Synthesis of Water Quality influences in ports of the Fitzroy region, Queensland

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Nicole Flint, Emma Jackson, Scott Wilson, Krista Verlis and John Rolfe

School of Medical and Applied Sciences, and School of Business and Law

CQUniversity Australia

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For further information contact:

Dr Nicole Flint
School of Medical and Applied Sciences
CQUniversity Australia
North Rockhampton Campus
Email: n.flint@cqu.edu.au
Phone: +61 7 4923 2128

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Fitzroy Basin Association Incorporated
PO Box 139, Rockhampton QLD 4700
Phone: (07) 4999 2800 | Fax: (07) 4921 2860

www.fba.org.au

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Fitzroy Basin Association Incorporated
PO Box 139, Rockhampton QLD 4700
Phone: (07) 4999 2800 | Fax: (07) 4921 2860

Executive summary

Australia is dependent on its port facilities for international trade. There are 20 ports in Queensland alone, two of which are within the Fitzroy Basin region. Water quality in ports is influenced by a wide variety of factors, some of which are unique to shipping and port operations. This synthesis report focuses on issues relating to water quality in the two Fitzroy region ports — the Port of Gladstone and the Port of Rockhampton, both managed by Gladstone Ports Corporation (GPC) — as part of the Water Quality Improvement Plan being developed by the Fitzroy Basin Association (FBA) for the Fitzroy and coastal catchments, through funding from the Australian Government Reef Programme.

Both of the Fitzroy region's ports are located in river estuaries, and the Port of Gladstone is also co-located with a regional city and a large industrial sector. The Port of Rockhampton is located in the delta of the Fitzroy River, which drains the largest river basin draining into the Great Barrier Reef (GBR) lagoon. Management, monitoring and assessment of water quality issues therefore has to occur in a framework where the multiple impacts on water quality of catchment, urban and industrial footprints interact with impacts from shipping and port operations.

The purpose of this study is to summarise the factors that influence water quality at the two ports and to synthesise the processes used to monitor and manage these influences. The study provides a summary of the port maintenance and industrial activities at both ports, identifies and gathers together data on the variety of factors that could potentially influence water quality in the ports, describes current water quality monitoring and reporting, and summarises the management and legislative structures around port water quality. It also provides an analysis of research and knowledge gaps in the Port of Gladstone and the Port of Rockhampton, developed with input from representatives of GPC.

Water quality in the Port of Gladstone and Port of Rockhampton may be influenced by a range of factors including:

- Catchment sources: agricultural and industrial run-off
- Urban sources: stormwater run-off and coastal development
- Shipping: ship movements, dumping of rubbish, discharge of ballast water and anti-fouling chemicals
- Ports activities: maintenance and capital dredging and wharf/loading facilities
- Discharge from port-side industries: managed emissions and incidents
- Ocean sources: marine debris, and
- Marine industries and recreation: commercial fishing, recreational fishing and boating, and shore-based recreation.

There are also processes outside of the Fitzroy Water Quality Improvement Plan's scope that influence water quality, including impacts of climate change such as ocean acidification, sea temperature rise, and the likelihood of increased frequency and intensity of tropical storms, storm surges and overland floods. These are issues that will require inter-governmental action.

Given its importance as one of the largest coal export terminals in Australia, and its proximity to the world heritage-listed GBR, the Port of Gladstone is one of the most intensively monitored and studied marine areas in Queensland. The Port Curtis Integrated Monitoring Program Inc. (PCIMP) has been conducting water quality monitoring in the port of Gladstone for almost 10 years. Monitoring in the Port of Rockhampton is much less comprehensive as it has been far less developed than the Port of Gladstone. Public reporting on marine environmental health is carried out in the proximity of both ports, by the Gladstone Healthy Harbour Partnership (GHHP; Gladstone Harbour) and the Fitzroy Partnership for River Health (FPRH; Fitzroy estuary) and also Reef Plan (for the wider Great Barrier Reef).

Water quality management in the ports is primarily the responsibility of the Queensland Government, but all levels of government have some influence and responsibility for aspects of water quality and factors influencing it, and some aspects are also subject to international agreements.

Despite these efforts, there remain some gaps in knowledge, including in terms of the relative contributions of the various sources (and potential sources) of water quality issues. Partly this is influenced by a mismatch between monitoring the state of the environment at different scales, and monitoring the change in drivers or pressures producing the change in state. These knowledge gaps make it difficult to predict the efficacy of proposed management actions aimed at ameliorating water quality concerns. There is also a lack of pre-industrial baseline water quality data for the Port of Gladstone; gaps in understanding of the impacts of sea and land disposal of dredge spoil; and a need for better understanding of how the impacts of climate change will affect resilience of the marine ecosystems within and around the ports.

Process gaps were identified in terms of cooperative research and data sharing amongst interest groups, particularly in the Port of Gladstone, which is of interest to a wider variety of agencies and organisations. Efficiency of monitoring and analysis of water quality and estuarine environments in the ports could be improved by the development of clearer communication channels or regular forums. This report provides a synthesis of existing data and it is hoped that this information might help to frame that communication, and direct research activities, in advance of discussions around a future Ports Water Quality Improvement Plan for the Fitzroy region.

1. Introduction

1.1. Background

The Fitzroy Water Quality Improvement Plan being developed by the Fitzroy Basin Association (FBA) is supported by studies focusing on specific elements of water quality in the Fitzroy Basin and coastal catchments (the Fitzroy region). This ports synthesis is one such supporting study; it focuses specifically on issues related to water quality in the ports of the Fitzroy region.

As an island nation Australia depends heavily on its port facilities for international trade. There are two ports in the Fitzroy region — the Port of Gladstone (sometimes referred to as Port Curtis or Gladstone Harbour) and the Port of Rockhampton (often referred to as Port Alma due to its location) (Figure 1.1). The Port of Gladstone is one of Australia's major port facilities — it is one of the largest coal export ports in the country and the fifth largest coal export port in the world. It is heavily industrialised and eight major industries are located close to the port. The Port of Rockhampton is a three-berth shipping terminal located to the north of the Port of Gladstone; it currently exports mostly ammonium nitrate, salt, bulk tallow and military equipment. It is the principal port for handling Class 1 explosives for eastern Australia. The only port-side industries are evaporative salt pans.

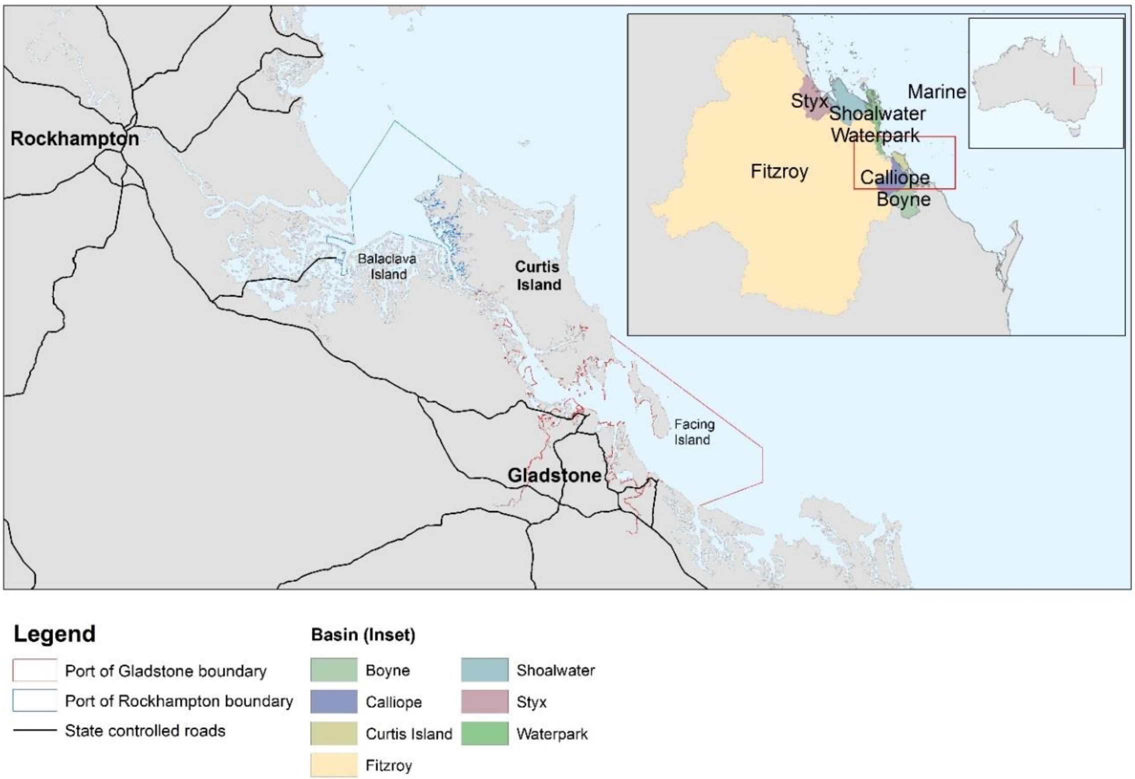

Figure 1.1: The Fitzroy Region and the boundaries of the Ports of Gladstone and Rockhampton.

Water quality in the Ports of Gladstone and Rockhampton is influenced by variety of factors, some of which are unique from other inshore marine habitats. There are catchment and urban contaminant sources similar to other inshore areas in the GBR, but also increased industrial activity, ports maintenance and shipping activities, fishing activities and potential for marine incidents (for example, oil and freight spills) and marine debris from various anthropogenic sources. Both the Port of Rockhampton and the Port of Gladstone are located in the estuaries of river basins. This means that unlike some other Australian ports, such as Abbot Point in north Queensland, water quality in the two Fitzroy region ports is subject to direct catchment influences and also to variable rainfall events and flooding.

Both of the ports are operationally managed by GPC and are subject to a variety of state and federal government legislation. Importantly, the two ports are also adjacent to the Great Barrier Reef Marine Park (GBRMP) and contained within the Great Barrier Reef World Heritage Area (GBRWHA). Australia has international obligations for the continuing protection of World Heritage values of the Reef.

The Port of Gladstone in particular is the subject of a wide variety of water quality research and assessment processes. The Port Curtis Integrated Monitoring Program (PCIMP) has been monitoring water quality in the port for almost a decade, and provides water quality monitoring data to its members. A large amount of ongoing marine environment research has been conducted under GPC’s Ecosystem Research and Monitoring Program (ERMP) and Biodiversity Offset Strategy (BOS) since 2011. Research in the Port of Rockhampton is less extensive although there have been assessments on particular environmental values and a suite of research projects were conducted in the Fitzroy area by the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management from 1999 to 2006. In terms of assessment, the Gladstone Healthy Harbour Partnership, formed in 2013, published a pilot Report Card in 2014 that scores the health of Gladstone Harbour (environmental, economic, social and cultural values), underpinned by research to support the development and implementation of the report card.

Given the amount of research and assessment that is currently underway in the Port of Gladstone, this report provides a synthesis of current knowledge rather than a full water quality improvement plan for ports, which would duplicate existing activities. The scope of this report includes influences on water quality within the Port of Gladstone and the Port of Rockhampton, and water quality issues that are related to ports but may occur outside of the port limits. Other supporting studies being conducted under the Fitzroy Water Quality Improvement Plan focus on catchment and urban influences on water quality, hence these two factors are not addressed in detail in this report. This report provides a review of available information about the two Fitzroy region ports including:

- Background and characterisation of port activities
- Factors influencing water quality
- Water quality monitoring and reporting, and
- Ports water quality management and relevant legislation.

The report also provides a discussion of gaps in knowledge and understanding of water quality and its management in Fitzroy region ports, and extra information that would be required in order to develop a full Ports Water Quality Improvement Plan.

2. Background and characterisation of the Port of Gladstone and the Port of Rockhampton

2.1. Introduction to the Port of Rockhampton

2.1.1. Port capacity and handling

The Port of Rockhampton, the deep sea shipping port for the Rockhampton region (often referred to as Port Alma, which represents the infrastructure locale and the Port Alma Shipping Terminal), is located approximately 62 km east of Rockhampton (23.585410°S, 150.861915°E) on the southern edge of the Fitzroy River Delta (see Figure 2.1) and just north of the Tropic of Capricorn. The port boundary covers a total area of 287 km^2. The port is managed by GPC (a statutory Queensland Government-owned corporation) and has three berths: two for general cargo and one dolphin berth (that is, not accessible from the shore by truck) for handling bulk liquids. The GPC facility has a 67 hectare block (lot 96) near Bajool. There are three operational berths with design depths of 9.2 m (GPC 2011). Road access to the port is via one main road, which meets the Bruce Highway at Bajool (portside of the highway) approximately 26 km from the port (Figure 2.1ure 2.1). The Port of Rockhampton had a nominated rail corridor that meets the main national rail route at Bajool for distribution to all points Australia-wide; however, the actual rail line was removed in 1986.

Average tonnage of exports from the Port of Rockhampton between 2008 and 2013 was 126,115 tonnes (t), with an export to import ratio of 1:3 (Ports Australia 2013). In financial year 2013–14 exports totalled 99,421 t. The port is targeted for the import and export of niche market products including ammonium nitrate, salt, bulk tallow (26,995 t in 2014) and equipment for military exercises held at Shoalwater Bay, north of Yeppoon. It is the principal designated port for the handling of Class 1 explosives and ammonium nitrate cargoes (59,761 t in 2014) for the east coast of Australia. Ship loading limits of 8,000 t (or up to 15,000 t with GPC approval) exist for Security Sensitive Ammonium Nitrate (SSAN) across berths one and two, and for Class 1 explosives of 1500 t over berths one and two. In 2014, 85 vessels visited the Port of Rockhampton and ammonium nitrate accounted for approximately 35% of total port throughput in 2014 (GPC 2015). Exports are primarily to other parts of Australia (50% of tonnage in 2014), Papua New Guinea (10%) and Singapore (14%), but also as far as Chile (6%). Imports are mainly from other parts of Australia (21% in 2014), Japan (17%) and China (13%), but as far away as Sweden (3%) (GPC 2015).

Industries adjacent to the Port of Rockhampton are limited, at present, to the CK Life Sciences (formerly Cheetham Salt Ltd) evaporative salt pans (Cheetham Saltfield, 486 ha and Port Alma

Saltfield 377 ha). The salt pans have been identified as important sites for shorebirds and waterbirds (Houston et al. 2012).

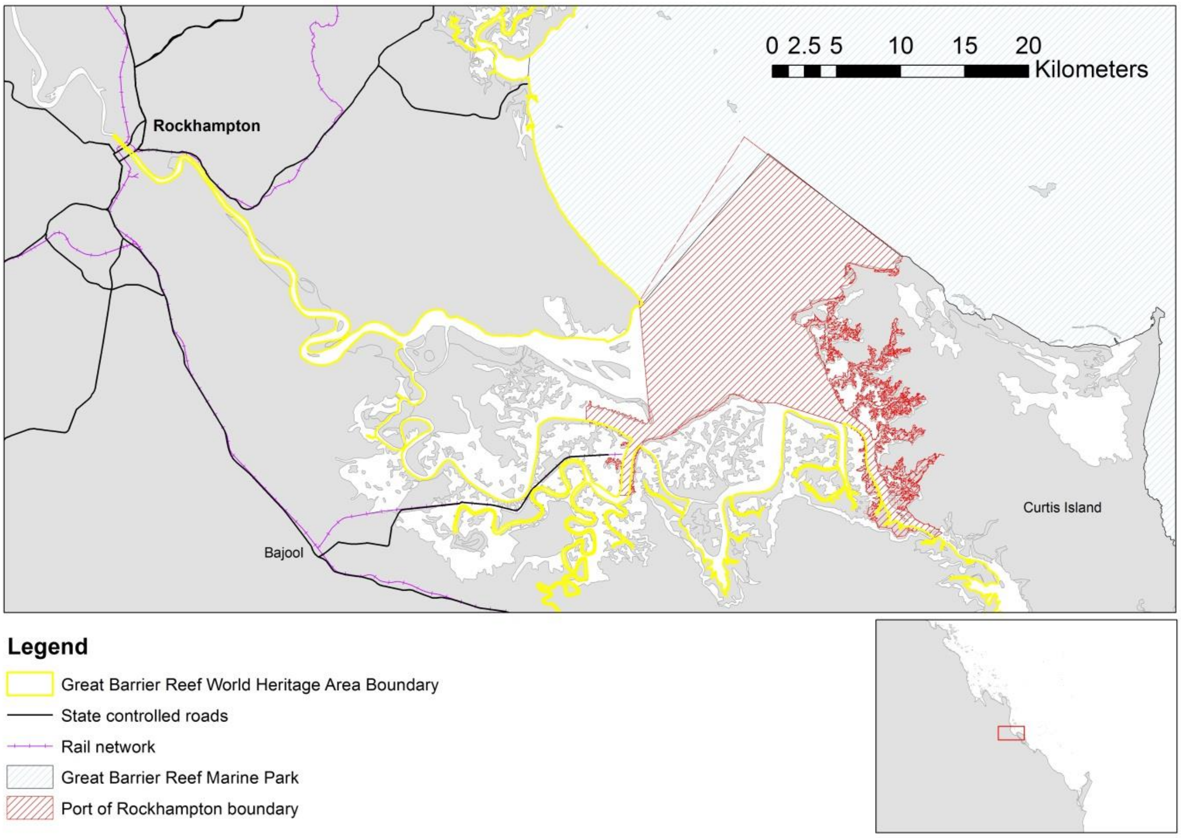

Figure 2.1 Location and map of the Port of Rockhampton, showing major management boundaries, road and rail network.

In 2013, a concept study and Environmental Impact Statement were undertaken to identify the potential for the $1.2 billion development in the Port of Rockhampton as a 22 Million tonne (Mt) deep water coal exporting terminal for Panamax-sized vessels[1] at Balaclava Island Balaclava Island Coal Export Terminal (BICET). The project was suspended in 2013. In order to offset losses of marine fish habitat in the Port of Gladstone, GPC must protect, in perpetuity, an area of 5330 ha of coastal land currently within GPC's strategic port land on Balaclava Island within the Port of Rockhampton boundary. The land is currently being assessed by Queensland Parks and Wildlife Service (QPWS) for inclusion into Queensland’s declared Fish Habitat Area (FHA) network (with a final decision expected by 2016) as an extension of the existing Fitzroy River FHA. The Port of Rockhampton lies within the boundaries of the GBRWHA. The GBRMP boundary stops at the port’s boundary (Figure 2.2).

[1] Cargo ships that are the maximum size for passing through the lock chambers of the Panama Canal (320 m long, 33 m wide and 12.5 m deep)

The benthic habitats alongside the Port of Rockhampton's wharves and much of the channel approaches is intertidal and sub-tidal mud, fringed by salt water couch grasslands, mangroves and salt pans. The site is within the Fitzroy statistical division for fisheries monitoring and the most commonly caught species is mud crab (*Scylla serrata*) (Taylor et al. 2012).

2.1.2. Catchment activities for the Port of Rockhampton

The Fitzroy Basin is the largest river basin draining into the GBR lagoon covering an area of 142,665 km[2]. It has 11 river catchments: Theresa, Connors, Upper Dawson, Lower Dawson, Callide, Upper Isaac, Lower Isaac, Nogoa, Comet, Mackenzie and Fitzroy. Annual rainfall is highly variable for the catchment, with El Niño conditions resulting in difficult dry conditions and strong La Niña wet seasons causing severe flooding. Average annual rainfall across the catchment ranges from 600 mm to 1000 mm (BOM 2015); however, there is high variability between years. Mean annual flow in the Fitzroy River for the period 1965 to 2008 amounts to 4.42 x 10^9 m^3 (Yu et al. 2013). Approximately 230,000 people live and work in the basin. The main land use of the catchment is agriculture (approximately 93% of the landscape, with 86% grazing and 7% arable) contributing up to $1.2 billion annually to the Queensland economy[2]. Of the remainder, 5% of the land is used for forestry, and 1% for urban, mining and feedlots (Queensland Government 2009). Although representing only a small percentage of the catchment land area, approximately 70% of Queensland's coal mines are located here, contributing an estimated $12.6 billion, which is67% of the gross regional product for the Fitzroy Region (QRC 2015). The Fitzroy Basin has been identified as major source of pollutants to the GBR lagoon (Packett et al. 2009). The most recent modelled average annual total suspended sediment (TSS) load for the Fitzroy Basin is 1740 kilo tonnes (kt) per year, four times the pre-development load estimate; and the Fitzroy is estimated to contribute 23% of the baseline fine sediment load to the GBR lagoon (Dougall et al. 2014).

[2] http://www.fba.org.au/fitzroy-basin/ Accessed June 2015

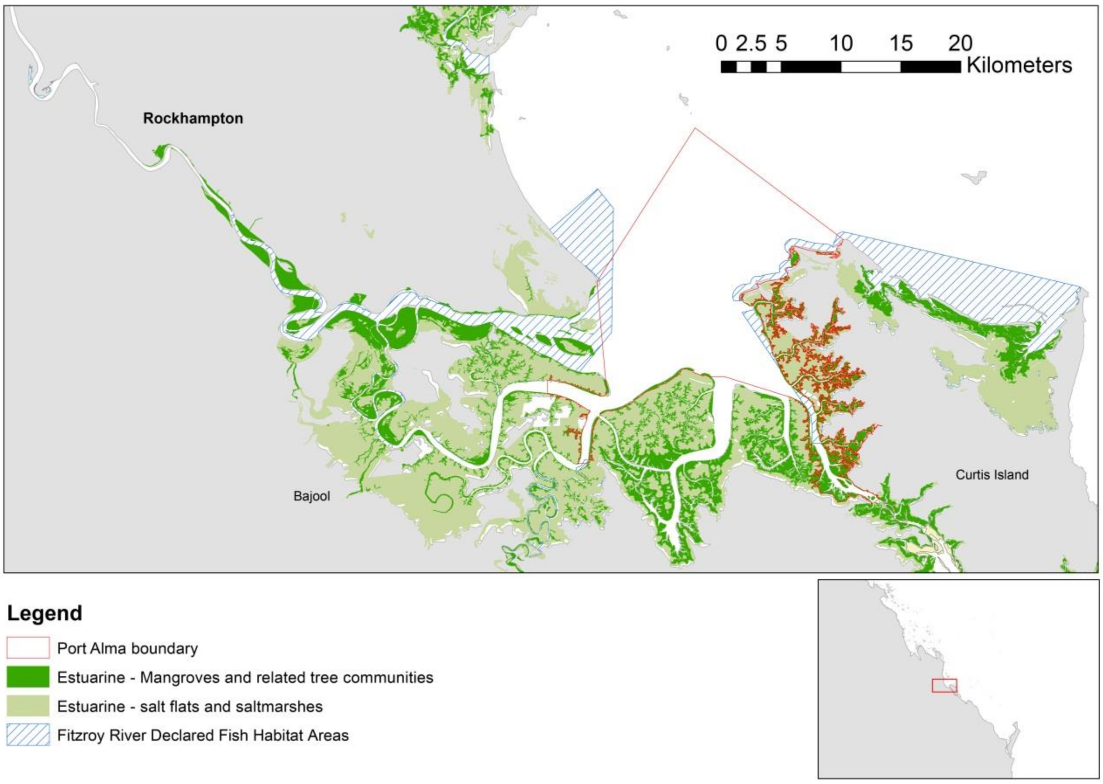

Figure 2.2: Location and map of the Port of Rockhampton, showing major habitats and conservation boundaries.

