	Club mangrove
Aegiceras corniculatum	River mangrove
Osbornia octodonta	Myrtle mangrove
Excoercaria agallocha	Milky mangrove
Lumnitzera racemosa	Black mangrove
Rhizophora stylosa	Red mangrove
Avicennia marina	Grey mangrove
Xylocarpus mekongensis	Cedar mangrove
Ceriops tegal	Yellow mangrove
Acanthus ilicifolius	Holly leaf mangrove
Acrostichum speciosum	Mangrove fern

Appendix F: Regional eco-systems for the Calliope River catchment.

Source: DEHP 2012

Regional eco-system	Description	*Vegetation Management Act 1999* status
11.1.1	Sporobolus virginicus grassland on marine clay plains	Not of concern
11.1.2	Samphire forbland on marine clay plains	Not of concern
11.1.4	Mangrove forest/woodland on marine clay plains	Not of concern
11.2.3	Microphyll vine forest (beach scrub) on sandy beach ridges	Of concern
11.3.2	Eucalyptus populnea woodland on alluvial plains	Of concern
11.3.4	Eucalyptus tereticornis and/or Eucalyptus spp. Tall woodland on alluvial plains	Of concern
11.3.11	Semi-evergreen vine thicket on alluvial plains	Endangered
11.3.25	Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines	Of concern
11.3.26	Eucalyptus moluccana or E. microcarpa woodland to open forest on margins of alluvial plains	Not of concern
11.3.27	Freshwater wetlands	Of concern
11.3.29	Eucalyptus crebra, E. exserta, Melaleuca spp. Woodland on alluvial plains	Not of concern
11.5.2	Eucalyptus crebra, Corymbia spp., with E. moluccana on lower slopes of Cainozoic sand plains/remnant surfaces	Not of concern
11.5.8	Melaleuca spp., Eucalyptus crebra, Corymbia intermedia woodland on Cainozoic sand plains/remnant surfaces	Not of concern
11.5.9	Eucalyptus crebra and other Eucalyptus spp. And Corymbia spp. woodland on Cainozoic sand plains/remnant surfaces. Plateaus and broad crests.	Not of concern
11.7.6	Corymbia citriodora or Eucalyptus crebra woodland on lateritic duricrust	Not of concern
11.8.3	Semi-evergreen vine thicket on Cainozoic igneous rocks. Steep hillsides	Of concern
11.8.4	Eucalyptus melanophloia woodland on Cainozoic igneous rocks. Hillsides	Not of concern
11.10.1	Corymbia citriodora open forest on	Not of concern

	coarse grained sedimentary rocks.	
11.11.3	Corymbia citriodora, Eucalyptus crebra, E. acmenoides open forest on old sedimentary rocks with varying degrees of metamorphism and folding. Coastal ranges	Not of concern
11.11.4	Eucalyptus crebra woodland on old sedimentary with varying degrees of metamorphism and folding. Coastal ranges	Not of concern
11.11.5	Microphyll vine forests +/- Araucaria cunninghamii on old sedimentary rocks with varying degrees of metamorphism and folding	Not of concern
11.11.10	Eucalyptus melanophloia woodland on deformed and metamorphosed sediments and interbedded volcanics	Of concern
11.11.14	Acacia harpophylla open forest on deformed and metamorphosed sediments and interbedded volcanics	Endangered
11.11.15	Eucalyptus crebra woodland on deformed and metamorphosed sediments and interbedded volcanics. Undulating plains	Not of concern
11.11.18	Semi-evergreen vine thicket on old sedimentary rocks with varying degrees of metamorphism and folding. Lowlands	Endangered
11.12.1	Eucalytpus crebra woodland in igneous rocks	Not of concern
11.12.2	Eucalyptus melanophloia woodland on igneous rocks	Not of concern
11.12.3	Eucalyptus crebra, E. tereticornis, Angophora leiocarpa woodland on igneous rocks, especially granite	Of concern
11.12.4	Semi-evergreen vine thicket and microphyll vine forest on igneous rocks	Not of concern
11.12.6	Corymbia citriodora open forest on igneous rocks (granite)	Not of concern
11.12.14	Lophostemon spp. Woodland on igneous rocks	Of concern
11.12.15	Allocasuarina torulosa, Livinstona drudei woodland in igneous rocks. Coastal hills	Of concern
11.12.17	Eucalyptus populnea woodland on igneous rocks. Colluvial lower slopes	Endangered
11.12.18	Montane shrubland on igneous rocks. Mountain tops	Of concern
12.1.2	Saltpan vegetation including grassland	Not of concern