2.2. Introduction to the Port of Gladstone

2.2.1. Port capacity and handling

The Port of Gladstone lies approximately 525 km north of Brisbane, directly south-east of the Port of Rockhampton, in Port Curtis (a natural and protected deep water harbour). The port boundary covers an area of 548 km^2 (including 7 km^2 of reclaimed land) and the area below lowest astronomical tide datum within the GBRWHA.

The port, which is also managed by GPC, is one of the largest coal export ports in Australia and the fifth largest coal export port in the world. In terms of total throughput it is the second largest port in Queensland after Hay Point (DTMR 2014). In 2013–14 the port handled more than 97.5 Mt of cargo (compared to 108.2 Mt at Hay Point). In 2011, approval was granted for three liquefied natural gas (LNG) processing facilities on Curtis Island, within Port Curtis. Shipments of LNG began in December 2014 and are projected by the resources sector to reach 25 Mt by the end of 2016[3], which could

[3] http://www.couriermail.com.au/business/gladstone-ports-corporation-expects-santos-gas-in-september-quarter-of-2015/story-fnihsps3-1227170411501 Accessed June 2015.

make Gladstone the largest port in Queensland. By comparison, Australia shipped 23.9 Mt of LNG cargoes in 2012–13.

There are 20 operational wharves and six anchorages within the Port of Gladstone. All berths are capable of handling vessels in excess of 180 m in length, with the berths at RG Tanna Coal Terminal, Wiggins Island and Curtis LNG Wharves accommodating vessels of approximately 320 m in length. Design depths range from 11.3 m (for example Auckland Point berths) to 18.8 m (Clinton Coal Wharves) (DTMR 2012a). In 2012–2013 the port experienced an increase in commercially registered vessels (generally between 12 and 50 m in length) engaged for commercial purposes, and commercial ship traffic associated with dredging of the port's western section, development of the Wiggins Island Coal Terminal and the transportation of workers and materials to three new LNG terminals (DTMR 2013b). Since 2014, following the construction of marine infrastructure on Curtis Island and the engagement of a base fleet of barges and ferries, the numbers of these commercially registered vessels has reduced significantly.

The Port of Gladstone's Port Central was designed for containerised and break bulk (non-containerised) general cargo. Major exports through the Port of Gladstone are coal (GPC activity), alumina, magnesia, grain, fly ash, scrap metal, cement clinker, ammonium nitrate, limestone, and grains. The major imports arriving at the Port of Gladstone are bauxite, caustic soda, petroleum products, liquefied petroleum gas, copper, bunker oil, liquified ammonia, sulfuric acid and magnetite.

Facilities at the Port of Gladstone include direct rail access from the port to the national rail network. Table 2.1 shows the main wharves, their size and details of cargoes handled. Currently one shipping channel (in three sections: Gatcombe, Golding and Wild Cattle channels) runs from South Trees in the south of the harbour out to the Fairway Buoy at the outer boundary of the port, with a number of bypass channels associated with Gatcombe, Golding and Clinton channels. In all there are eight sections of channel (four in the inner harbour and four in the outer harbour). The outer harbour consists of Boyne, Wild Cattle, Gatcombe and Golding channels. The inner harbour consists of Auckland, Clinton, Targinie and Jacobs channels. Duplication of the Gatcombe and Golding channels have been proposed to provide a two-way passage from the outer harbour, around East Banks, to the western side of Facing Island. The draft Environmental Impact Statement (EIS) guidelines were released for public comment by the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) on 14 January 2013, and are currently being progressed[4]. The $400 million channel development will be 9.12 km long, have a depth of 16 m and a width of 200 m, creating an estimated 12 Mm^3 of dredged material for disposal.

In addition to bulk freight wharves, the Port of Gladstone also has a marina for charter boats, fishing boats, the Heron and Curtis Island Ferries and mooring for privately owned yachts. The marina handles boats up to 27 m in length with a maximum draught of 4 m and there are 320 berths and

[4] http://www.statedevelopment.qld.gov.au/assessments-and-approvals/port-gladstone-gatcombe-golding-cutting-channel-duplication-project.html Accessed July 2015.

moorings. The sheltered marina was created through a land reclamation project during the 1981–1982 dredging program. Within the 50 Year Strategic Plan (GPC 2012) for the port and commercial industries and tenants, there are plans to create a second marina at Boyne Island.

Table 2.1: Information on the Port of Gladstone wharves. Source: DTMR 2012a; www.worldportsource.com[5]; GPC 2012)

Location	Number of wharves	Design depth (m)	Max Length on Arrival (m)	Main cargos	Annual handling (million tonnes)
Auckland Point	4	11.3–11.4	200–238	Magnesia, calcite, break bulk, grain, petroleum products, caustic soda, general cargo and containers, gypsum, magnetite, liquefied petroleum gas, scrap metal, and ammonium nitrate.	1.4
RG Tanna Coal Terminal (Clinton Coal)	4	18.8	315	Coal	70
Wiggins Island Coal export Terminal (WICT)	1 (4 in development)			Coal	27 (84 projected)
Curtis Island	3			LNG	23.9 (projected)
Barney Point Terminal*	1	15	270	Coal, bunker coal, magnesia, limonite, cotton seed	8*
Fishermans landing	4	11.2–12.9	180–250	Bauxite, alumina, caustic soda, cement and cement clinker, fly ash, limestone and liquified ammonia, sulfuric acid	12.5
South Trees	2	12.8	265	Alumina, caustic soda, bunker oil, bauxite, and bunker coal.	13
Boyne Smelter wharf	1	15	230	Aluminium, petroleum coke, liquid pitch, and general break bulk cargo	0.6

*Due to close to coal in 2016–17 in response to the opening of the nearby Wiggins Island Coal Terminal.

A number of major industries depend on the port and are located either on the shores of Port Curtis or within the adjacent coastal area and connected by road and rail (Figure 2.3)[6]. These include:

- **Queensland Curtis Island Liquified Natural Gas project**: three processing plants on Curtis Island
- **Queensland Alumina Ltd**: one of the world's largest alumina refineries
- **Rio Tinto Alcan Yarwun**: a newer alumina refinery, commencing operations in 2004

[5] http://www.worldportsource.com/ports/commerce/AUS_Port_of_Gladstone_490.php Accessed June 2015.
[6] http://www.gladstoneregion.info/attractions/industrial-giants/ Accessed April 2015.

- **Boyne Smelters Ltd (BSL)**: the largest aluminium smelter in Australia
- **Cement Australia Gladstone**: the largest cement plant in Australia
- **Orica Australia:** chlor-alkali, ammonium nitrate (500,000 t per year) and sodium cyanide plants, and
- **NRG Gladstone Power Station**: Queensland's largest coal-fired power station.

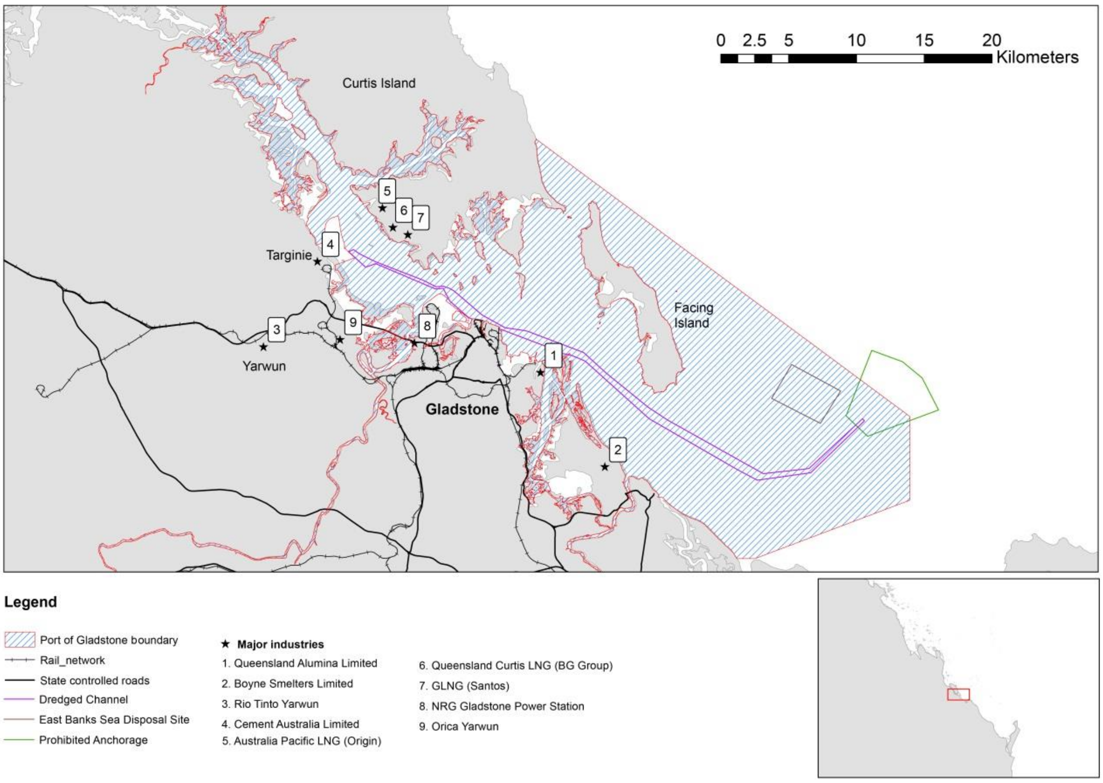

Figure 2.3: Location and map of the Port of Gladstone, showing rail and road link and major industries.

The Port Curtis region is a macro-tidal estuarine system. It includes an intricate network of rivers, creeks, inlets, shoals, mud banks, channels and islands. Due to these physical features, complex water circulation patterns occur throughout the harbour and are primarily governed by a large barotropic tidal flow which contributes to high natural sediment loads (Herzfeld et al. 2004). The mean spring tidal range is 3.2 m (high water tides of 4.8 m and low water down to 0.3 m) and 1.5 m during neap tides. Tidal currents often reach speeds of 2.5 knots (but can reach 4 knots during strong winds and spring tides) (Herzfeld et al. 2004). The port experiences easterly to south-easterly prevailing winds but Facing and Curtis islands protect it from onshore waves and tropical cyclones. Shallow waters (2 to 3 m in depth) to the south of Facing Island and north of Wild Cattle Island also protect the area from prevailing winds. The Port of Gladstone is at risk from tropical cyclones potentially affecting the area during the months of November to April. The estuary has salinities of 30 to 35 parts per thousand (ppt) for most of the year, due to low fresh water inputs. Spatial variability in salinity is due to evaporative losses in shallow sheltered bays and there is temporal variability following pulses of freshwater input to the system during the wet season and following storm events (Apte et al. 2005).

The region includes a diversity of marine and coastal habitats including coral reef, seagrass meadows, mangrove, saltmarsh, salt pans, sand dunes, oyster and rocky reef. The intertidal wetlands of Port Curtis were last characterised in depth in 2006 by Connolly et al. (2006), using combined data from Landsat imagery, aerial photography and field observations. Connolly et al. (2006) identified that 18% of the intertidal area was salt flats without vegetation, saltmarsh (4% of the intertidal), mangroves (31%), unvegetated mudflats (25%) and seagrass (20%). Mangrove monitoring has only recently been reinstated and therefore it is difficult to identify trends; however, regular monitoring of the seagrass extent has identified declines of 50-75% over the past decade (Bryant et al. 2014). Despite increases in meadow area in 2014, seagrass meadow area and biomass generally remain below the long-term average following significant declines in 2009–2010 (Carter et al. 2015). The Port Curtis region also sustains a recreational and professional fishing industry (trawl, net and trap fisheries) for species such as mud crab (*Scylla serrata*), banana prawn (*Penaeus merguiensis*), barramundi (*Lates calcarifer*) and sea mullet (*Mugil cephalus*).

Reflecting its ecosystem value the port boundaries overlap with the Coral Sea, GBRWHA, Dugong Protection Areas, Boyne Island Conservation Park and various national parks and state forests (Figure 2.4). GPC is also currently funding a project managed by Queensland Parks and Wildlife Service (QPWS) to investigate the Calliope River, Gladstone, for its suitability for inclusion into the declared Fish Habitat Area network. Over the past century, extensive areas (approximately 1,600 ha) of mangroves, seagrass meadows and salt marshes/salt pans have been reclaimed for infrastructure at the port and marina, as well as for industrial and urban development (Jones et al. 2005). For example, dredged spoil from the 1981–1982 dredging campaign was used to reclaim the GPC Marina and Spinnaker Parklands and in 2011 an extension to the wharves at Fishermans Landing reclaimed 300 ha resulting in the loss of 90 ha of seagrass habitat.

The Port of Gladstone lies within the boundaries of the GBRWHA and is adjacent to the GBRMP and the Port Curtis Coral Coast (PCCC) regional Traditional Use of Marine Resources Agreement (TUMRA), which was developed under the Reef Rescue Land and Sea Country Indigenous Partnerships Program. The PCCC TUMRA area extends from Burrum Heads (south of Bundaberg), to the mouth of the Fitzroy River and covers the Gooreng Gooreng, Gurang, Tarebilang Bunda and Bailai people's 26,386 km^2 of Sea Country.

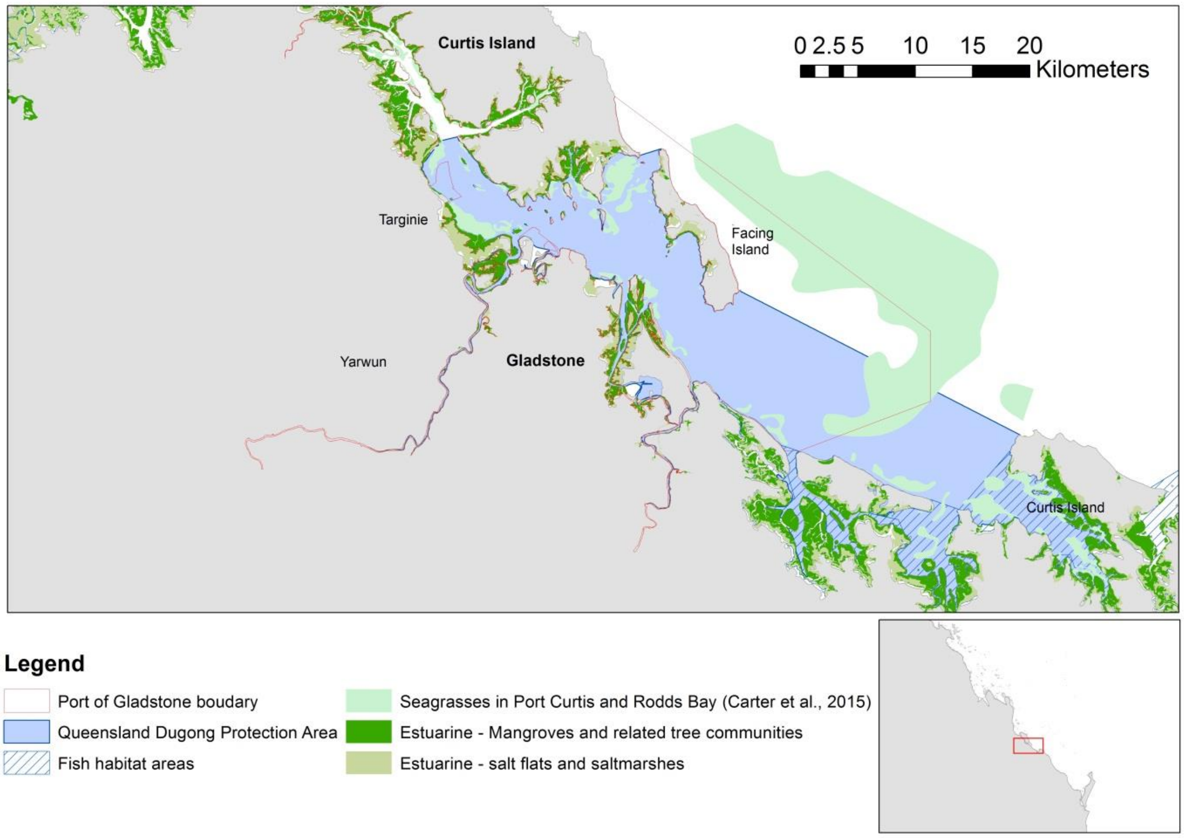

Figure 2.4: Map of important wetlands and boundaries of Important Fish Habitat Areas and Dugong Protection Areas within and adjacent to the Port of Gladstone.

2.2.2. Catchment activities for the Port of Gladstone

The Port of Gladstone climate is a seasonal wet summer, dry winter regime. Compared to the Port of Rockhampton, freshwater inflow is relatively low. Two main rivers drain into Port Curtis Bay: the Calliope River and the Boyne River. The Calliope River mouth enters Port Curtis just north of Gladstone, adjacent to the NRG Power Station. The Calliope catchment is bounded by the Calliope Range to the west and the Mount Larcom Range to the north and covers 2236 km^2 (DNRW 2007). Mean annual rainfall (from 1920 to 1969) is between 800 and 1000 mm (60% of which falls between December and March) and annual river discharge estimates are 153,000 ML (Castlehope gauging station) (C&R Consulting 2005). Over 60% of the basin's native vegetation has been cleared (C&R Consulting 2005), primarily for agriculture. The Calliope Basin also encompasses part of the Gladstone State Development Area (GSDA), a significant industrial land bank established by the Queensland Government in 1993 to secure a large area of land with ready access to the Port for large industrial development over a 30- to 50-year timeframe. Land use within the GDSA is governed by a planning scheme that is controlled by the coordinator-general. Dougall et al. (2014) modelled average annual loads of TSS released into the GBR region from the Calliope as 44 kt per year, an estimated 2.8 times higher than pre-development loads (see also Section 3.2 of this report).

The Boyne River drains into Port Curtis just south of Gladstone, between Boyne Island and Tannum Sands. The Boyne River basin, which covers about 2,590 km^2, consists of one major river system (the Boyne River) and a number of tributaries (including Ridler, Degalgil, Marble and Diglum creeks) (DNRM 2014). Predominant land use within the catchment is agriculture. Approximately 15 km south-west of the mouth of the Boyne River, the river has been dammed to create a reservoir (Awoonga Dam), which has a storage volume of approximately 777,000 ML and is owned and managed by Gladstone Area Water Board (GAWB) to supply urban, industry, power generation and port facilities (such as parklands) in Gladstone. Average annual rainfall in the Boyne catchment ranges from 800 to 1,000 mm. Dougall et al. (2014) modelled average annual loads of total suspended solids (TSS) released into the GBR region from the Boyne as 11 kt per year, which is a 3.7 times increase on estimated pre-development loads. Prior to this Kroon et al. (2012) reported estimated loads of TSS released into the GBR region from the Boyne as 43 kt per year, 2 kt more than estimated for pre-European loads. However, no information is provided on the dates the Kroon et al. (2012) average loads were derived from and therefore comparisons should be made with caution.

The Port of Gladstone is also influenced by sediment from the Fitzroy Basin to the north and during intense flood events (for example those experienced in 2011) flood plumes from the Mary-Burnett River catchments to the south have been identified as contributing to TSS in the region (Devlin et al. 2011). Strong tidal currents operating within the shallow complex environment of the Port of Gladstone induce regular re-suspension of bottom sediments, which often mask river plume signals (Petus & Devlin 2012); however, during extreme events river plumes may exceed harbour re-suspension.

2.3. Quality Assurance and Environmental Certifications

Operation of the Port of Rockhampton and the Port of Gladstone occurs within GPC’s Environmental Management System (EMS), which is based on the internationally recognised specification for environmental management, AS/NZSISO14001:2004. External certification of the GPC EMS to AS/NZSISO14001:2004 was achieved by the port early in 2006. ISO 14001:2004 requirements for an environmental management system (EMS) are to enable an organisation to develop and implement a policy and objectives that take into account legal requirements and other requirements to which the organisation subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organisation identifies as those it can control and those it can influence. It does not itself state specific environmental performance criteria. Section 5 of this report provides more detail on environmental management structures in the two ports.

Following concerns voiced to UNESCO and the International Union for Conservation of Nature (IUCN) in 2012 regarding the environmental management and governance of development occurring in the Port of Gladstone, an independent review was instigated. The review found that the environmental management and governance were generally comprehensive but identified areas of improvement in terms of incorporating world heritage status and other environmental protection into port planning in a more singular, comprehensive and consultative way; assessing and addressing cumulative impacts; and having more meaningful and ongoing stakeholder engagement (including better data sharing) (SEWPaC 2013). A response to the latter was the establishment, by the Queensland Government, of the Gladstone Healthy Harbour Partnership (GHHP). More information on harbour health reporting by GHHP is provided in Section 4 of this report.

2.4. National and international context of port operations

In terms of cargo throughput, at 98 Mt per annum, the Port of Gladstone ranks fourth in size in Australia, after Port Hedland (372 Mt), Dampier (178 Mt) and Hay Point (108 Mt) (BITRE 2014). Figure Figure 2.5 shows the trend in export value for Australia's top 10 ports based on value of goods from 2003 to 2013 and illustrates that in 2013 the Port of Gladstone ranked ninth in Australia in terms of value of exported goods.

Globally, the Port of Gladstone ranks fortieth in terms of tonnage, approximately six-fold smaller than the largest port (Shanghai: 696 Mt per annum). The Port of Rockhampton does not rank among the top 100 ports of the world. Australia has 32% of the world coal export share (Indonesia also has 32%), and the Port of Gladstone is the world's fifth largest coal export port.

Global liquefied gas shipments have increased in Australia, from 514 port calls by LNG (84) and LPG (430) tankers in Australian Ports in 2003–04, to 974 in 2012–13, just 10 years later (BITRE, 2014). They were estimated to rise by a further 5% in 2014 (UNCTAD, 2014), alongside a projected increase in consumption and the discovery of new gas fields worldwide. With shipments of LNG projected to reach 24 Mt per annum in Gladstone, the growth in the size of the port is assured.

The Port of Gladstone is one of only four major ports to occur within the boundaries of a UNESCO World Heritage Area (i.e. the GBRWHA). Also within the boundary of the GBRWHA are the major Ports of Hay Point and Abbot Point, and the smaller ports of Cairns, Townsville and Mackay. Table 2.2 is adapted from Table 4 in the 2015 GBRMPA Dredge Synthesis Report (McCook et al. 2015), and illustrates that maintenance dredging volumes are lower for the Port of Gladstone than other ports in the GBRWHA, noting that these figures do not include capital dredging. The amount of coral and seagrass within 10 km of the port is greater for Gladstone than for the other major ports of Abbot Point and Hay Point, which are headlands as opposed to sheltered estuaries.

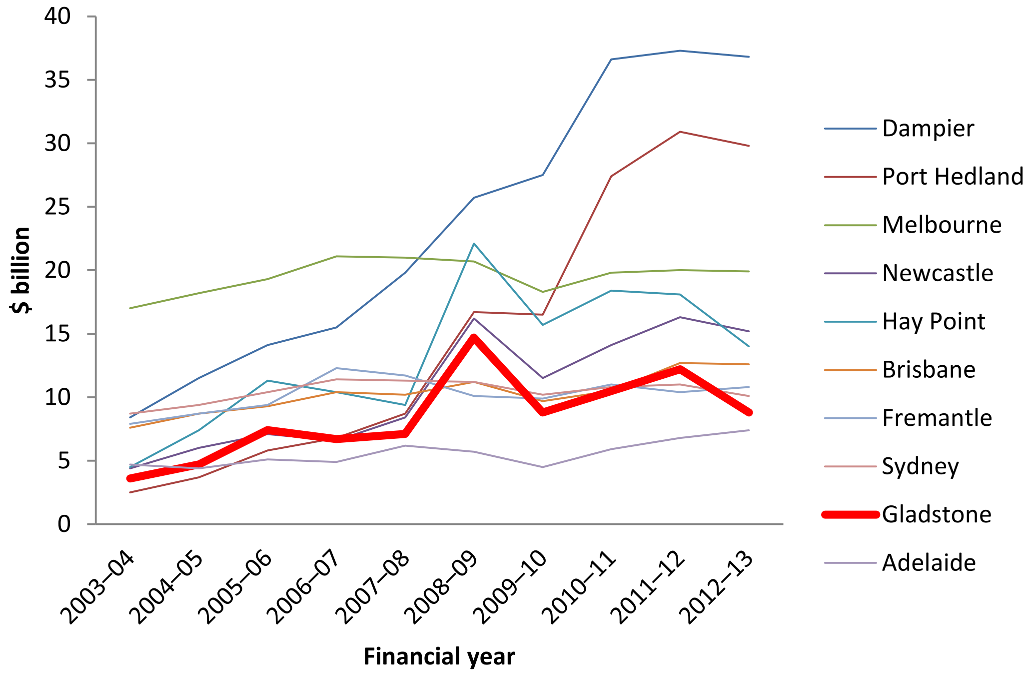

Figure 2.5: Top 10 Australian international sea freight ports with highest export value ($ billion) (Source: BITRE 2014).

Table 2.2: Proximity of coral reefs and seagrass meadows to maintenance dredging and disposal activities associated with major ports (adapted from McCook et al. 2015).

Location	Dredging history (years)	Maintenance dredging	Amount of coral within:				Amount of seagrass within:			
			0-2 km	2-10 km	10-30 km	30-50 km	0-2 km	2-10 km	10-30 km	30-50 km
Cairns	~100	***	-	*	**	***	**	***	***	***
Townsville	131	***	***	***	**	**	**	***	***	***
Abbot Pt	30	*	-	*	**	***	**	**	**	***
Mackay	~75	*	*	-	**	**	*	**	***	***
Hay Point	~43	**	-	*	**	***	**	**	**	***
Gladstone	~100	*	*	**	**	***	**	***	***	**

Amounts shown are relative to other ports: – nil; * little; ** moderate; *** large amounts.

In 2012 a comparison of dissolved metals in Port Curtis (Port of Gladstone) to other industrialised harbours in the world was produced by Angel et al. (2012) (Table 2.3). Concentrations of dissolved cadmium, copper, nickel and zinc were an order of magnitude lower in the Port of Gladstone compared to the Humber Estuary (United Kingdom) and the Scheldt Estuary (Netherlands) and comparable with Port Jackson (New South Wales, Australia) for cadmium and nickel (Table 2.3), but higher than measurements for the New South Wales coast (Eden, Ulladulla, Terrigal, Port Macquarie and Yamba). It should also be noted that estimated background concentrations of nickel, arsenic and chromium in Port Curtis sediments appear to be related to local geology with contributions from the Doonside and Wandilla formations; according to Vincente-Beckett et al. (2006).

Table 2.3: Comparison of dissolved metal concentrations in Port Cutis in 2011 to other industrialised harbours and coasts (Source: Angel et al. 2012).

LOCATION	DISSOLVED METAL CONCENTRATION, ng/L				REFERENCE
	Cadmium	Copper	Nickel	Zinc	
Port Curtis, Dec 2011	4	717	538	306	This study
Port Curtis Harbour	7.0	510	340	170	Angel *et al.*, 2010
The Narrows	8.0	530	650	110	Angel *et al.*, 2010
Port Jackson, Australia	6-104	932-2550	175-1610	3270-9660	Hatje *et al.* 2003
Torres Straight & Gulf of Papua	<1-29	36-986	940-4600	-	Apte and Day, 1998
Port Phillip Bay, Australia	<5-70	400-630	540-1100	250-1050	Fabris and Monahan, 1995
Nine estuaries, northern Australia	1.4-72	150-5500	120-4250	<10-11300	Munksguard and Parry, 2001
Humber estuary, UK	80-450	180-10100	2500-12000	3000-20500	Comber *et al.* 1995
Scheldt estuary, Netherlands	15-100	750-1800	1000-6800	1000-10000	Baeyens *et al.* 2005
San Francisco Bay estuary, USA	22-123	315-2230	140-2410	160-1960	Sanudo-Wilhelmy *et al.* 1996
NSW coast	2.5	30	180	<22	Apte *et al.* 1998
North Pacific Ocean	0.3-112	-	-	15-520	Bruland *et al.* 1994
Australian Guideline values (95% species protection)[1]	5500	1300	70000	15000	ANZECC/ARMCANZ 2000

[1]ANZECC/ARMCANZ (2000) 95% values with 50% confidence

Other major ports abroad are situated directly adjacent to the boundaries of World Heritage Areas (WHAs). For example, the major German ports of Hamburg, Bremen/Bremerhaven and Wilhelmshaven, the Dutch Eemshaven and the Danish Esbjerg, whilst just outside the Wadden Sea WHA boundaries, experience similar challenges of managing ecosystem health with port expansion and large-scale industrialisation (Kabat et al. 2012). The Elbe Estuary, which leads to the Port of Hamburg (third largest port in Europe, and fifteenth largest in the world) is characterised by strong tidal influence, large and increasing sediment loads (leading to increased dredging), large areas of valuable wetland ecosystems, industrial development and significant dredging activities[7]. One major difference for some of these ports is that sedimentation, and balancing the sediment budget of the estuaries, is considered an important part of managing the wetland habitats within the area, and therefore spoil disposal is preferentially carried out within the system (Deltares 2012). In February 2015, the Queensland Government committed to legislate to restrict capital dredging for the expansion of existing port facilities to within the regulated port limits of Gladstone, Hay Point/Mackay, Abbot Point and Townsville, and to prohibit the sea-based disposal of capital dredge material from these sites in the GBRWHA. Removal of dredge material to land may contribute to a net change in the balance of sediments within the bay.

Similar to the situation in the Ports of Gladstone and Rockhampton, many European ports must manage water quality issues resulting not only form their own activities but in terms of catchment activities and those of adjacent industry. Through implementing environmental directives, Europe has moved towards coordinated and integrated catchment-to-coast management, following the most novel legislation on ecosystem-based approaches worldwide (Borja et al. 2010). The European Water Framework Directive (WFD), which was adopted in 2000, changed water management in all member states of the European Union (EU) fundamentally, putting aquatic ecology at the base of management decisions. The European Marine Strategy Framework directive was transposed into national legislations across the European Union in 2010 and enshrines, in a legislative framework, the ecosystem approach to the management of human activities having an impact on the marine environment, integrating the concepts of environmental protection and sustainable use. It is the first EU legislative instrument related to the protection of marine biodiversity, as it contains the explicit regulatory objective that "biodiversity is maintained by 2020"[8].

[7] http://www.tide-project.eu Accessed June 2015.
[8] Directive 2008/56/EC of the European Parliament ec.europa.eu Accessed June 2015.

3. Factors influencing port water quality

The quality of water in industrial ports is influenced by different drivers and pressures than other coastal marine waters. Port water quality is influenced by a variety of factors including river and stream inputs (similar to other coastal marine waters); urban run-off and stormwater, which is often more concentrated around ports; discharge and run-off from port-side industries; fishing and boating activities; and port-related activities including construction and dredging, shipping movements, loading and unloading (Figure 3.1). The Port of Gladstone and the Port of Rockhampton are both influenced by all of these factors, to different degrees. The Port of Gladstone is directly influenced by the city of Gladstone, whereas the Port of Rockhampton is less directly influenced by urban inputs, being approximately 50 km downstream of the city of Rockhampton. While the Port of Gladstone is much more industrialised and busier in terms of shipping movements and construction activities, the Port of Rockhampton is subject to influence from a much larger catchment area in its location at the delta of the Fitzroy River.

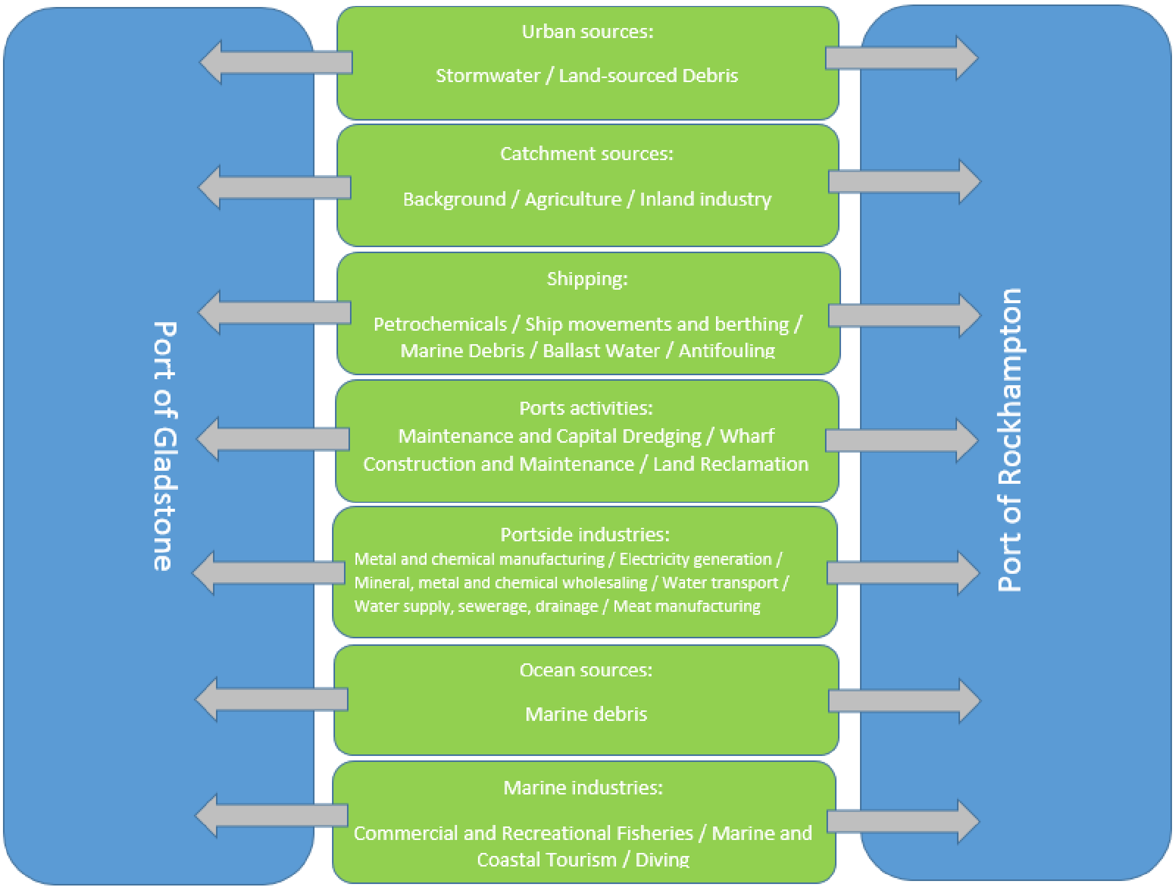

Figure 3.1: Factors influencing water quality in the Port of Gladstone and Port of Rockhampton.

In this section we review the factors influencing water quality in the two ports of the Fitzroy region, and summarise available data on the level of activity and (where available) quantity of emissions from each of these factors. Urban sources and catchment sources are both subject to separate studies being done as part of the Fitzroy Water Quality Improvement Plan as described below, and are not considered in detail as part of this Ports Synthesis.

3.1. Urban sources

Urban sources that potentially influence port water quality include sediments, nutrients and contaminants (e.g. metals and petrochemicals) in diffuse stormwater and point source (e.g. wastewater) discharges; and urban litter that, when expelled into the marine environment, becomes one of three possible sources of marine debris (the other two being shipping and boating, and ocean sources).

The quantity of pollution reaching ports from urban environments is a factor of the geographical size and human population of the urban centre, stormwater and litter management processes, sewage treatment processes, degree of coastal development, the proximity of the centre to the marine environment and the extent of buffering environments such as coastal wetlands. An Urban Water Quality Improvement Scoping Study is being conducted for the Fitzroy Water Quality Improvement Plan and will gather information about urban water cycle management and water quality monitoring for the main urban areas in Gladstone Regional Council, Rockhampton City Council and Livingstone Shire Council local government areas. The study will include a list of priority actions to improve urban water quality in those urban centres in the Fitzroy region including foundation activities required to progress urban water quality improvement.

3.2. Catchment sources

Catchment run-off is a major source of sediments, nutrients and pesticides in coastal marine waters (e.g. Dougall et al. 2005; Kroon et al. 2012; Dougall et al. 2014) including ports. As described in Section 2 of this report, the Port of Gladstone is directly influenced by run-off draining from the Calliope and Boyne basins, and is also potentially influenced by the Fitzroy Basin, which drains to the north and the Baffle, Kolan, Mary and Burnett basins draining to the coast south of Gladstone. Situated in the mouth of the Fitzroy River, the Port of Rockhampton is strongly influenced by the quality of water draining from the large Fitzroy Basin. The Styx, Shoalwater and Water Park catchments all drain to the north of the Port of Rockhampton, and influence surrounding marine waters but are unlikely to have a significant influence on the port in comparison to the much larger Fitzroy. As well as anthropogenic land-use influences, water quality running off catchments into the marine area can also be influenced in part by natural factors such as rainfall and geology (e.g. Bartley et al. 2012).

Dougall et al. (2014) modelled average annual pollutant loads for the Fitzroy Natural Resource Management (NRM) Region catchments. Total suspended sediment, nutrients (total nitrogen, dissolved inorganic nitrogen, dissolved organic nitrogen, particulate nitrogen, total phosphorus, dissolved inorganic phosphorus, dissolved organic phosphorus, particulate phosphorus) and selected photosynthesis II-inhibiting herbicides (known as PSII herbicides) of atrazine, hexazinone, diuron, tebuthiuron, ametryn loads were modelled (Table 3.1). Catchment loads are further discussed in the study Ecologically Relevant Targets for Pollutant Discharge from the Drainage Basins of the Fitzroy Region, Great Barrier Reef, which is also being conducted through the Fitzroy Water Quality Improvement Plan.

Table 3.1: Contribution of major basins to regional total baseline load for the Fitzroy NRM Region (Source: Dougall et al. 2014).

River basin	Basin area (km^2)	TSS (kt/yr)	TN (t/yr)	DIN (t/yr)	DON (t/yr)	PN (t/yr)	TP (t/yr)	DIP (t/yr)	DOP (t/yr)	PP (t/yr)	PSII (kg/yr)
Styx	3013	68	154	38	56	60	38	8	1	29	22
Shoalwater	3601	53	137	45	66	25	21	9	2	10	14
Waterpark	1836	32	150	54	79	18	19	10	2	6	10
Fitzroy	142552	1740	3688	1106	1548	1035	983	245	50	687	521
Calliope	2241	44	90	23	33	34	27	4	1	21	10
Boyne	2496	11	24	6	9	10	6	1	0	4	2
TOTAL	**152727**	**1948**	**4244**	**1272**	**1790**	**1181**	**1093**	**278**	**56**	**759**	**579**

3.3. Shipping

Commercial shipping is a factor influencing water quality, which is unique to port areas and shipping routes. Currently, the primary shipping activity in both of the Fitzroy ports is multi-cargo import and export shipping (see also Section 2 of this report). There is also a proposal for P&O cruise ships to stop in Gladstone on regular tours of Queensland waters. Pollutant sources associated with shipping activities include:

- Ship movements
  - propeller wash and berthing settlement (re-suspension of sediments)
  - petrochemical emissions
- Shipping incidents and grounding, including oil spills, hazardous material spills and waste
- Marine debris (dumping/losing garbage at sea)
- Discharge of ballast water, and

- Use of anti-fouling paints.

Activity and emissions data available for the Ports of Gladstone and Rockhampton are detailed below.

3.3.1. Ship movements: sediment re-suspension and emissions

Shipping movements, propeller wash from large ships and berthing can all potentially result in re-suspension of sediments from the benthos (Grech et al. 2013). Shipping movements are also accompanied by engine operation, which results in emissions of petrochemicals and airborne nitrogen oxide and oxides of sulfur, although current knowledge about ship emissions in Australian ports is limited (Goldsworthy & Galbally 2011). While there are no specific data quantifying the impacts on water quality of shipping emissions, the level of shipping activity in a port can give an indication of the potential level of influence. Shipping activity can be reported as the number of commercial vessel registrations and the number of ship movements per annum.

The number of commercial vessels registered in Queensland including the Gladstone region[9] were comparable between months and years from Maritime Safety Queensland (MSQ) data from 2008 until July 2013. During that time the peak for the Gladstone region was in 2012 at around 960 vessels (DTMR 2013a; MSQ 2015). Following July 2013, commercial vessel registrations are operating under different legislation meaning the registration numbers are not comparable with previous registration numbers from that date onwards. The most common size classes of registered commercial vessels in the Gladstone region are 3.00 to 4.49 m, 4.50 to 5.99 m and 12.00-14.99 m (Table 3.2).

Following the completion of major marine construction projects including dredging of the Western Basin, construction of berths at Wiggins Island and Curtis Island and rationalisation of the construction fleet operating between the mainland and Curtis Island, the number of commercial vessels within the Port of Gladstone decreased substantially (GPC Pers. Comm., 31 July 2015). The quantum of construction traffic is reflected by shipping movements data, which indicate a large increase during port expansion projects in 2011–12. In 2011–12 shipping movements increased by 514% on 2010–11, with 202,050 movements in 2011–12 in comparison to 32,878 movements in the previous year (DTMR 2012b).

3.3.2. Shipping incidents

The Australian Maritime Safety Authority (AMSA) and MSQ maintain databases on incidents of pollution. Quantitative data are publicly available for the reported shipping incidents recorded by

[9] MSQ's operational boundaries for the Gladstone maritime region includes 1868 km of mainland coastline from Double Island Point to St. Lawrence, 1342 km of island coastline and 26,190 km of inland waterways. There are three major trading ports in the region—the Port of Gladstone, the Port of Rockhampton and the Port of Bundaberg, as well as major marinas in Hervey Bay, Bundaberg and Rosslyn Bay which together have berths for approximately 900 vessels (DTMR, 2013a).

MSQ per annum (although data are less detailed from 2007 onwards than in earlier years) and the number of incident prosecutions recorded by AMSA.

Oil discharge refers to any discharges or suspected discharges of oil from a vessel in excess of that permitted under the International Convention for the Prevention of Pollution From Ships, MARPOL 73/78 (usually 15 ppm oil in water), and oil spills are defined as accidental spills from incidents such as vessel collisions or groundings, overflowing tanks or burst hoses. The data on oil spills into the Port of Gladstone between 2009 and 2013 is summarised in Table 3.3. No reports of spills were recorded for the Port of Rockhampton during the same period. The most significant reported events by volume were a land-based spill of 1000 L of diesel in 2009, and a ship-based spill of 1500 L of sewage and grey water in 2012. Small amounts of diesel and hydraulic fluid are the most frequent spills from both land and ship sources.