	and herbland on marine clay plains	
12.1.3	Mangrove shrubland to low closed forest in marine clay plains and estuaries	Not of concern
12.3.1	Gallery rainforest (notophyll vine forest) on alluvial plains	Endangered
12.3.3	Eucalyptus tereticornis woodland to open forest on alluvial plains	Endangered
12.3.7	Eucalyptus tereticornis, Callistemon viminalis, Casuarina cunninghamiana fringing forest	Not of concern
12.3.12	Eucalyptus latisinensis or E. exserta, Melaleuca viridiflora on alluvial plains	Of concern
12.5.1	Open forest complex with Corymbia citriodora on subcoastal remnant Tertiary surfaces. Usually red soils	Not of concern
12.11.4	Semi-evergreen vine thicket on metamorphics +/- interbedded volcanics	Of concern
12.11.6	Corymbia citriodora, Eucalyptus crebra open forest on metamorphics +/- interbedded volcanics	Not of concern
12.11.7	Eucalyptus crebra woodland on metamorphics +/- interbedded volcanics	Not of concern
12.11.9	Eucalyptus tereticornis open forest on metamorphics +/- interbedded volcanics. Usually higher altitudes	Of concern
12.11.12	Aruacarian complex microphyll vine forest on metamorphics +/- interbedded volcanics; usually northern half of bioregion	Of concern
12.11.14	Eucalyptus crebra, E. tereticornis woodland on metamorphics +/- interbedded volcanics	Of concern
12.11.17	Eucalyptus acmenoides or E. portuensis open forest on metamorphics +/- interbedded volcanics	Of concern
12.11.18	Eucalyptus moluccana open forest on metamorphics +/- interbedded volcanics	Not of concern
12.12.5	Corymbia citriodora, Eucalyptus crebra open forest on Mesozoic to Proterozoic igneous rocks	Not of concern
12.12.7	Eucalyptus crebra woodland on Mesozoic to Proterozoic igneous rocks	Not of concern
12.12.20	Corymbia intermedia, Lophostemon suaveolens woodland on metamorphics +/- interbedded volcanics	Of concern

Appendix G: Declared Fish Habitat Area assessment criteria

(NPRSR 2013)

Fisheries criteria	**Compatible with management 'B' area**	**Compatible with management 'A' area**
High fish species richness	Fish species richness similar to that of comparable regional 'benchmark' waterways.	
High diversity and abundance of regionally targeted fish species (adult or juvenile)	>10 regionally targeted fish species highly abundant.	> 15 regionally targeted fish species highly abundant.
Supports existing fisheries	Regular use of area by commercial, recreational or traditional fishers.	Major commercial and/or recreational and/or traditional fishery within area.
Supports external / regional fisheries	Commercial, recreational or traditional fishing occurs adjoining the area or in adjacent offshore waters, targeting species that are directly linked to the area.	Major commercial, recreational or traditional fisheries occurs adjoining the area or in adjacent offshore waters, targeting species that are directly linked to the area.

Fish habitat criteria	**Compatible with management 'B' area**	**Compatible with management 'A' area**
Large in size	> 100 ha	> 500 ha
Diverse habitat types	> 4 habitat types represented	> 7 habitat types represented
Presence of a functioning riparian buffer zone	> 50% of the length of the riparian zone is adequately vegetated and functioning effectively.	> 80% of the length of the riparian zone is adequately vegetated and functioning effectively.
Limited disturbance from artificial in-stream structures	Minimal disturbance from artificial structures (e.g. jetties, boat ramps, revetments). Average separation between structures 100 – 400 m and / or < 5% of the riverbank altered by artificial structures.	Nil to minimal disturbances from artificial structures (e.g. jetties, boat ramps, revetments). Average separation between structures > 400 m and / or < 5% of the riverbank altered by artificial structures.
Good water quality	Water quality standard meets the Queensland Water Quality Guidelines (DERM 2009) or water quality objectives under the Environmental Protection (Water) Policy 2009 where applicable, for the protection of aquatic ecosystems; or Documented water quality improvement program is in place to enable the area to meet the Queensland Water Quality Guideline or water quality objectives within five years or less.	

Limited disturbance from, or ongoing reduction of impacts from, water impoundment structures	1. No water impoundment structures are present on the main stream and any major tributary of the main stream; or 2. The main stream and any major tributaries of the main stream only have water impoundment structures that: allow for > 75% of flows to overtop the structure or are managed to release adequate (from a fisheries perspective) environmental flows; and drown out regularly enough to allow for adequate fish passage or have a functional fishway; or 3. Fish passage and environmental flows in the main stream and any major tributaries will be maintained and a proposed program of water management activities will ensure a net improvement in fish passage and / or environmental flows within a 10 year timeframe.	
Limited interaction with developments of major significance to the state	No developments of major significance to the state are present within or adjoining the area; or Any adjoining developments of major significance to the state are in a location and can be appropriately buffered to ensure that they will have no existing or future impacts on the area.	
Compatible adjacent land and aquatic planning	Adjacent land and aquatic planning compatible with intent of management B area.	Adjacent land and aquatic planning compatible with intent of the strict management A area.
	No reduction in habitat values through inappropriate public or a proliferation of private structures or impacts from development.	

Regionally unique features	**Compatible with management 'B' area**	**Compatible with management 'A' area**
Presence of regionally unique natural fish habitat features	Contains one or more regionally unique features, e.g. habitat type, spawning ground, nursery location or habitat assemblage.	