Summarised in Table 3.4 are the published records of successful oil and chemical pollution prosecutions in Gladstone and Rockhampton locations with associated penalty amounts. Major shipping incidents are listed separately on AMSA’s website and include two oil spills in the vicinity of the Ports of Gladstone and Rockhampton. In January 2006 a 25 t heavy fuel oil spill occurred in the Port of Gladstone from the breached hull of a bulk carrier ship (Korean origin, *Global Peace*), which was damaged during berthing at the RG Tanner coal loading facility[10]. Surveys of PAH concentrations were subsequently conducted and exceedances of Australian and New Zealand Sediment Quality Guidelines (ANZECC/ARMCANZ 2000) were identified, with very few to no crabholes in the high intertidal zone compared to a non-impacted control site (Andersen et al. 2008). In February 2010, a bulk coal carrier (Chinese origin, *Shen Neng 1*) ran aground on Douglas Shoal in the GBRMP east of Great Keppel Island, carrying 68,000 t of coal, which it had loaded in the Port of Gladstone[11]. The *Shen Neng 1* spilled 4 t of fuel oil from a ruptured fuel tank.

[10] https://www.amsa.gov.au/environment/major-historical-incidents/Global_Peace/index.asp Accessed June 2015

[11] https://www.amsa.gov.au/environment/major-historical-incidents/Shen_Neng1/index.asp Accessed June 2015

Table 3.2: Commercial registrations by vessel size for Gladstone Region as of 30 September of reported years (2008–2014) (data source: MSQ 2015).

Size (m)	2008	2009	2010	2011	2012	2013*	2014*
Up to 2.99	0	0	0	0	0	0	0
3.00-4.49	250	232	214	227	211	164	79
4.50-5.99	181	186	197	206	225	131	16
6.00-7.99	33	32	32	39	43	37	0
8.00-9.99	50	53	49	53	55	43	0
10.00-11.99	73	69	71	78	78	51	2
12.00-14.99	122	111	106	104	101	83	0
15.00-17.99	52	47	52	58	63	49	0
18.00-24.99	84	85	83	84	91	72	0
25.00-34.99	15	14	15	19	32	21	0
>35.00	9	9	12	32	51	22	0
Total	**868**	**838**	**831**	**900**	**950**	**673**	**97**

** "Note: As of 1 July 2013 the majority of commercial vessels registered in Queensland are now operating under the* Marine Safety (Domestic Commercial Vessel) National Law Act 2012*. It is estimated that there are approximately 500 vessels that will not be subject to the National Law that will remain registered as commercial vessels in Queensland come 30 June 2014. The remainder of the vessels are those that have a current Queensland commercial registration certificate, which is deemed to be a Certificate of Operation under the National Law for the transitional period, and will not be renewed in the Queensland system." (MSQ 2015a).*

Table 3.3: Oil spills and pollution events in the Port of Gladstone reported to MSQ in 2013, ship and land-based sources (Queensland Government 2014). U = unknown quantity.

Date	Source	Ship type	Area	Location	Oil type	Litres
5/01/09	Unknown	N/A	Port	Auckland Creek, Gladstone	Sheen	U
1/02/09	Unknown	N/A	Port	Gladstone Marina	Diesel	20
10/02/09	Ship	Commercial	Port	North Channel, Gladstone	Diesel	20
27/02/09	Land	N/A	Port	Walby Creek, Gladstone	Diesel	1,000
23/08/09	Unknown	N/A	Port	Mouth of Auckland Creek, Gladstone	unknown	U
4/01/10	Unknown	N/A	Port	Auckland Creek, Gladstone	Diesel	U
13/04/10	Unknown	N/A	Port	Gladstone Marina	Diesel	10
28/07/10	Unknown	N/A	Port	South Trees West Wharf, Gladstone	Diesel	U
13/08/10	Land	N/A	Port	South Trees East Wharf, Gladstone	HFO	100
11/02/11	Ship	Commercial	Port	Auckland Pt Wharf, Gladstone	Diesel	15
11/04/11	Ship	Commercial	Port	North China Bay, Gladstone	Hydraulic	20
13/07/11	Unknown	Unknown	Port	Between Q4 and Q6 beacons in Quoin Channel, Gladstone	Sheen	N/A
14/07/11	Ship	Commercial	Port	LNG Maritime Offload Facility Curtis Island, Gladstone	Hydraulic	20
23/07/11	Unknown	Unknown	Port	Fishermans Landing (Bechtel Barge Ramp), Gladstone	Hydraulic	5
16/08/11	Ship	Commercial	Port	North Passage Island, Gladstone	Engine	10
31/10/11	Land	N/A	Port	GLNG MOF Pioneer Barge Ramp south of China Bay Curtis Island	Coolant	50
2/11/11	Land	N/A	Port	GLNG MOF south of China Bay Curtis Island	Hydraulic	U
21/11/11	Ship	Commercial	Port	North Passage, China Bay	Hydraulic	50
12/12/11	Ship	Commercial	Port	North Passage Island Channel	Hydraulic	10
25/12/11	Ship	Commercial	Port	Curtis Island side of Passage Island Channel	Hydraulic	10
28/03/12	Ship	Recreational	Port	Curtis Island side of Passage Island Channel	Hydraulic	U
30/04/12	Ship	Commercial	Port	Jacobs Channel, Curtis Island	Sheen	U
24/05/12	Ship	Commercial	Port	Curtis Island QCLNG Project: Offload Facility	Hydraulic	2
2/06/12	Ship	Commercial	Port	Curtis Island GLNG Marine Offload Facility	Hydraulic	20
3/06/12	Ship	Commercial	Port	RG Tanna Loadout Facility	Diesel	1
4/09/12	Ship	Commercial	Port limits	Gladstone Harbour	Bilge	10
14/07/12	Unknown	Unknown	Port Limits	Fishermans Landing	Diesel	100
10/11/12	Ship	Fishing	Port limits	Fishermans Finger, Gladstone	Diesel	30
2/08/12	Ship	Commercial	Port limits	Behind Clinton Wharf	Hydraulic Fluid	2
5/08/12	Ship	Commercial	Port limits	North Passage Island, Gladstone	Hydraulic Fluid	5
14/10/12	Ship	Commercial	Port limits	Clinton Wharf	Hydraulic Fluid	10
24/11/12	Ship	Commercial	Port limits	China Bay, Curtis Island	Hydraulic Fluid	1
13/08/12	Ship	Commercial	Port limits	Middle Bank Quoin Anchorage	N/A	U

22/10/12	Ship	Commercial	Port limits	South Passage Island	Sewage & grey water	1500
15/10/12	Land	N/A	Port limits	GLNG MOF, Gladstone	sodium Hypochlorite	100
10/11/12	Ship	Fishing	Port limits	Fishermans Finger, Gladstone	Diesel	30
24/11/12	Ship	Commercial	Port limits	China Bay Curtis Island	Hydraulic Fluid	1
12/05/13	Ship	Commercial	Port limits	Gladstone Harbour	Diesel	0.3
20/06/13	Ship	Commercial	Port limits	Passage Island Channel, Gladstone	Diesel	
14/03/13	Land	N/A	Port limits	Curtis LNG	Hydraulic Fluid	25
11/04/13	Land	N/A	Port limits	Curtis LNG	Hydraulic Fluid	1
18/04/13	Land	N/A	Port limits	Curtis LNG	Hydraulic Fluid	0.1
14/05/13	Ship	Commercial	Port limits	Gladstone Harbour	Hydraulic Fluid	0.1
20/06/13	Ship	Commercial	Port limits	Wiggins Island Coal Terminal	Hydraulic Fluid	1
10/06/13	Land	N/A	Port limits	Curtis LNG	Lanolin	1
14/03/13	Land	N/A	Port limits	Curtis LNG	Hydraulic Fluid	25
11/04/13	Land	N/A	Port limits	Curtis LNG	Hydraulic Fluid	1
18/04/13	Land	N/A	Port limits	Curtis LNG	Hydraulic Fluid	0.1
12/05/13	Ship	Commercial	Port limits	Gladstone Harbour	Diesel	0.3
14/05/13	Ship	Commercial	Port limits	Gladstone Harbour	Hydraulic Fluid	0.1
10/06/13	Land	N/A	Port limits	Curtis LNG	Lanolin	1
20/06/13	Ship	Commercial	Port limits	Wiggins Island Coal Terminal	Hydraulic Fluid	1
20/06/13	Ship	Commercial	Port limits	Passage Island Channel, Gladstone	Diesel	U

Table 3.4: Prosecutions for oil and chemical pollution under Commonwealth and State legislation from 1997 in Gladstone and Rockhampton locations[12]. Note that Rosslyn Bay Boat Harbour is outside of the limits of the Port of Rockhampton.

Date of Prosecution	Date of Incident	Jurisdiction	Vessel name	Vessel type	Location	Pollutant Type	Litres	Penalty
21/02/07	16/01/06	Queensland	*Larcom*	Barge	Gladstone	Oil	1000	Owner $25000 Master $5000
25/11/04	5/01/03	Queensland Yeppoon Magistrates court	*Taobruo*	Fishing vessel	Rosslyn Bay Boat Harbour	Oily mixture (bilge contents)	10	Owner $3500
xx/12/04	28/04/03	Queensland Yeppoon Magistrates court	*Friendship R*	Passenger (tourist) vessel	Rosslyn Bay Boat Harbour	Oil	200-1200	Owner $20000
13/06/03	27/07/01	*Queensland Transport Operations (Marine Pollution) Act 1995* Rockhampton Magistrates Court	*Ji Chong Lee*	Fishing vessel	Rockhamp-ton	Diesel & engine lubricating oil	2200	Owner $25000
27/06/03	17/04/02	*Queensland Transport Operations (Marine Pollution) Act 1995* Gladstone Magistrates Court	*Warden Point*	Bulk carrier	Gladstone	Fuel oil	Not quantified (50-100?)	Owner $20000 Master $200 Chief engine er $1000

3.3.3. Marine debris and ship-sourced pollution

In Queensland, prosecutions for ship-sourced pollution are covered under the *Transport Operations (Marine Pollution) Act 1995*. This legislation is designed to protect Queensland's marine and coastal environment from deliberate and negligent discharges of ship-based pollution. This includes discharges of oil, noxious liquids, sewage and garbage (as per MARPOL Annexes I, II, IV, V) from ships operating in Queensland coastal waters and pilotage areas. The *Protection of the Sea (Prevention from Pollution from Ships) Act 1983* is administered by AMSA, and implements the international MARPOL (International Convention for the Prevention of Pollution from Ships) in Australian waters. Jurisdiction extends from 3 nautical miles (nm) from the coast out to the Australian Economic

[12] https://www.amsa.gov.au/environment/legislation-and-prevention/prosecutions/oil/table.asp Accessed June 2015.

Exclusive Zone (200 nm) and applies within 3 nm where the State does not have complementary legislation.

Publicly available records of prosecutions for ship-sourced garbage pollution are maintained by AMSA. Thirteen of 22 records were from within or near the GBRMP, and the records from incidents offshore of the Fitzroy region are provided in the Appendix (see Table A.1). The most recent incidents offshore of the Fitzroy region were as follows. A Chinese shipping company was fined $20,000 when a vessel (Panama-registered, *Xin Tai Hai*) disposed of rubbish overboard approximately 16 nm off the Port of Gladstone in June 2013[13]; and in June 2012 a Chinese shipping company was fined $5,000 and the ship master $300, after garbage was dumped from the *Hope Star* 210 km north-east of Gladstone[14]. These incidents may not have influenced water quality in the Port of Gladstone as they occurred offshore.

The broader topic of marine debris is discussed in more detail in Sections 3.6 and 4.1.6.

3.3.4. Discharge of ballast water

The discharge of high-risk ballast water into Australian ports or territorial sea is prohibited, and the Australian Government's Australian Ballast Water Management Requirements — Version 5, deems "salt water from ports and coastal waters outside Australia's territorial sea to be a 'high-risk' and capable of introducing exotic marine pests into Australia". The following ballast water types are deemed to be 'low-risk':

- Fresh potable water sourced from a municipal water supply, with supporting documentation
- Ballast water that has been exchanged at an approved location (mid-ocean) by an approved method
- Ballast water of which at least 95% was taken up in mid-ocean, and
- Ballast water of which at least 95% was taken up inside Australia's territorial sea.[15]

Ballast water taken up within Australian territorial seas or from domestic ports is managed by State or Territory government agencies. All vessels must have a Ballast Water Management Plan on board that specifically applies to that vessel and must provide detailed instructions for the ship's crew on the safe management of ballast regardless of conditions at sea (DAFF 2011). Ballast water management is important because ships can carry up to 70,000 t of ballast water, in which potentially noxious species could be transported, including plankton, larvae of invertebrates and fish and pathogens (Low 2003).

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[13] https://www.amsa.gov.au/media/documents/xx112014MediaReleaseGarbageProsecution.pdf Accessed June 2015

[14] http://www.gladstoneobserver.com.au/news/hope-star-captain-and-owner-fined-reef-rubbish-tos/1647762/ Accessed June 2015

[15] http://www.agriculture.gov.au/biosecurity/avm/vessels/quarantine-concerns/ballast/australian-ballast-water-management-requirements Accessed August 2015

Ten introduced marine species were identified in the Port of Gladstone in 2001 (Table 3.5; Lewis et al. 2001). None of the identified species were invasive species or were of significant concern and all were thought to be translocated via hull fouling, suggesting that the number of ships and residence time of ships visiting wharves are important considerations (Lewis et al. 2001).

A number of invasive marine species have the potential to be introduced to Queensland marine environments (Table 3.6), with the Asian bag mussel (*Musculista senhousia*) identified as having the greatest potential to establish in Queensland waters. In their response to the 2014 National Marine Pest Biosecurity Review, Ports Australia expressed concern that responses to incursions of Asian green mussel, Asian bag mussel and Caribbean tube worm in 2002, 2007 and 2009 were uncoordinated and under-resourced (Fryda-Blackwell 2014).

Table 3.5: Introduced species identified in Port Curtis survey of marine species in March 2000 (source: Lewis et al. 2001).

Name	Class	Probable origin	Likely introduction vector	Reported distribution in Australia	Distribution in Port Curtis
Botrylloides leachi	Ascidea (sea squirt)	North-eastern Atlantic/Europe	Hull fouling/boring, mariculture	NSW, VIC, SA, WA, QLD	Auckland Point, South Trees Wharf
Styela plicata	Ascidea (sea squirt)	Philippines	Hull fouling/boring, mariculture	WA, SA, NSW, VIC, QLD	Wharf pylons throughout Port Curtis
Amathia distans	Bryozoa (lace coral)	Brazil		QLD, WA, SA, VIC	Wharf pylons throughout Port Curtis
Bugula neritina	Bryozoa (lace coral)	Europe	Hull fouling/boring, mariculture	SA, VIC, NSW, WA, QLD	Gladstone Marina, Wharf pylons throughout Port Curtis
Cryptosula pallasiana	Bryozoa (lace coral)	North Atlantic	Hull fouling/boring, mariculture	TAS	Wharf pylons throughout Port Curtis
Watersipora subtorquata/acuata	Bryozoa (lace coral)	Pacific	Hull fouling/boring, mariculture	WA, SA, NSW, VIC, TAS, QLD	Wharf pylons throughout Port Curtis
Zoobotryon verticillatum	Bryozoa (lace coral)	North Europe	Hull fouling/boring, mariculture		Gladstone Marina, Wharf pylons throughout Port Curtis
Obelia longissima	Hydrozoa	North Atlantic	Hull fouling/boring	QLD	Wharf pylons throughout Port Curtis
Paracerceis sculpta	Isopoda (slater)	North American Pacific coast	Hull fouling	QLD, WA, VIC, SA, NSW	South Trees Wharf
Alexandrium sp.					Auckland Point, Channel Marker S19

No introduced species surveys have been undertaken in the Port of Rockhampton to date, although a proposal for a survey similar to the Port of Gladstone survey by Lewis et al. (2001) has been proposed in the past. Macrobenthic studies in the Port of Rockhampton suggest that the likelihood of any exotic species currently present having a significant ecological impact is low (Curry & Small 2005). Lewis et al. (2001) also recommended continued monitoring to detect target species with qualitative assessments of wharves, channel markers and dredged spoil grounds annually and a quantitative assessment on a quarterly basis. Routine assessment of hull fouling was also recommended as this is a primary vector of introductions to ports. The Australian Government Department of Agriculture is currently finalising the National Marine Pest Biosecurity Review; the department will then make recommendations to strengthen the national approach to marine pests[16].

The country of origin of ships (and other vessels, including recreational boats and yachts) visiting ports is relevant to the possibility of marine pest incursions, particularly for ships arriving in light draft to load at a port for export. Countries of origin of ships arriving for export to the Ports of Gladstone and Rockhampton are given in Tables 3.7 and 3.8 respectively.

Table 3.6: Species with a moderate to high potential of being introduced to Queensland marine environments (source: Lewis et al. 2001).

Species recorded from other Australian states	Estimated potential to establish
Musculista senhousia	High (SE Qld)
Potamorcorbula amurensis	Moderate (SE Qld)
Megabalanus rosa	Moderate (Qld)
Corophium insidiosum	Moderate (Qld)
Neomysis haponica	Moderate (SE Qld)
Perna viridis	Moderate (Qld)
Zoobotryon verticillatum	Moderate (Qld)
Bowerbankia spp.	Moderate (Qld)
Sparidentex hasta	Moderate to low (SE Qld)
Species not yet recorded in Australia	**Estimated potential to establish**
Cliona vastifera	Moderate (Qld)
Perinereis vancuaria tetradenta	Moderate (SE Qld)
Hyroides cf. *ezoensis*	Moderate to low (SE Qld)
Pomatoleios krausii	Moderate to low (SE Qld)
Chthamalus proteus	Moderate to low (SE Qld)
Acartiella sinensis	Moderate to low (Qld)
Pseudodiaptomus marinus	Moderate to low (Qld)
Chama elatensis	Moderate to low (Qld)
Lyrodus pedicellatus	Moderate to low (Qld)

[16] http://www.agriculture.gov.au/pests-diseases-weeds/marine-pests/review-national-marine-pest-biosecurity Accessed August 2015.

Table 3.7: Top 10 countries of export from the Port of Gladstone in 2014 by number of vessels[17].

Export Countries	Tonnage	No. vessels
Japan	11,263,302	119
Australia	1,632,495	96
China	9,029,541	87
India	6,300,532	84
Korea	4,749,629	35
Taiwan	1,619,470	20
Brazil	810,925	11
Russia	404,465	10
Indonesia	238,298	10
Malaysia	247,426	8

Table 3.8: Countries of export from the Port of Rockhampton in 2014 by number of vessels[18].

Export Countries	Tonnage	No. vessels
Australia	24,310	6
Papua New Guinea	6,577	5
Singapore	8,746	4
China	3,080	2
Micronesia	6,617	1
Chile	6,336	1
Taiwan	908	1
Philippines	35	1

3.3.5. Use of anti-fouling paints

Tributyltin (TBT) biocide compounds were introduced in the 1960s to anti-fouling paints to prevent the attachment of organisms, such as seaweed, barnacles and tube worms to ship hulls. TBT has since been shown to be universally toxic, causing severe damage to non-target species in the wider marine environment (Evans et al. 1995). Significant impacts to marine life can occur from concentrations of only a few nanograms per litre, and desorption of sediment-bound TBT and leaching from paint chips may delay the decline of TBT in seawater concentrations (Newman & McIntosh 1991). Following restrictions on TBT use, copper-based biocides have become the predominant anti-fouling agent; however, the use of copper is now also being restricted or regulated in some areas due to its potential for toxic effects (Dafforn et al. 2011).

[17] https://content1.gpcl.com.au/ViewContent/CargoComparisonsSelection/CargoComparisonsSelection.aspx Accessed April 2015.
[18] Ibid.

In 1989 the Australian Government introduced legislation for the phase-out of TBT-based anti-fouling paint; in 1999 Australia's Oceans Policy committed Australia to ban anti-fouling paints containing TBT; and in October 2001 the International Maritime Organisation (IMO) adopted the International Convention on the Control of Harmful Anti-Fouling Systems on Ships (the HAFS Convention)[19]. Australia implements the HAFS Convention through the *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006* (see Section 5.1.1. of this report). As the phase-out was part of a larger IMO mandate, all vessels entering into Australian waters are obliged to not have TBT paints on their hulls, and the same applies to Australian ships entering international ports, shipyards or offshore terminals.

The main sources of TBT are commercial shipping and historically, recreational boats. TBT is expected to be an issue for all large ports, but a 2005 report noted that concentrations in the Port of Gladstone were expected to decline over the next decade as TBT was phased out worldwide (Apte et al. 2005).

Imposex, the imposition of male sexual characteristics on female marine snails, occurs as a result of exposure to TBT even at extremely low concentrations. As a result, imposex occurrence is considered a sensitive bioindicator of TBT exposure and is an alternative to difficult and expensive chemical analysis (Andersen 2004). A survey of imposex in Port Curtis was undertaken in 2004, and showed up to 43% of female snails at any one site being affected by imposex, with prevalence related to intensity of shipping (Andersen 2004). This was still considered to be a low incidence of imposex, compared to other Australian studies that have shown up to 100% of snails affected (Andersen 2004). A follow-up survey conducted in Port Curtis in 2008 showed imposex in 13 of the 17 surveyed sites but the degree and frequency was at low-moderate levels and was not thought to be a threat to the reproductive capacity of studied species (Wilson 2009). Similar to other studies, the sites with the greatest imposex were in areas with high to moderate shipping traffic, but the higher prevalence of dibutyltin than TBT in tissues indicate that sediment sources were more likely (Wilson 2009).

3.4. Ports activities

3.4.1. Maintenance and capital dredging

Dredging is an important maintenance activity needed to retain channels and berths for transportation activities and for safe and efficient port operations. GPC must conduct maintenance dredging to fulfil its operational obligations under the Queensland *Transport Infrastructure Act 1994*. GPC undertakes maintenance dredging in the Port of Gladstone in annual campaigns (or more frequently if required) and disposes of dredge material at the East Banks Sea Disposal Site in

[19] http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-the-Control-of-Harmful-Anti-fouling-Systems-on-Ships-(AFS).aspx Accessed April 2015.

accordance with permits issued under the Australian *Environment Protection (Sea Dumping) Act 1981* (GPC 2014b).

GPC's sea dumping permits and Long Term Monitoring and Management Plan (LTMMP) (GPC 2014b) manage GPC's maintenance dredging and sea disposal activities from a Commonwealth perspective and also satisfy the Queensland Government requirement for a Receiving Environmental Management Plan as specified in the Environmental Authority that authorises maintenance dredging activities under the Queensland *Environment Protection Act 1994.*

Annual maintenance dredge volumes for the period of 2004 to 2013 are provided in Table 3.9. A total of 63,000 m^3 has been dredged from the Port of Rockhampton during this time; and approximately 1.64 million m^3 (Mm^3) from the Port of Gladstone. GPC established a Technical Advisory Consultative Committee (TACC) for the purpose of maintenance dredging consultation in 2000. Membership includes a wide representation of stakeholders including government, industry, research, Indigenous, conservation and fishing interests.

Table 3.9: Maintenance dredging annual volumes (m^3) in the Port of Gladstone and Port of Rockhampton (GPC Pers. Comm., 5 August 2015).

Year	Port of Rockhampton	Port of Gladstone
2004	0	174,150
2005	0	148,426
2006	0	225,242
2007	0	160,927
2008	0	17,995
2009	23,000	282,000
2010	0	0
2011	40,000	309,000
2012	0	150,000
2013	0	174,150

Dredging is also undertaken during capital projects such as the Western Basin Dredging and Disposal Project (WBDDP), which increased port access by deepening, widening and creating new shipping channels to the Western Basin. Approximately 22.5 Mm^3 has been dredged to date in the WBDDP, of an approved 42.3 Mm^3 (Queensland Government) / 46 Mm^3 (Australian Government) (Table 3.10; GPC Pers. Comm., 5 August 2015).

As part of the WBDDP, a reclamation area was constructed that allowed for a maximum of 45 Mm^3 of spoil to be contained; however, a leak in the bund wall retaining the spoil led to the release of fine sediments from the dredge spoil into the port. An independent review of the Port of Gladstone was commissioned by the Australian Government in February 2013, and an addendum to the review was commissioned on 30 January 2014 to examine the design and construction of the reclamation bund wall. The Independent Review Panel made 37 findings and 19 recommendations, and found that aspects of the design and construction of the bund wall were not consistent with industry best practice. The panel further found that there “is insufficient evidence to attribute motive or, indeed, overall long-term harm from these deficiencies. In fact, genuine attempts were made by all parties to reduce impacts on the environment” (DoE, 2014).

Table 3.10: Western Basin Dredging and Disposal Project (WBDDP), dredging volumes approved. EIS = Queensland Government Environmental Impact Statement; SEWPaC = (then) Australian Government Department of Sustainability, Environment, Water, Population and Communities. (Source: GPC Pers. Comm., 5 August 2015).

WBDDP EIS	WBDDP Supplementary EIS (Dredge volume as at 19 March 2010) Section 4.1.2	WBDDP Supplementary EIS (Maximum Dredge Volume) Section 5.5.1	Queensland Coordinator General's Approval	SEWPaC Approval
Stage 1A North China Bay LNG Precinct = 16 Mm^3	Stage 1A (Curtis Is including APLNG initial Stages) = 22.4 Mm^3	Stage 1A (Curtis Channel and MOFs) = 22.4 Mm^3		Stage 1A and 1B = 25 Mm^3
Stage 1B Fishermans Landing = 6.1 Mm^3	Stage 1B (including all stages of GLNG LTD) = 5.3 Mm^3	Stage 1B (Fishermans Landing) = 5.6 Mm^3		Stage 2, 3 and 4 = 21 Mm^3
Stage 2 Laird Point = 4.5 Mm^3	Stages 2 and 3 = 10 Mm^3	Stage 2 = Laird Point = 4.5 Mm^3		
Stage 3 Fishermans Landing =5.5 Mm^3	Stage 4 (including Hamilton Point and Final LNG development) = 4.6 Mm^3	Stage 3 Fishermans Landing Development = 5.5 Mm^3		
Stage 4 Hamilton Point = 3.9 Mm^3		Stage 4 (including Hamilton Point and Final LNG development) = 5.5 Mm^3		
Total = 36 Mm^3	**Total = 42.3 Mm^3**	**Total = 45.3 Mm^3**	**Total = 42.3 Mm^3**	**Total = 46 Mm^3**

Capital dredging and reclamation activities can have negative environmental impacts in terms of direct loss of inshore habitats (e.g. seagrasses), and sediment and pollutant inputs to the marine environment. Rates of localised turbidity, sedimentation and deposition from dredging exceed normal levels and this can lead to alteration of habitat and a loss of organisms and changes in species composition in an area (Erftemeijer & Lewis 2006). Pollutants (if present) can readily bind to fine-grained sediments that are often found in ports, and when dredging occurs, the contaminants may be released and become bioavailable to organisms in the area (Lohrer & Wetz 2003; Erftemeijer et al. 2012). However, no detectable elevations in metal concentrations were found at capital dredging sites in the Port of Gladstone in 2011 (Angel et al. 2012) and maintenance dredging sites in the Port of Gladstone were found to be uncontaminated in sediment quality assessments in 2012 and 2014 (BMT WBM 2014a; cited in GPC 2014b). Guideline exceedances recorded for arsenic (likely from natural sources) and TBT sediment concentrations were further analysed and found unlikely to result in water quality impacts. The Independent Review of the Port of Gladstone noted that dredged sediments complied with the requirements of the National Assessment Guidelines for Dredging 2009 in relation to ocean disposal and stated that water and sediment quality testing demonstrated that “dredged sediments were not contaminated to levels that would lead to toxicological effects” (SEWPaC, 2013).

Few data are available on impacts of dredging in the Port of Rockhampton; however, a study undertaken at Keppel Bay Marina (an enclosed marina located on the Capricorn Coast to the north of the Port of Rockhampton) examined the effects of maintenance dredging activities through analysis of water quality, macroinvertebrate assemblages, metal concentrations in sediments and resident oysters, and coral community health immediately after commencement of dredging and two weeks after the dredging was completed (Alquezar & Stratford 2007). Significant changes in water quality, sediment physicochemical parameters and in macrobenthic assemblages were identified post-dredging at sites at the marina and adjacent locations. No such changes were seen at the reference location, indicating the impacts were a direct result of dredging and not caused by seasonal or natural events. It is important to note that while Keppel Bay Marina is an enclosed water body, the Port of Rockhampton is in a well-flushed estuary and the effects of dredging would vary between these two different marine environments.

Dredge disposal (whether on land or at sea) also has impacts on water quality. The degree of impact depends on the quantity disposed, method of disposal, proximity of disposal areas to sensitive ecosystems, the potential for dispersal of sediments and the sediment qualities (i.e. particle size, density and contamination) (Erftemeijer & Lewis 2006). Sensitivity of ecosystems is dependent on their initial condition, resilience and the conditions that they normally experience (Erftemeijer et al. 2012). A 2014 study by consultants BMT WBM identified potential contaminants of concern in sediments in the Port of Gladstone as: metals and metalloids; polycyclic aromatic hydrocarbons (PAHs); and organotin compounds (TBT, dibutyltin, monobutyltin — see also Section 3.3.5 of this report) (BMT 2014; cited in GPC 2014b). Potential pollutant sources were analysed in the same study, as follows:

- Shipping: hydrocarbons (BTEX: benzene, toluene, ethylbenzene, and xylenes; and total petroleum hydrocarbons); polycyclic aromatic hydrocarbons (PAHs); organotins; product spillage during import and export (e.g. bauxite, coal, clinker, alumina)
- Natural geology: metals, metalloids (e.g. arsenic and nickel) and PAHs
- Industrial discharges and run-off: metals, metalloids and organics
- Landfills: metals, metalloids and other leachates (only small inactive landfills close to the coast)
- Agriculture and horticulture: herbicides and pesticides — horticulture reduced in recent years
- Urban stormwater discharges: PAHs, metals, metalloids and hydrocarbons, and
- Sewage treatment plants: secondary treated water re-used at local industrial sites.

Sea disposal of dredge material in the Port of Gladstone occurs at East Banks Sea Disposal Site (location illustrated in Figure 2.3 of this report) and sea disposal permit details are available in GPC's LTMMP (GPC 2014a). While some attention has been given to the impacts of sea disposal of dredge material in the Australian scientific literature (e.g. Smith & Rule 2001; Grech et al. 2013; Brodie 2014), scientific studies for land disposal of dredge material are lacking. Land reclamation using dredged marine sediments is not uncommon in Australia and in some areas the need for fill material is the reason for dredging. Land reclamation is one of several land-based 'beneficial reuses' of dredge material; others include raw construction material, wetland restoration/creation and flood mitigation (Sheehan & Harrington 2012). The Queensland Government's inclusion in the Sustainable Ports Development Bill 2015[20] of an action to prohibit sea disposal of capital dredge material in the GBRWHA (see also Section 5.1.3 of this report) means there is likely to be an increased focus on land-based disposal options and beneficial reuse. Given the potential implications of land disposal for the coastal environment there is a need for further research in this area.

3.4.2. Wharf facilities

The number of wharf facilities in a port is a direct function of its level of shipping activity. Wharves can be a source of water quality contamination through spills and wash down during and after loading and unloading freight (GPC 2014b) and these activities are covered by Environmental Authorities under the Queensland *Environment Protection Act 1994*. Studies offshore from the Hay Point coal terminal showed that PAH concentrations approach the estimates of toxicity for marine organisms at both inshore and offshore coral reefs, and this was attributed to coal dust from the terminal (Burns & Brinkman 2011; Burns 2014).

There are 20 operational wharves and six anchorages within the Port of Gladstone (see section 2.2.1 of this report). Quarantine and customs services are available to commercial vessels coming into port. Garbage disposal and sterilisation services are provided by GPC, and quarantine waste is kept in sealed bags on board the vessel until time of collection. Collection of tank wash slops, oily bilge and oily mixtures with chemicals, sewage, or oil sludge is provided by Nationwide Oil Pty Ltd[21].

This differs to the smaller Port of Rockhampton, which has only three berths (one of which is a dolphin berth) and far fewer shipping movements (see also section 2.1.1 of this report). Here, no pre-organised shipside garbage collection and/or quarantine waste services are available (although these can be arranged by GPC as required), and the procedures information provided to vessels coming into port is to retain these materials on board in covered receptacles[22]. The Australian

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[20] http://www.statedevelopment.qld.gov.au/industry-development/sustainable-port-development.html Accessed June 2015.

[21] http://www.msq.qld.gov.au/Shipping/Port-procedures/Port-procedures-gladstone.aspx Accessed April 2015.

[22] http://www.msq.qld.gov.au/Shipping/Port-procedures/Port-procedures/port-alma.aspx Accessed April 2015.

Government recently approved live cattle exports from the Port of Rockhampton[23] although details of any required changes to port facilities should these exports commence are not yet available.

3.5. Discharge from port-side industries

Substantial developments have occurred in the Gladstone area over the past century with increased urbanisation, industrialisation and shipping. As a result, the port is expected to have increased quantities of inputs from both diffuse and point source discharges transported via air and water (Apte et al. 2006). Previous studies have attributed natural, industrial and anthropogenic discharge as sources of elevated trace metal contaminants in the port. As detailed in Section 2 of this report, the Port of Gladstone is highly industrialised with several important industries occupying port-side locations. Industrial activity is regulated under Australian and Queensland government legislation, and Environmental Authorities under the Queensland *Environment Protection Act 1994* are needed to conduct any Environmentally Relevant Activity[24].

3.5.1. Discharge and emissions

Metals found in Gladstone Harbour are not thought to be sourced from particulates (air emissions) (Apte et al. 2005) thus the focus on reported industrial discharge and emissions is on direct water inputs only in this report. The National Pollution Inventory (NPI) provides a database of emissions and transfers of toxic substances that are emitted at a local level within Australia. The NPI reports on 93 substances that have been identified as being important as a result of their potential impact on the health of humans and the environment.

In Gladstone, there were 23 reporting facilities, and 29 in Rockhampton in the 2013–14 reporting period (it is recognised that by aggregating data by category, some nearby local industries that are not strictly located on port land are included). In Gladstone in 2013–14, emissions are reported for five industrial categories (basic non-ferrous metal manufacturing; basic chemical manufacturing; electricity generation; mineral, metal and chemical wholesaling; and water transport services), with oil and gas extraction sometimes being a contributor in other years. In Rockhampton, three industrial categories contributed emissions in the 2013–14 reporting period (electricity generation; water supply, sewerage and drainage services; and meat and meat product manufacturing).

There were 20 reportable chemical compounds discharged by Gladstone facilities in 2013–14. The greatest volume of inputs was for fluoride compounds (160,940 kg/yr) (Table 3.11). Similar trends were seen in previous years, with the basic non-ferrous manufacturing industrial category being the greatest contributor from 2001 to the current reporting period. Nutrients (total nitrogen, total phosphorus and ammonia) were the highest rating emissions for Rockhampton. In 2013–14, 15 compounds were discharged into the water from the main industrial categories. Total nitrogen

[23] http://www.abc.net.au/news/2015-08-06/cattle-producers-welcome-live-export-plan-for-central-qld/6678886 Accessed August 2015.
[24] https://www.business.qld.gov.au/business/running/environment/licences-permits/applying-environmental-authority/environmentally-relevant-activities Accessed August 2015.

accounted for the greatest amount of discharge from two industrial categories (water supply, sewerage and drainage services; and meat and meat product manufacturing) in Rockhampton during the 2013–14 reporting period (144,957 kg/yr) (Table 3.12).

Table 3.11: Industrial emissions for Gladstone waters (kg/year) for 2013–14 (Source: NPI search[25]).

INDUSTRY	Ammonia (total)	Benzene	Cadmium & compounds	Chlorine & compounds	Chromium (III) compound	Cobalt & compounds	Copper & compounds	Cyanide (inorganic) compounds	Ethylbenzene	Fluoride compounds	Lead & compounds	Manganese & compounds	Mercury & compounds	Nickel & compounds	Polycyclic aromatic hydrocarbons	Toluene (methyl-benzene)	Total Nitrogen	Total Phosphorus	Xylenes (individual or mixed isomers)	Zinc & compounds
Basic Non-Ferrous Metal Manufacturing [213]	518		353		20	6	363			160940	16	485	0.2	26	0.3		141730	9331		551
Basic Chemical Manufacturing [181]	6321			321	5		18	20					0.06	3			20208	1010		437
Electricity Generation [261]	0				13		8				2	129		3						
Mineral, Metal and Chemical Wholesaling [332]		0.004							0.003							0.02			0.01	
Water Transport Support Services [521]											0.006		0.001							

[25] http://www.npi.gov.au/npidata/action/load/browse-search Accessed April 2015.

Table 3.12: Industrial emissions for Rockhampton waters (kg/year) for 2013–14 (Source: NPI search[26]).

INDUSTRY	Ammonia (total)	Arsenic & compounds	Boron & compounds	Cadmium & compounds	Chlorine & compounds	Chromium (III) compounds	Chromium (VI) compounds	Fluoride compounds	Lead & compounds	Manganese & compounds	Mercury & compounds	Nickel & compounds	Total Nitrogen	Total Phosphorus	Zinc &compounds
Electricity Generation [261]		29	786	0.3	66	3.23	0.2	2,620	2.62	235	0.3	23			35
Water Supply, Sewerage and Drainage Services [281]	52,328				4,321								78,967	30,955	
Meat and Meat Product Manufacturing [111]	52,040												65,990	20,380	

[26] http://www.npi.gov.au/npidata/action/load/browse-search Accessed April 2015.

3.5.2. Recent industrial incidents

As well as regulated emissions, industrial incidents occasionally occur and these may potentially influence water quality in the ports. No recent incidents have been reported in proximity to the Port of Rockhampton (likely reflecting the lower level of industrialisation of this port); however, several incidents have been reported for Gladstone.

In November 2012 Orica Australia Pty Ltd was fined $432,000 for releases of cyanide-contaminated water[27]. Orica Yarwun is a chemical plant in Gladstone producing ammonium nitrate and sodium cyanide for the mining industry. The 270 offences recorded included release of contaminants in excess of license limits, a failure to notify the Department of Environment and Heritage Protection upon becoming aware of contraventions to section 435(1) of the *Environmental Protection Act 1994*, and a failure to test for contaminants prior to releasing effluent.

In November 2013 the alumina refinery Rio Tinto Alcan Yarwun was fined $35,000 for environmental condition breaches relating to insufficient storage capacity of its red mud dam[28].

In recent land-based industrial incidents: in December 2013 Gladstone alumina refinery Queensland Alumina Ltd (QAL) was fined $125,000 for allowing the release of caustic aerosol spray containing sodium hydroxide across nearby houses[29]; and also in December 2013 Streeters Earthmoving Pty Ltd was fined $45,000 for land-based unauthorised waste oil and diesel spills at Yarwun Quarries near Gladstone[30]. An ethylene leak was reported for QCLNG in October 2014[31], and a recent large caustic leak also occurred from the QAL refinery in June 2015[32].

3.5.3. Acid sulfate soils

Acid sulfate soils (ASS) cover 4,650 ha of the Fitzroy-Curtis coast (EPA 2008). When disturbed, ASS release sulfuric acid, and can lead to low pH and heavy metal mobilisation in coastal waters (particularly brackish waters) causing degradation of plant communities and killing marine organisms (EHP 2011).

In the Gladstone area, ASS occur from Tannum Sands to Fishermans Landing, encompassing an area of 3,471 ha of land (1,466.5 ha with actual acid sulfate soils and 2,004.5 ha potential) (Ross 2004). A

[27] http://statements.qld.gov.au/Statement/2012/11/1/orica-penalised-432000-for-releasing-contaminated-water Accessed June 2015.
[28] http://statements.qld.gov.au/Statement/2013/11/22/protection-of-turtles-boosted-from-court-imposed-fine Accessed June 2015.
[29] http://statements.qld.gov.au/Statement/2013/12/19/qal-fined-125000-for-causing-serious-environmental-harm Accessed June 2015.
[30] http://statements.qld.gov.au/Statement/2013/12/18/earthmoving-company-fined-45000-over-waste-oil-and-diesel-spills Accessed June 2015.
[31] http://www.gladstoneobserver.com.au/news/workers-stood-down-after-chemical-leak/2423068/ Accessed July 2015.
[32] http://www.gladstoneobserver.com.au/news/caustic-leak-qal-investigated/2668096/ Accessed June 2015.

further 1,820 ha of disturbed land is thought to contain ASS (Ross 2004). Spoil from the capital and maintenance dredging programs in the Port of Gladstone could contain Potential Acid Sulfate Soil (PASS) material, which, if found to be present during pre-dredge testing, would need to be carefully disposed of to ensure no adverse environmental impacts (Holton 2011). A number of reports have been undertaken examining various ASS as part of the Western Basin dredging and reclamation project, and an ASS management plan was developed for this project and ongoing monitoring (Holton 2011).

3.6. Ocean sources (of pollution)

The primary ocean-based water quality issue in the region relates to marine debris. Marine debris surveys conducted around Gladstone and Rockhampton indicate debris is not just originating from local land sources, but also from commercial shipping and from fishing activities (recreational and commercial) occurring within the area (Table 3.13). Factors such as ocean currents, seasonal wind patterns and the northerly longshore drift influence the sources and the deposition of debris in the Gladstone region (Wilson 2013). Recommendations to address this include increased education and awareness, with targeted campaigns aimed at reducing inputs from the local fishing and boating enthusiasts and from industry and shipping groups (Wilson & Hansler 2014), in addition to continued sampling regimes (Wilson & Cartraud 2014). Further details on marine debris monitoring and results are provided in Section 4 of this report. Other potential sources of ocean-sourced pollution such as oil, toxicants and ocean acidification are currently not a major issue in the region but should be monitored going forward.

Table 3.13: Debris surveys at Gladstone shoreline locations (Sources: Wilson & Cartraud 2014; Wilson & Hansler 2014).

Survey Location	Year	Item total	Weight total (kg)	Mean items/m^2	Accumulation rate
Shoreline surveys at popular fishing and boat ramp locations	2013 - 2014	7,594	204	0.11	4.2 items/ day
Gladstone Beaches at Chinaman, Fishermans, and Facing Islands, and Rodds Peninsula	2014	23,306	311.7	0.48	-

3.7. Marine industries and recreation

Marine industries and recreation, including commercial fishing, game and charter fishing, recreational fishing and boating, and tourism, have the potential to influence water quality. Impacts can be as a result of vessel movements/emissions, anti-fouling paints (see also section 3.3.5 of this report), maritime incidents causing petrochemical spills, garbage disposal and sullage, and (particularly for commercial fisheries) discarding unwanted fish and fish products. While the individual impacts of small commercial and recreational vessels are likely to be less than the individual impacts of very large vessels, the scale of marine industries and recreational boating can, at times, be high with the potential for significant cumulative impacts. Marinas and slipyards are also potential sources of water pollution including nutrients, anti-fouling chemicals and petrochemicals.

3.7.1. Recreation

Non-fishing recreation can impact on marine environments including through water quality impacts. Some impacts of recreational use on the GBR include: localised damage to corals and disturbance to wildlife, contribution to litter (and consequently marine debris), anchor damage to coral and seagrass habitats, risks of introducing species through vessel fouling, oil and chemical spills, vessel sewage discharge, vessel groundings and sinkings (GBRMPA 2014). In 2008 GBRMPA commissioned a study investigating the direct effect of recreation on water quality in GBRMP (Gregg & Greiner 2008). The study considered only self-guided visits to the marine park that are non-commercial, non-research and not classed as a tourist visit. The study concluded that a key water quality issue for this group was the use of 2-stroke carburettor outboard engine-powered vessels. These outboards are the most polluting marine engines on the market and their use is restricted in some European countries and in the United States (US), yet in 2007 they made up more than 60% of engine sales in Australia and are still commonly used by recreational fishers and boaters. The study suggested that these engines could feasibly cause measurable water quality impacts in areas of high use (for example near boat ramps, in estuaries and near-shore environments).

While no specific data are available describing emissions from marine industries and recreation in the Port of Gladstone or the Port of Rockhampton, indicators of activity levels that can be measured include the number of boat ramps and jetties for use by trailer craft, and marina facilities. There are more boat ramps within the Port of Gladstone than within the Port of Rockhampton, reflecting the closer proximity of Gladstone's port to a regional centre, although there are a number of boat ramps upstream of the Port of Rockhampton and along the nearby Capricorn Coast (Appendix A).

There is a marina facility in Gladstone, with 320 mooring booths, and the additional pile moorings located in Auckland Inlet are also managed by the Gladstone Marina. There are additional moorings in the lower Boyne River. The GPC 50 Year Plan includes a proposal to develop marina facilities close to the mouth of the Boyne River, with this facility also possibly being used for pilotage access. While there are no marinas within the limits of the Port of Rockhampton, Keppel Bay Marina is nearby on the Capricorn Coast, with over 500 berths catering for vessels up to 35 m.

A further indicator of recreational boating activity is the number of recreational vessel registrations. In Queensland, there are about 250,000 recreational vessels registered each year. In 2014, 47,293 vessels were registered in the Gladstone region, and boats between 3.01 to 4.0 m were the most common size class registered (Table 3.14).

Table 3.14: Gladstone region recreational vessel registrations by size class, as of 30 September of each reported year (Source: MSQ 2015b).

Size (m)	2008	2009	2010	2011	2012	2013	2014
Up to 3.00	1,293	1,310	1,287	1,244	1,233	1,250	1,225
3.01-4.00	15,910	16,293	16,921	17,105	17,563	17,908	18,113
4.01-4.50	10,117	10,471	10,845	11,103	11,431	11,782	12,173
4.51-5.00	4,690	4,845	4,971	5,027	5,099	5,232	5,300
5.01-6.00	4,752	4,999	5,255	5,448	5,584	5,777	5,846
6.01-8.00	2,139	2,288	2,429	2,565	2,721	2,872	2,905
8.01-10.00	665	686	714	727	732	735	713
10.01-12.00	494	512	529	549	554	561	545
12.01-15.00	355	357	354	365	391	387	392
15.01-18.00	52	58	65	66	64	64	64
18.01-20.00	8	11	9	10	11	11	22
20.01-25.00	5	7	5	5	6	7	13
>25.00	4	3	3	3	3	3	4
Total	**40,484**	**41,840**	**43,387**	**44,217**	**45,392**	**46,589**	**47,293**

Vessel incidents have the potential to cause stored garbage and toxicants to enter the marine environment. Records are available for incidents involving recreational and commercial vessels in Gladstone. Data are freely available for the years 2011 to 2013, with only limited data available for 2008 and 2009 (Table 3.15). The most commonly reported marine vessel incidents in Gladstone in 2013 were unintentional groundings (n=50), collisions with a fixed object (n=39), and collisions between ships (n=30). Similar to the Queensland-wide data, most incidents in the Gladstone region occurred in smooth or partially smooth waters. Trend reporting from 1996 to 2012 illustrated a similar trend of increasing incidents for Gladstone as for the rest of Queensland (Figure 3.1). The increase in commercial vessel incidents in 2011 to 2013 coincided with construction activities on Curtis Island and associated construction traffic increases (514% increase from 2010–11 to 2011–12, see also section 3.3.1).

Table 3.15: The number of incidents for commercial and recreational vessels in Gladstone (Source: MSQ 2014).

Vessel Type	2008	2009	2011	2012	2013
Commercial vessels			110	239	133
Recreational vessels			71	93	121
Hire & Drive vessels				3	5

Commercial fishing vessels	11	26	14

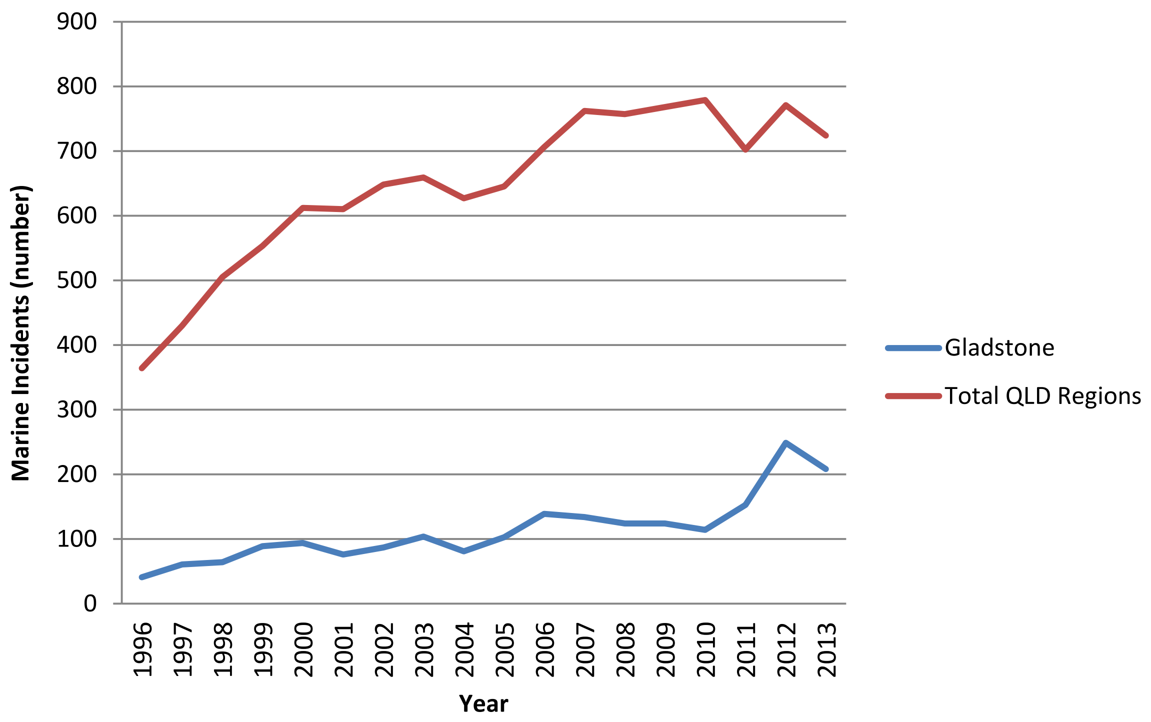

Figure 3.2: The number of incidents and Gladstone compare to the rest of Queensland for reported years 1996 to 2013 (MSQ[33]).

Recreational boating (particularly fishing) is a recognised source of marine debris. In 2013, TAngler bins were introduced to help reduce the amount of recreational fishing debris in the Gladstone Region marine environment. Monitoring of this initiative has suggested positive environmental results with 1,472 items weighing 12.3 kg collected from the bins, which equates to approximately 1,000 items/week (Wilson 2014b). Not surprisingly, 70% of items recovered from the bins were fishing-related items (line, bait bags, tackle), and a corresponding shoreline survey conducted around the bins found a decrease in fishing-related items in the debris collected from the surrounding environment (Wilson 2014b). Interestingly, the bins at shore-based fishing sites had greater usage than those located at boat ramps (Wilson 2014b).

Recreational fishing is a popular activity in both the Port of Gladstone and the Port of Rockhampton, and a survey recently conducted in Gladstone found a 25% increase in fishing effort over the past six years, with an estimated 31,000 fishing trips undertaken from key boat ramps from summer 2013 to spring 2014 (Sawynok et al. 2014). The composition of species caught changed significantly with the influx of barramundi (*Lates calcarifer*) from Lake Awoonga when the dam overflowed following an extreme rainfall event in 2011, although that effect was reduced by 2014 (Sawynok et al. 2014).

[33] http://www.msq.qld.gov.au/About-us/Maritime-statistics-and-reports-library.aspx Accessed April 2015.

3.7.2. Commercial fishing

A small but significant commercial fishing industry is based in the Ports of Gladstone and Rockhampton, including trawl, line, gillnet and crab pot fisheries. Species of highest importance include mud crabs (*Scylla serrata*), banana prawns (*Penaeus merguiensis*), blue threadfin (*Eleutheronema tetradactylum*), grey mackerel (*Scomberomorus semifasciatus*), mullet (*Mugil cephalus*/*Liza vaigiensis*), shark (*Carcharhinus* spp.) and barramundi (*Lates calcarifer*) (DAFF 2012). From 1 November 2015 the Fitzroy River and Capricorn Coast will become a net-free fishing zone[34].

The most important commercial species by weight in Gladstone (reporting grid S30) are mud crabs (2,054.68 kg caught from 1990 to 2014), followed by banana prawns (1,370.19 kg). The most important commercial fish species by weight for Rockhampton (reporting grid R30) was again mud crabs (1,457.59 kg caught from 1990 to 2014) (see also Appendix).

Tropical prawn fisheries (otter trawls) generate a higher proportion of bycatch-to-catch than any other fishing method (Stobutzki et al. 1996). Banana prawns are of particular concern as trawling occurs during daylight hours in very shallow waters, close to the coast, and bycatch will wash up on shore causing concern to local tourism operators and recreational fishers as it is highly visible (Stobutzki et al. 1996). Robins and Courtney (1998) found that on average, only 27% of the total banana prawn trawl catch was banana prawns (ranging from 4.91% to 41.35% in 35 trawls). Extrapolating from the 1,370 t of banana prawns caught in Gladstone (Appendix A), a 27% banana prawn catch rate would imply a total catch of 5,074 t. After subtracting the 1,370 t of prawns and 531 t of scallops retained by fishers, as much as 3,173 t of fish may have been discarded in Gladstone between 1990 and 2014; an average of 132 t per year. Whether this discard rate has a localised influence on water quality would depend on discard rates per trip, how much is consumed by birds and fish when it is discarded, and whether discards are released from trawlers in one area or gradually while steaming.

Like recreational vessels (section 3.7.1), commercial fishing vessels may also emit toxins including petrochemicals and anti-fouling chemicals into the marine environment.

[34] https://publications.qld.gov.au/dataset/maps-of-final-net-free-fishing-zones-in-queensland/resource/59882c71-b5d4-4235-9680-4d2e256dccf9 Accessed August 2015.

4. Current water quality monitoring and reporting

Within the Port of Gladstone and Port of Rockhampton there are number of ongoing or recent monitoring programs and studies that have examined water quality issues. This section summarises the monitoring activities that have occurred since 2012 and focuses primarily on regular monitoring over an extended period in each port.

4.1. Port of Gladstone Monitoring

4.1.1. Port Curtis Integrated Monitoring Program

The Port Curtis Integrated Monitoring Program Inc. (PCIMP) is a partnership of Gladstone industries and organisations that undertakes ambient far-field water quality monitoring in Port Curtis and Rodds Bay. PCIMP has been monitoring the health of coastal and marine environments in Port Curtis since 2005. The current program involves quarterly collection and analysis of physico-chemical and water analytes at 54 sites around the port quarterly. Sediment analytes are monitored annually and oysters are also deployed to measure bioaccumulation of metals and fluoride twice per year (Table 4.1).

Table 4.1: Water and sediment quality parameters measured by PCIMP.

Category	Parameter
Physical and chemical	pH, dissolved oxygen saturation, temperature, conductivity, turbidity, total suspended solids, euphotic depth, photosynthetically active radiation, oxidation reduction potential
Metals and non-metals in water	Dissolved metals and metalloids in (filtered) water grabs: aluminium, arsenic, cadmium, chromium, cobalt, copper, gallium, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, uranium, vanadium and zinc
	Total metals and metalloids in water grabs: aluminium, arsenic, cadmium, chromium, cobalt, copper, gallium, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, uranium, vanadium and zinc
	Non-metal in water grabs: cyanide (free, WAD and total), fluoride
Nutrients in water	Chlorophyll *a,* total phosphorus, orthophosphate, total nitrogen, nitrate – N, ammonia – N, nitrite – N, total organic carbon, dissolved organic carbon
Oyster bioaccumulation	Metals and metalloids in oyster tissue: aluminium, arsenic, cadmium, chromium, cobalt, copper, gallium, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, uranium, vanadium and zinc
	Oyster shell: fluoride
Sediment quality	Metals and metalloids in sediment grabs: aluminium, arsenic, cadmium, chromium, cobalt, copper, gallium, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, vanadium and zinc
	Nutrients in sediment grabs: total solids, total nitrogen, total kjeldahl nitrogen, total organic carbon
	Total fluoride in sediment grabs
	Sediment particle size distribution

The site data from PCIMP monitoring is grouped into 13 zones, including all major estuaries, inner to outer harbour locations, and nearby reference areas. The zones were established in collaboration with EHP and are defined in the EHP Water Quality Objectives and used in the zoning for the Gladstone Healthy Harbour Partnership report card.

4.1.2. Gladstone Ports Corporation monitoring

As the port operator and the major shoreline landholder in the area, GPC undertakes a number of water quality monitoring and assessment activities. As discussed in section 3.4.1, GPC has a Long Term Monitoring and Management Plan (LTMMP) for sea disposal of maintenance dredge material as part of its Environmental Management System. This plan is a working management document that seeks to ensure that all reasonable and practicable measures will be implemented to prevent and/or minimise the likelihood of environmental harm caused by sea dumping activities. These include routine water quality monitoring such as:

- Two sites at the East Banks Sea Disposal Site are sampled for the same parameters measured by PCIMP, i.e. quarterly water physico-chemical parameters, nutrients and metals; quarterly oyster deployment for bioaccumulation of metals; twice-yearly sediment metals.
- Continuous monitoring of physico-chemical parameters is undertaken at the Boyne, Clinton and Fishermans Landing wharves.
- Photosynthetically active radiation (a measure of sub-surface light) is currently being monitored continuously at seven locations.
- Seven seagrass beds are monitored for extent, composition and condition quarterly, until 2016.

A major recent undertaking was the development and expansion of the facilities in the Western Basin of the Port of Gladstone. The WBDDP involved the deepening and widening of existing channels and swing basins as well as the creation of new channels, basins and berths. As a condition of environmental approval by the (then) SEWPaC, a Port Curtis and Port Alma Ecosystem Research and Monitoring Program (ERMP) was developed and implemented (see also Section 5 of this report).

The ERMP has funded a variety of marine ecosystem research projects including an assessment of trends in water quality in Port Curtis and Port Alma. These are only one component of a large array of water quality studies conducted recently by Queensland Government agencies (see section 4.1.4 below for more detail). The findings from the ERMP funded study by Hale (2013) are summarised below:

- The WBDDP had a dedicated water quality monitoring program with a total of 22 sites (17 of which are within the Port Curtis study area). The program comprised continuous (15 minute interval) logging of physico-chemical parameters (temperature, salinity, turbidity, pH and dissolved oxygen) and light attenuation; as well as monthly samples for nutrient and contaminant analysis. The program commenced in 2009 and data was provided for the period November 2009 to September 2012 for physico-chemical logger data and from July 2010 to January 2013 for periodic nutrient and contaminant data.

- The findings of the water quality monitoring showed that salinity, temperature and dissolved oxygen are all influenced by climate, and follow seasonal as well as longer term climatic cycles. Increased rainfall and associated river flow since late 2009 resulted in a trend of declining salinity in estuary sites and this is reflected in lower median salinity at inshore sites in Port Curtis during the wet season.
- Dissolved oxygen concentrations were lower at inshore sites, compared to those offshore, perhaps due to increased river influences and organic material in the water column. However, dissolved oxygen was within water quality guidelines at all sites in Port Curtis.
- Suspended sediments within Port Curtis are from two predominant sources: inflows from the catchment and re-suspension from the seabed either by natural forces of waves and currents or human intervention. Dredging, increased rainfall and river flows have influenced water clarity. There is a trend of increased turbidity in the Calliope and Fitzroy rivers since increased rainfall in late 2009. This affected water clarity in the Port Curtis region. There is also evidence of increased turbidity associated with dredging in the Western Basin, but these effects do not extend out into the outer harbour and beyond.
- The pH in Port Curtis remained within water quality guideline values. Nutrients in Port Curtis are strongly influenced by catchment inputs. There is trend of increased nutrients in the Fitzroy and Calliope estuaries from late 2009 onwards.
- Median nutrient concentrations at inshore sites in Port Curtis were higher than those offshore, reflecting the influence of river discharges. Concentrations of total nitrogen, ammonium, and orthophosphate were within water quality guidelines. Water quality guidelines for nitrate-nitrite and total phosphorus were exceeded at some inshore sites. Chlorophyll *a* concentrations, however, remained within guideline levels.
- One of the major findings was that there is little or no data available for the Port Alma section of the study area.

4.1.3. Other industry near-field monitoring

A number of industries utilise the waterways and foreshores of the Port of Gladstone. These include metal and non-metal manufacturing, mineral and metal wholesaling, chemical manufacturing and power generation. As part of their environmental approvals or conditions to operate, ongoing water quality monitoring takes place in their near-field environment. Monitoring is undertaken for physico-chemical parameters, metals, nutrients and other selected parameters depending on the industry. Table 4.2 summarises the number of sites and frequency of this monitoring as well as all other relevant programs within the port including PCIMP, GPC monitoring, Queensland Government monitoring, industry near-field monitoring, community monitoring and ongoing research programs.

Table 4.2: Summary of water quality monitoring for the Port of Gladstone presented as: number of sites (frequency per year). ">" means greater than.

Parameter	Far Field - PCIMP	Estuarine - Queensland Government	Near field - Industry	Community	Research
Physical and chemical parameters	54 (4)	15 (12)	>18 (continuous/ hourly/monthly)	4 (4)	
Metals – dissolved	54 (4)		>18 (12)		
Metals – total	54 (4)		>18 (12)		
Cyanide	54 (4)				
Nutrients	54 (4)	4 (12)	>18 (12)		
Chlorophyll *a*	54 (4)	15 (12)	>12 (12)		
Light (PAR*)	54 (4)		7 (continuous)		
Fluoride	54 (4)		12 (12)		
TOC/DOC*	54 (4)		>18 (12)		
Major cations/anions			>18 (12)		
Sediment analytes	54 (1-2)		>18 (1-2)		
Sedimentation/TSS*	54 (4)		6 (continuous/ monthly)		
Plastics/debris				4 (4)	11 (2)
Biomonitors – oysters	54 (2)		6 (once/quarterly)		
Plankton, mangroves, seagrass			>7 (4)	4 (4)	200km(2)

* Abbreviations: PAR = photosynthetically active radiation; TOC = total organic carbon; DOC = dissolved organic carbon; TSS = total suspended solids

4.1.4. Queensland Government monitoring

The Queensland Department of Science, Information Technology and Innovation (DSITI) and its predecessor organisation (DSITIA) have routinely monitored estuaries within the Gladstone region, amongst others in the state. Site- or event-specific monitoring is also undertaken *ad hoc* by the Department of Environment and Heritage Protection (DEHP). Recent monitoring activities by both these organisations are described below.

- Routine monthly monitoring has been ongoing since 1993 at selected estuarine sites to provide condition and trend data. There are five sites in the Boyne River estuary (mouth to Benaraby) and 10 in the Calliope River estuary (mouth to Devils Elbow). Water quality recorded includes electrical conductivity, temperature, pH, dissolved oxygen, turbidity, clarity (secchi depth), nutrients (nitrates and phosphates) and chlorophyll *a*. The Calliope and Boyne rivers rarely have water quality exceedances above ANZECC water quality trigger values. These are mostly for turbidity (near the mouth) or dissolved oxygen after high flow.
- The Baffle Creek estuary to the south of Agnes Water is also monitored monthly for five sites as above. Added to this, a monitoring station situated 16 km upstream of the creek mouth has been recording continuous water quality data since 2012. This station reports at 30 minute intervals for electrical conductivity, temperature, pH, dissolved oxygen, turbidity and

chlorophyll *a*. While outside of the port area and outside of the Fitzroy Basin region, this site provides important reference water quality condition, both current and historical.

- In September 2011, in response to the fish health concerns in Gladstone Harbour, monthly water and sediment quality monitoring was conducted for 12 months. This included analysis at sites across the harbour for physico-chemistry, nutrient, metals and metalloids and chlorophyll *a* (DEHP, 2012). The findings concluded that water quality on the whole did not vary from historical records apart from the result of an exceptional wet period in 2011. Aluminium, arsenic, copper, molybdenum and zinc all exceeded water quality trigger values at some times but these instances were few and were not likely attributable to fish health issues. Geographically, aluminium was found to be elevated in South Trees Inlet linked to inputs from local industry. Turbidity was similarly elevated across the whole harbour and was positively correlated with manganese, molybdenum and vanadium. These metals, however, rarely exceeded their respective trigger values.

In response to a significant flooding event from Lake Awoonga and the Boyne River in January 2013 the water quality in the Gladstone waterways was monitored regularly until September 2013. Physico-chemistry, nutrient, metals and metalloids and chlorophyll *a* were recorded from up to 52 sites. The major findings were that turbidity and nutrients were elevated throughout the region but dropped shortly after the pulse. Dissolved aluminium was elevated in the Boyne River and South Trees Inlet post-flood exceeding the low reliability trigger value (0.5 ug/L). Molybdenum and arsenic also exceeded respective trigger values briefly in South Trees Inlet. Investigation of the fractions of aluminium at selected sites found that the Boyne River sites were predominantly in the less bioavailable colloidal fraction likely from natural catchment sources. The South Trees sites, however, were higher in low molecular weight fractions linked to other sources (DSITIA 2013).

4.1.5. Port Curtis Harbour Watch

Port Curtis Harbour Watch is a school- and community-based program that monitors marine and estuarine water and substrate in Gladstone Harbour and the surrounding environment. The program is facilitated by the Boyne Island Environmental Education Centre. The aims of Harbour Watch are to:

- expose students to the practice of science in contemporary and socially engaged settings
- provide opportunities for community members to become involved in assessing the condition of their local environment
- assist in gathering data as a contribution to regional monitoring, evaluation and reporting strategies, and
- promote wider community stewardship and responsibility for the future health of the harbour and potentially linking with the GHHP.

The program has been operating since April 2014 and records physical, chemical and biological parameters at selected locations in the harbour. Parameters are recorded at sites outside of that recorded in PCIMP and include selected nutrients, temperature, pH, dissolved oxygen, conductivity and turbidity as well as plankton and macrobenthos. Since their official launch, over 1000 students have participated in Harbour Watch and the program continues to grow annually.

4.1.6. Marine debris research

Since 2011, quarterly surveys of marine debris at four beaches within the Port Curtis region (two harbour and two coast sites) have been undertaken by Conservation Volunteers Australia and CQUniversity (Wilson & Hansler 2014). The aim was to determine the amounts and types of marine debris across the region and to document changes over time. This is one of the few areas along the Queensland coast where quantifiable studies have been conducted.

A total of 20,999 debris items were collected over the three-year study with the amounts of debris found per m^2 rating the region's coastal beaches as "clean" on the Clean Coast Index (Table 4.3). Comparatively, data from sites in Keppel Bay were found to have similar levels of debris to the Gladstone sites but Nine Mile Beach on the Shoalwater Peninsula to the north was classed as "dirty" due to the localised currents bringing in oceanic debris (Wilson 2012). The amounts of debris within the Gladstone region can be considered typical for a regional Queensland coastal city.

There was no significant change in debris loads within the Gladstone region (Wilson & Hansler 2014) across the three-year sample period (Figure 4.1). Plastics made up between 77% to 97% of the total loads depending on location and time. The most common individual item was plastic fragments, indicative of the fractionation of plastic that commonly occurs once it enters the marine environment and highlights the potential risks that local fauna may be exposed to from this type of debris. The second most prevalent item was rope, which was representative of the high levels of boating and fishing activities occurring in the region. Water-borne sources were the major source of debris identified, with land-based sources accounting for approximately a third of the total.

Table 4.3: Mean marine debris accumulation rate for the Gladstone Region 2011–2014.

	Year	Fishermans Landing	Chinaman Island	Facing Island	Rodds Peninsula	Total
Mean debris (items/m^2)	2013/2014	0.09	0.12	0.09	0.12	0.11
	2012	0.04	0.08	0.14	0.10	0.09
	2011	0.09	0.23	0.17	-	0.16

Shoreline debris surveys and TAngler (fishing line waste) bin assessments were also undertaken within the Gladstone Region in 2013 (Wilson 2014b; Wilson & Cartraud 2014) as part of GPC's Biodiversity Offset Strategy (BOS) — a condition of approval for the WBDDP (see also section 5.3 for further details) at different locations to those reported above. Fourteen TAngler bins from 10 sites were assessed in two six-week blocks (winter and summer) and a total of 1,472 items of litter weighing 12.3 kg were found in the bins over the entire sampling program equating to 123 items at 1.03kg per week. Fishing-related items (line, tackle, bait bags) were the most common items found in the bins, making up approximately 70% of all items by number.

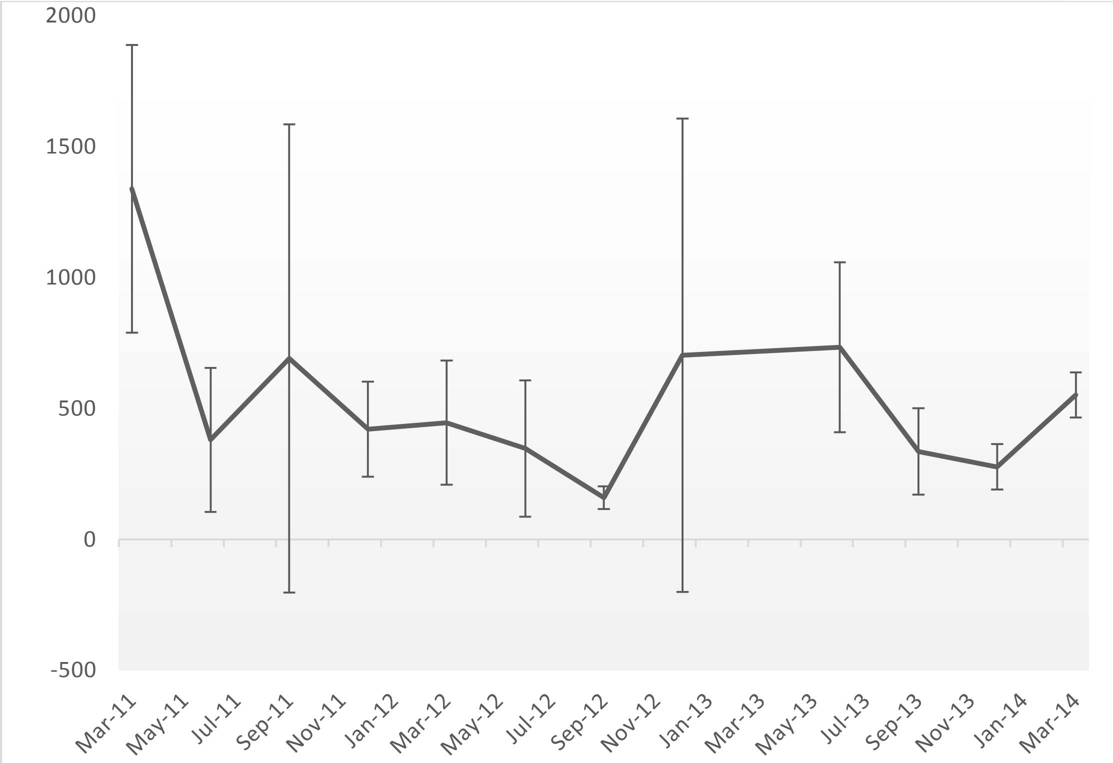

Figure 4.1: Mean beach debris loads found in Gladstone between March 2011 and March 2014.

To evaluate the success of these bins at reducing shoreline debris loads, 12 sites across the region were analysed both prior to bin instalment and post-instalment. A total of 23,306 items of litter weighing 311.67 kg were collected from Gladstone's estuarine shoreline, equating to 0.48 items and 6.41 g/m^2. On the Clean Coast Index of litter loads, this data rates Gladstone as a "moderate" level of pollution. All shorelines had debris present throughout the study, with sites popular for fishing or boating recording the most debris. Glass, metal, hard plastics and rope/fishing line were the most common items found. A decline in overall debris loads and specifically rope and fishing line (although not statistically significant) was found at sites after the bins had been installed (compared to prior) and at sites with TAngler Bins present (compared to those without), suggesting that these bins were partly successful at removing a proportion of this type of debris.

Debris tracking studies using drift cards and satellite trackers have been undertaken with both the Port of Gladstone and Port Alma regions. In 2012–13, a study by CQUniversity (Wilson 2013), found coastal outputs from the Gladstone Harbour and Fitzroy River sites influenced the near-shore beaches immediately to the north of the outputs. This was in line with the prevailing south-easterly winds and the northerly longshore current. The aspect of the coast in this region also means that debris from these sources will generally not travel large distances from the source (e.g. up to 50 km) under low-flow conditions. The debris from offshore shipping berths off Gladstone and the channel out to the Reef suggest that litter will move north up the coast and land on the northern beaches of the region (e.g. North Keppel Island, Nine Mile Beach, Five Rocks and the Shoalwater peninsula). These are distances in excess of 100 km. Despite the location there appeared to be parallel movements of loggers both near-shore and offshore up the coast.

A more intensive tracker study within the Port of Gladstone was undertaken in 2014 (Wilson 2014a). The data from both drift cards and satellite trackers indicated that deposition hot spots occur in the harbour at Barney Point and Parsons Point and on the coast at Lillies/Boyne Beach and Tannum Sands Beaches, depending on the release points. The majority of cards were reported back within 30 days of release but some cards moved relatively rapidly out of the harbour (less than a day) reflecting the large tidal fluctuations present in the region. The data also indicates that once debris reaches the coastal currents the distribution becomes more widespread but follows the predominantly northward pattern with the longshore current, as documented in the previous study.

4.1.7. MangroveWatch

MangroveWatch is a community-based monitoring program run by James Cook University that records the condition of mangroves. In March 2015 an ERMP project was launched with support from Gidarjil Development Corporation. The program will assess 200 km of mangrove shoreline twice a year.

This Port Curtis and Port Alma project relies primarily on video assessment of shoreline habitats collected by community volunteers and sent to the hub for analysis. The Shoreline Video Assessment Method (SVAM) uses qualitative assessments of shoreline habitat, physical condition and human influence, determined from continuous video recordings of the shoreline and intertidal zone along coastline/estuary banks. The video is analysed for a number of features that relate to the condition of the coast. Simultaneous GPS data enables these features to be mapped to give a spatial representation of shoreline habitats and their condition. These ground surveys are supplemented with aerial habitat mapping.

4.2. Gladstone Healthy Harbour Partnership

Gladstone Healthy Harbour Partnership (GHHP) is a forum to bring together parties and stakeholders to maintain and, if necessary, improve the health of Gladstone Harbour. GHHP aims to bring about efficient, cost-effective, targeted monitoring and research activities focused on GHHP needs and priorities, and management recommendations and action to avoid any monitoring/research duplication — including existing industry and research effort to maximise and optimise value of investment (both time and money) while improving the quality of the data generated from monitoring and research programs. GHHP is overseen by a Management Committee whilst research and monitoring is overseen by an Independent Science Panel.

A key aspect of the partnership is the development of a report card for Gladstone Harbour. It seeks to report on the environmental, social, cultural and economic factors based on harbour zones or local government boundaries. For the environmental results, the harbour is divided into 13 zones. A pilot report was released in 2014 with the following overall grades reported:

- Environmental – C
- Social – C
- Economic – B
- Cultural – No report

Within the 2014 environmental reporting category, data was based upon the following parameters derived from the PCIMP water quality data set: dissolved oxygen saturation, turbidity, total nitrogen, total phosphorus, aluminium and copper.

Nine of the 13 Gladstone Harbour zones received an overall environmental score of greater than 0.50 (≥C grade; "satisfactory"). The highest scores for water quality were recorded in the Inner Harbour (0.74), Outer Harbour (0.69), South Trees Inlet (0.68) and Graham Creek (0.68), while the estuarine zones of Auckland Inlet (0.41), Boat Creek (0.47), Boyne Estuary (0.47) and Calliope Estuary (0.48) recorded D ("poor") grades (Figure 4.2).

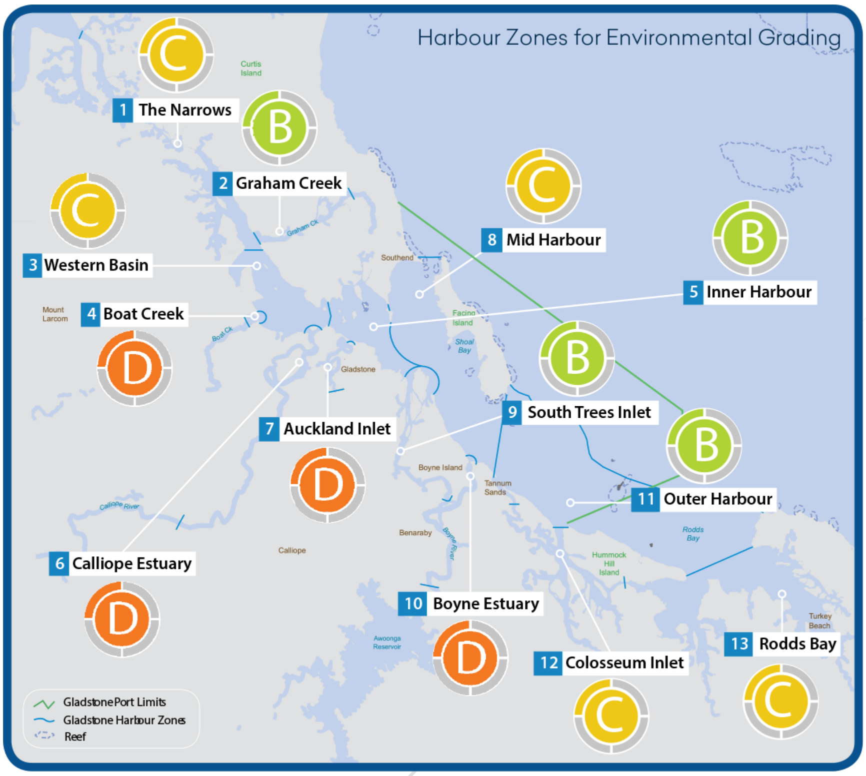

Figure 4.2: GHHP 2014 Pilot Report Card environmental grades (Source: GHHP[35])

From 2015 the report card will include the following additional environmental indicator groups: sediment quality, connectivity, habitats (seagrass, mangroves and coral), fish and crab health.

Social health was assessed based upon a community survey of 400 people. Of the three indicator groups used overall, respondents were satisfied with harbour access, liveability and wellbeing and harbour usability (all three indicators scored a C; "satisfactory"). For economic health, economic stimulus received the highest score of 0.87 (A; "very good") and economic performance and economic value were both graded B ("good"). The economic stimulus grade reflects the comparatively high socio-economic status of the Gladstone community and high levels of employment.

[35] http://rc.ghhp.org.au/report-cards Accessed June 2015

4.3. Port of Rockhampton monitoring

4.3.1. Gladstone Ports Corporation monitoring

As part of the routine monitoring of the Port of Rockhampton, two sites are monitored quarterly in a similar program to PCIMP and the two GPC East Banks monitoring sites in the Port of Gladstone. Parameters measured include physico-chemical parameters, nutrients and metals in water and sediment, and oysters are deployed quarterly for bioaccumulation of metals (Table 4.4). Benthic sampling is also being undertaken at both sites in 2015.

4.3.2. Queensland Government monitoring

EHP and lately DSITI routinely monitor the Fitzroy River estuary. This includes the following routine monthly monitoring (ongoing since 1993) in the Fitzroy River estuary (mouth to the barrage) at (currently) 13 sites. The following water quality parameters are recorded: electrical conductivity, temperature, pH, dissolved oxygen, turbidity, clarity (secchi depth), nutrients (nitrates and phosphates at two sites only) and chlorophyll *a*. For the Fitzroy River, turbidity is naturally elevated and as the estuarine portion is longer than 40 km, the Queensland turbidity guideline value does not apply. Dissolved oxygen only falls below guideline values after high flow events but for the most part, is within range. Nutrients in the Fitzroy consistently exceed water quality guidelines levels, the highest closest to the sewage discharge.

4.3.3. MangroveWatch

James Cook University facilitates MangroveWatch surveys for region that include the mangroves in and around the Port of Rockhampton, the Fitzroy Delta and The Narrows. These are monitored twice annually using the video assessment technique as described above for the Port of Gladstone under the GPC ERMP (recorded as research monitoring in Table 4.4).

Table 4.4: Summary of water quality monitoring for the Port of Rockhampton presented as: number of sites (frequency per year). “>” means greater than.

Parameter	Far Field	Estuarine – Queensland Government	Near field – Industry	Community	Research
Physico-chemistry		13 (12)	2 (4)		
Metals – dissolved			2 (4)		
Metals – total			2 (4)		
Non-metals – cyanide					
Nutrients		2 (12)	2 (4)		
Chlorophyll a		13 (12)	2 (4)		
Light (PAR*)					
Fluoride					
TOC/DOC*			2 (4)		
Major cations					
Sediment metals					
Sedimentation/TSS*					
Plastics/debris					1 (2)
Biomonitors – oysters			2 (4)		
Mangroves					200 km (2)

* Abbreviations: PAR = photosynthetically active radiation; TOC = total organic carbon; DOC = dissolved organic carbon; TSS = total suspended solids

4.4. Fitzroy Partnership for River Health

The Fitzroy Partnership for River Health is a collective of government, agriculture, resources, industry, research and community interests across the Fitzroy Basin in Central Queensland. The partners have a common goal of providing a more complete picture on river health and support this goal by providing funding, resources and contributing water quality and ecosystem health monitoring data through data-sharing arrangements. The Fitzroy Partnership was formally established in February 2012 with the first report card on the aquatic ecosystem health released in May 2013 from 2010–11 data. Two subsequent aquatic ecosystem health report cards were released in 2014, for the 2011–12 and 2012–13 water years and the 2013–14 report card was released at the end of June 2015. Details on the development of the Ecosystem Health Index and Report Card for the Fitzroy Partnership for River Health (Flint et al. 2012) are available on the Fitzroy Partnership website[36].

The overall grade for Aquatic Ecosystem health for the Fitzroy Basin for the last report for the 2013–14 period was B; ‘good’. In the Fitzroy estuary zone, overall ecosystem health was found to be in a B; ‘good’ condition this period with:

- Good results for physico-chemical indicators
- Good or Fair results for nutrient indicators, and
- Good or Fair results for biological indictors.

[36] http://riverhealth.org.au/resources/program-design/cqu-report/

The assessment was based on 12 sites (1,259 samples) to determine the overall estuary grade.

4.5. Other programs and studies

There are a number of other programs or studies that fall outside the scope of this report noted below.

4.5.1. Creek Watch Gladstone

The Gladstone Creek Watch program is a citizen science approach to monitoring local waterways. The program began in March 2015 and seeks to engage the local community and school groups and develop a sense of ownership for individual waterways in the region. The program monitors the Police Creek, and upper Calliope and Boyne river catchments every two weeks. Data on physico-chemistry, macro-invertebrates and fish are recorded as well as notes on the presence of pest and weed species. The data and program design is overseen by a technical committee made up of representatives from government agencies and universities.

4.5.2. Other Queensland Government monitoring

In the freshwater reaches of the catchment the Queensland Government records rainfall and flow conditions as well as electrical conductivity at some sites. These are managed by the Queensland Department of Natural Resources and Mines and the Australian Bureau of Meteorology. There are numerous gauging stations present in the Fitzroy River catchment and a single station at Castlehope on the Calliope River and one below Awoonga Dam on the Boyne River. Rainfall gauge stations are present throughout the region.

4.5.3. Marine Monitoring Program

The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for the Marine Monitoring Program (MMP) that measures concentrations of dissolved and particulate nutrients (nitrogen, phosphorus and carbon), chlorophyll, salinity, temperature, suspended solids and pesticides using various techniques such as satellite remote sensing, automated data loggers, passive samplers and in situ water sample collection. In the Capricorn and Curtis region most of the monitoring is undertaken in Keppel Bay (see Figure 4.3, as an example). The MMP is a key component of the Reef Water Quality Protection Plan (Reef Plan), a joint commitment of the Australian and Queensland governments. MMP data is combined with paddock and catchment level data to produce an annual report card on the health of the Reef.

4.5.4. AIMS monitoring

The Australian Institute of Marine Science (AIMS) hosts a number of programs monitoring water quality in marine and coastal areas that feed into the GBRMPA water quality guidelines for the Great Barrier Reef. In the near-shore coastal environment, measurement of water column temperature, salinity, turbidity, nutrient, chlorophyll and suspended sediment concentrations takes place as part of the MMP. There is also long-term chlorophyll *a* monitoring in coastal areas within the region and biological monitoring of inshore reefs. AIMS are also involved in the Great Barrier Reef Ocean

Observing System (GBROOS) node of the nation-wide Integrated Marine Observing Scheme (IMOS), which includes high-frequency and broad-scale reef water quality in the Reef. This includes using "underway" sensor systems installed on vessels that traverse the Reef. An IMOS radar station at Tannum Sands provides current flow and condition for the local area.

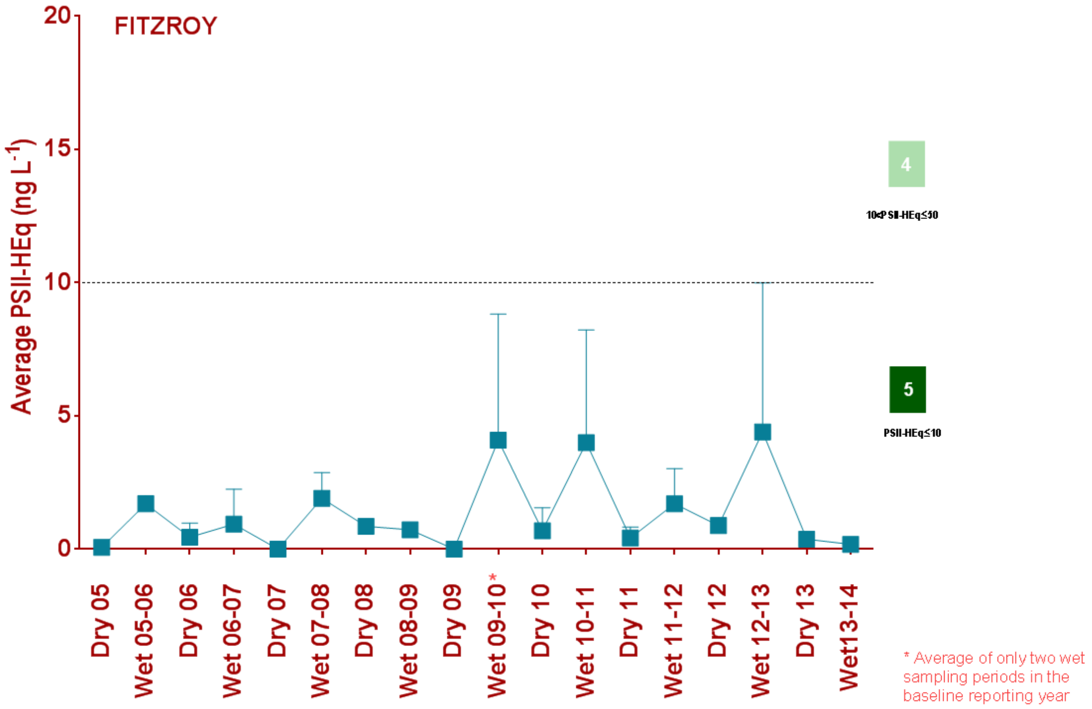

Figure 4.3: PSII herbicide ranges for North Keppel site over time (Gallen et al. 2014)

4.5.5. Other studies

There are numerous scientific studies that have been undertaken within the Port of Gladstone and Port of Rockhampton. Most of these have been one-off, short-term or historical studies but provide baseline or further information on water quality issues in the region and can assist in water quality improvement. These include:

- Environmental Impact Statements from various proponents that may or may not have eventuated e.g. Fitzroy Terminal Project, BICET, APLNG, QGC, GLNG, WICET, WBDDP, Channel duplication.
- Coastal CRC for Coastal Zone, various Estuary and Water Management reports (1999–2006)
- Other Government agency studies e.g. CSIRO metals in water and sediment 2012, EHP Turtle monitoring, DAFF fish health studies 2011–2012.
- Postgraduate theses e.g. Manganese toxicity and oxidation in Port Curtis (Anastasi 2015), Conservation of dolphins in Capricorn coast (Cagnazzi 2010), Coral reef condition in Keppel Islands (Jones 2009), Mud crab shell disease (Andersen 2003), Water quality risk assessment for Port Curtis (Jones 2002).

- Other research studies e.g. CQUni seagrass research, Southern Cross University dolphin research, James Cook University seagrass research, ERMP migratory bird, coral and megafauna studies and ambient noise studies.
- Other industry-funded programs e.g. Gas Industry Social and Environmental Research Alliance (2011–2016) have conducted an integrated study of the Gladstone marine environment. This study included bio-optical water properties, seagrass distribution and growth and turtle movements (Babcock et al. 2015).

5. Water quality management

Environmental management in the Ports of Gladstone and Rockhampton is primarily the responsibility of the Queensland Government, which is also responsible for the management of catchment activities impacting on water quality, such as land clearing and industrial emissions (SEWPaC 2013). The Queensland Government has granted GPC the authority to manage port operations (SEWPaC 2013) and it operates in accordance with an accredited environmental management system (EMS). The Australian Government also has a role in environmental management in the ports, relating to the national interest, the protection of matters of National Environmental Significance and maritime issues such as sea dumping and ballast water.

5.1. Environmental legislation and agreements

Water quality has local, state, national and international implications, and there is water quality legislation and legislation managing matters that may be impacted by poor water quality at all levels of government, as well as agreements at the international level. Figure 5.1 summarises some of the legislation and agreements that are most relevant to water quality issues in the Ports of Gladstone and Rockhampton. However, there are many more policies and legislative instruments that have some relevance to water quality management than those described here.

Queensland Government

- *Environmental Protection Act 1994*
- *Nature Conservation Act 1992*
- *Fisheries Act 1994*
- *Sustainable Planning Act 2009*
- *State Development and Public Works Organisation Act 1971*
- *Coastal Protection and Management Act 1995*
- *Land Act 1994*
- *Marine Parks Act 2004*
- *Transport Operations (Marine Pollution) Act 1995*
- *Vegetation Management Act 1999*
- *Water Act 2000*

Australian Government

- *Environment Protection and Biodiversity Conservation Act 1999*
- *Environment Protection (Sea Dumping) Act 1981*
- *Protection of the Sea (Prevention of Pollution by Ships) Act 1983*
- *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006*
- *Australian Maritime Safety Authority Act 1990*
- *Great Barrier Reef Marine Park Act 1975* (proximity to the GBRMP)

International Agreements

- International Convention for the Prevention of Pollution from Ships (MARPOL)
- International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM)
- International Convention on the Control of Harmful Anti-fouling Systems on Ships (HAFS)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- UNESCO World Heritage List (Great Barrier Reef)
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention; London Protocol)

Figure 5.1: Some of the international agreements, Australian Government and Queensland Government legislation relating to managing water quality, and managing matters that may be affected by water quality, in the Ports of Gladstone and Rockhampton.

5.1.1. International Agreements

The international agreements with highest relevance to the water quality in the Port of Gladstone and the Port of Rockhampton are:

- MARPOL: The International Convention for the Prevention of Pollution from Ships aims to prevent and minimise both accidental and operational shipping pollution. It was adopted on 2 November 1973 at the International Maritime Organization. A 1978 protocol was then adopted following a series of tanker accidents in 1976–77, and as the 1973 protocol hadn't yet come into force a combined instrument was created which came into force on 2 October 1983. Since then there have been several further amendments to MARPOL including the adoption of an Annex in 2005 that focuses on air pollution including setting limits on sulfur oxide and nitrogen oxide emissions from ship exhausts. As a signatory to MARPOL since 1987, Australia requires ships to report pollution or potential pollution incidents; this is managed by AMSA (under the *Australian Maritime Safety Authority Act 1990*)[37]. The

[37] http://www.amsa.gov.au/environment/legislation-and-prevention/amsas-role-in-maritime-environment-issues/ Accessed June 2015.

legislation giving effect to MARPOL in Australia includes the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*[38].

- HAFS Convention: The International Convention on the Control of Harmful Anti-Fouling Systems on Ships (HAFS Convention) prohibits the use of harmful organotins (including TBT) in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems. Organotins were prohibited because of their impacts on non-target marine life. They persist in the water after leaching from anti-fouling paints, harming the environment and possibly bioaccumulating through the food chain. Parties to the HAFS Convention are required to "prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships not entitled to fly their flag but which operate under their authority and all ships that enter a port, shipyard or offshore terminal of a Party". Prohibited and controlled anti-fouling systems are listed in an annex to the Convention, which is updated when necessary[39]. Australia became a party to the Convention in 2007 and implements the Convention through the *Protection of the Sea (Harmful Anti-fouling Systems) Act 2006*[40].

- BWM Convention: The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted by Australia in 2005. The convention will enter into force "12 months after 30 States with combined merchant fleets constituting 35% of the gross tonnage of the world's merchant shipping have signed"[41]. It will require all ships to implement ballast water management plans, carry ballast water record books and carry out ballast water management procedures to a defined standard. Australia has applied ballast water management in its waters since 2001. The Australian Department of Agriculture is currently developing new ballast risk-management legislation (the Biosecurity Bill 2014).

- London Protocol: The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (the "London Convention"), in force since 1975, is a global convention to protect the marine environment from human activities. Its objective is to "promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter"[42]. Currently, 87 States are Parties to the London Convention. The "London Protocol" was agreed in 1996 as a means of modernising and eventually replacing the Convention. Under the London Protocol all dumping is prohibited, except for possibly acceptable wastes that have been explicitly permitted (on the 'reverse list'). There are currently 45 Parties to the Protocol. See also *Environment Protection (Sea Dumping) Act 1981,* in section 5.1.2 of this report.

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[38] https://www.amsa.gov.au/environment/legislation-and-prevention/protection-of-the-sea/index.asp Accessed June 2015.
[39] http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-the-Control-of-Harmful-Anti-fouling-Systems-on-Ships-(AFS).aspx Accessed August 2015.
[40] https://infrastructure.gov.au/maritime/environment/anti_fouling.aspx Accessed August 2015.
[41] http://www.amsa.gov.au/environment/legislation-and-prevention/amsas-role-in-maritime-environment-issues Accessed June 2015.
[42] http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx Accessed August 2015.

- GBR World Heritage Listing: The GBR was inscribed on the UNESCO World Heritage List in 1981 for its outstanding universal value. Those values could be threatened by water quality issues and in 2012 the World Heritage Centre and IUCN conducted a reactive monitoring mission to the GBR to assess the state of the world heritage property, stating in the Mission Report: "Considering the overarching importance of water quality to the Reef's health, it is indispensable that the current level of investment in measures to tackle this threat is maintained and the recent positive trends are sustained"[43]. On 29 May 2015, following consideration by the World Heritage Committee of the state of conservation of the GBR World Heritage Area, the World Heritage Centre recommended against the GBR being listed as 'in danger'. The recommendation was made following Australian and Queensland government actions to protect the Reef, including $200 million in funding, bans on disposal of capital dredge material in the World Heritage Area and restrictions on port development[44]. The Ports of Gladstone and Rockhampton are both within the World Heritage Area, and predate its inscription (SEWPaC 2013).

- Bonn Convention: The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) is an environmental treaty under the United Nations Environment Program, providing for the conservation and sustainable use of migratory animals and their habitats[45]. In Australia, the species listed under the Bonn Convention are automatically listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as "migratory species". Migratory species also includes species listed under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China-Australia Migratory Bird Agreement (CAMBA); and any native, migratory species identified in a list established under international agreements approved by the Minister (e.g. the Republic of Korea-Australia Migratory Bird Agreement — ROKAMBA)[46]. Species found in the marine areas of the Fitzroy region and potentially in the ports include 10 migratory marine bird species, two species of migratory mammals (dugong and humpback whale) and seven migratory reptiles (e.g. marine turtles and the saltwater crocodile) (GBRMPA 2013). Water quality can directly influence the health of some of these species, and can have flow-on impacts through trophic cascades and behaviour impacts in others.

5.1.2. Australian Government legislation

A variety of Australian Government legislation and policies have relevance to ports and/or marine water quality. As well as the *Australian Maritime Safety Authority Act 1990, Protection of the Sea (Harmful Anti-fouling Systems) Act 2006,* and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* described above, the most significant of these include:

- EPBC Act: Administered by the Department of the Environment, the EPBC Act covers matters including protected species (migratory species as described above, "marine species" and

[43] http://whc.unesco.org/document/117104 Accessed August 2015.
[44] http://www.environment.gov.au/minister/hunt/2015/mr20150529.html Accessed June 2015.
[45] http://www.cms.int/en/legalinstrument/cms Accessed June 2015.
[46] http://www.environment.gov.au/cgi-bin/sprat/public/publicshowmigratory.pl Accessed June 2015.

"listed threatened species and ecological communities") and other matters of National Environment Significance: world heritage properties, national heritage places, wetlands of international importance (under the Ramsar Convention), Commonwealth marine areas, the GBRMP, nuclear actions (including uranium mines) and water resources (in relation to coal seam gas and large coal mining development)[47].

- *Environment Protection (Sea Dumping) Act 1981*: Australia regulates waste at sea under the Sea Dumping Act, fulfilling its obligations as a signatory to the London Protocol (or Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter). The Act most usually applies to dredging operations, the creation of artificial reefs and vessel dumping[48].

- *Great Barrier Reef Marine Park Act 1975* (GBRMP Act): The Ports of Gladstone and Rockhampton are not within, but are in close proximity to the GBRMP, which is managed by GBRMPA under the GBRMP Act. The GBRMP Act is the primary act relating to the marine park, and provides for the long-term protection and conservation of the environment, biodiversity and heritage values of the GBR Region[49].

5.1.3. Queensland Government legislation

Similar to Australian Government legislation, there is a variety of State legislation relating to water quality. The most relevant Queensland Government legislation to the Ports of Gladstone and Rockhampton includes:

- *Environmental Protection Act 1994* (EP Act): The EP Act provides for Environmental Authorities that allow industrial, resource or intensive agricultural activities with the potential to release contaminants into the environment to be undertaken[50]. Port-side industries in Gladstone and Rockhampton operate under Environmental Authorities and it is usually the conditions on these authorities that require environmental monitoring be undertaken (as described in Section 4 of this report).

- *Nature Conservation Act 1992*: This Act and its subordinate Regulations aim to conserve nature while allowing for social and cultural values, and ecologically sustainable use. The Nature Conservation (Wildlife) Regulation 2006 lists 814 plant and animal species that are threatened in Queensland including a variety of marine species (e.g. sea turtles, crocodiles, dugong, several species of dolphin and humpback whales)[51]. Some of these species could be directly or indirectly impacted by poor marine water quality.

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[47] http://www.environment.gov.au/epbc/what-is-protected Accessed June 2015.
[48] http://www.environment.gov.au/topics/marine/marine-pollution/sea-dumping/sea-dumping-act Accessed June 2015.
[49] https://www.comlaw.gov.au/Details/C2015C00168 Accessed June 2015.
[50] http://www.ehp.qld.gov.au/management/non-mining/environmental-authority.html Accessed June 2015.
[51] https://www.ehp.qld.gov.au/wildlife/threatened-species/index.html Accessed June 2015.

- *Fisheries Act 1994*: The Fisheries Act sets out responsibilities for "economically viable, socially acceptable and ecologically sustainable development of Queensland's fisheries resources"[52]. The Act and the Fisheries Regulation 2008 provide for the declaration and management of Fish Habitat Areas. There are several Declared Fish Habitat Areas in proximity to the Ports of Rockhampton and Gladstone (see Figure 2.4, Section 2 of this report). A Declared Fish Habitat Area Investigations Program — Central Queensland, funded by GPC as part of an offsets program, is investigating the declaration of two new Fish Habitat Areas (Calliope River and Leekes Creek on Great Keppel Island) and the possible expansion of two existing declared areas (Cawarral Creek and Fitzroy River, both near Rockhampton)[53]. Dugong Protection Areas are also declared under the Fisheries Regulation (see Figure 2.4, Section 2 of this report). Fish stocks (including commercial fish stocks) can potentially be impacted by marine water quality.

- *Sustainable Planning Act 2009*: This Act is the overarching legislation for Queensland's development and planning, and supersedes the previous *Integrated Planning Act 1997*. The Act seeks to achieve ecological sustainability through development management and planning coordination, including managing the effects of development on the environment[54]. A Sustainable Ports Development Bill 2015 was introduced to Queensland Government on 3 June 2015, to implement key port-related actions of the Reef 2050 Long Term Sustainability Plan[55]. The Bill, if passed as legislation would restrict new port development in and adjoining the GBRWHA, prohibit capital dredging in the World Heritage Area outside four priority ports (ports of Gladstone, Abbot Point, Hay Point/Mackay and Townsville), prohibit sea-based disposal of capital dredge spoil in the World Heritage Area, and mandate that capital dredged material be beneficially reused or disposed on land. The Queensland Government has committed to protecting the Fitzroy Delta, Keppel Bay and North Curtis Island, and the Port of Rockhampton is not a priority port[56].

- *State Development and Public Works Organisation Act 1971* (SDPWO Act): The SDPWO act provides the Coordinator-General the power to declare a project to be a "significant project" based on one or more of the following criteria:
    - complex approval requirements, including local, State and Australian Government involvement
    - a high level of investment in the state
    - potential effects on infrastructure and/or the environment
    - provision of substantial employment opportunities, and
    - strategic significance to a locality, region or the state.

[52] https://www.daf.qld.gov.au/fisheries/consultations-and-legislation/legislation Accessed June 2015.
[53] http://www.nprsr.qld.gov.au/managing/habitat-areas/investigations-program-cq.html Accessed June 2015.
[54] http://dilgp.qld.gov.au/planning/planning-framework/sustainable-planning-act-2009.html Accessed June 2015.
[55] http://www.statedevelopment.qld.gov.au/industry-development/sustainable-port-development.html Accessed June 2015.
[56] http://www.statedevelopment.qld.gov.au/industry-development/sustainable-port-development.html Accessed June 2015.

The SDPWO Act is used to assess projects that are deemed to be of 'State significance' as well as the State Development Areas[57] . Once a project is declared significant an Environmental Impact Statement (EIS) is usually required to ensure the project's environmental, social and economic impacts are appropriately considered. Only the most important or complex projects are generally declared to be significant projects, signalling that a robust assessment process is warranted involving whole-of-government coordination. Under the process, the proponent is required to prepare and lodge an initial advice statement (IAS). This can lead to the project being declared as 'significant'. At the same time, the project is referred to the Australian Government for potential coverage under the EPBC Act or other statutes. Following these State and Australian government reviews, the terms of reference for the EIS are drafted and released for public comment. The EIS is then prepared and submitted to the Coordinator-General, after which it goes through a government and public review process. To address any issues that might be raised, the proponent may have to prepare a supplementary EIS. Government agencies then review the final document, identify any conditions that have to be met, and then project approvals can be granted.

An independent review of the Port of Gladstone commissioned by the Australian Government (SEWPaC 2013) also listed the following Queensland legislation as relevant to port operations. Because of their influence on port activities and development they also have relevance to port water quality:

- *Coastal Protection and Management Act 1995*
- *Land Act 1994*
- *Marine Parks Act 2004*
- *Transport Operations (Marine Pollution) Act 1995*
- *Vegetation Management Act 1999,* and
- *Water Act 2000.*

5.2. Water Quality Guidelines

Four sets of water quality guidelines apply to water quality in the Ports of Gladstone and Rockhampton. The guidelines are applied in the order of: most locally relevant guidelines (Water Quality Objectives; see Section 5.2.1 below), through state-level guidelines (Queensland Water Quality Guidelines; DERM 2009) to national guidelines (Australian and New Zealand guidelines; ANZECC/ARMCANZ 2000). There are also specific guidelines that have been developed for the GBRMP (GBRMPA 2010).

The Queensland Government has recently finalised the Capricorn and Curtis coast region waters — environmental values (EVs) and water quality objectives (WQOs). The EVs and WQOs are included in Schedule 1 of the Environment Protection (Water) Policy 2009 (the EPP Water), which identifies locally relevant values and objectives based on local water quality monitoring data. The WQOs for

[57] http://www.statedevelopment.qld.gov.au/laws-and-regulations/state-development-and-public-works-organisation-act.html

Capricorn and Curtis coast region waters (Figure 5.2) provide water quality indicator thresholds for GHHP report card grades[58].

Separate EVs and WQOs are in place for the Fitzroy Basin freshwater aquatic ecosystems (divided into river catchments) and the Fitzroy River and estuary (Figure 5.3). These were finalised in 2011 and are also scheduled in the EPP Water. These WQOs provide some indicator thresholds for FPRH report card grades in the freshwater catchment and estuary zones (FPRH 2014).

For some parameters (e.g. metals) locally relevant data are not available for the Capricorn and Curtis coasts or the Fitzroy Basin, and hence WQOs could not be developed. In these cases the State (Queensland Water Quality Guidelines; DERM 2009) and national (ANZECC Guidelines; ANZECC/ARMCANZ 2000) water quality guidelines are relevant.

[58] EHP Capricorn and Curtis Coast region waters – environmental values and water quality objectives: http://www.westernbasinportdevelopment.com.au/biodiversity-offset-strategy. Accessed April 2015.

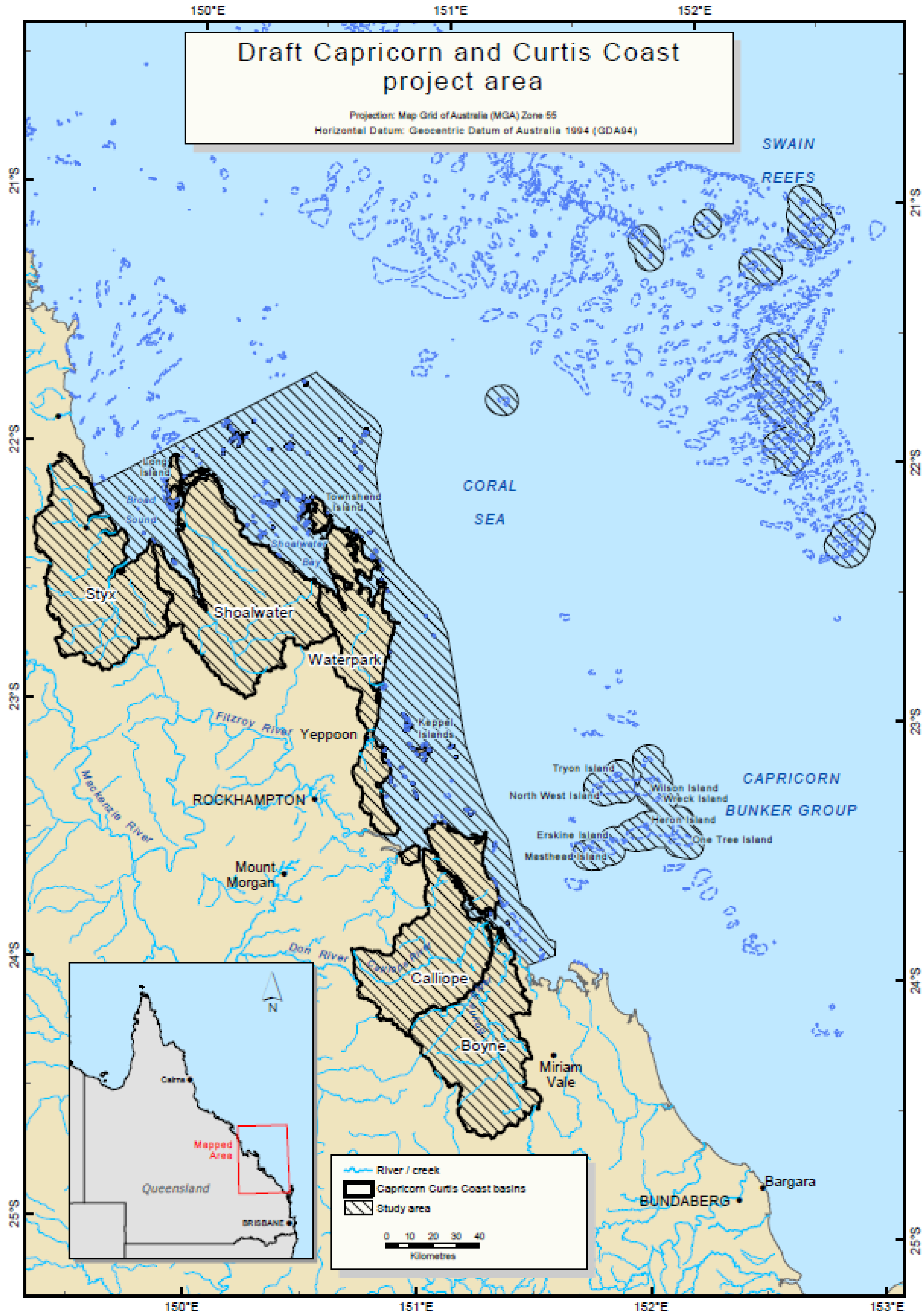

Figure 5.2: Capricorn and Curtis coast waters as defined for the EVs and WQOs in Schedule 1 of the EPP Water. Source: Queensland Government Department of Environment and Heritage Protection[59].

[59] https://www.ehp.qld.gov.au/water/policy/pdf/capricorn-curtis-coast-map.pdf Accessed May 2015.

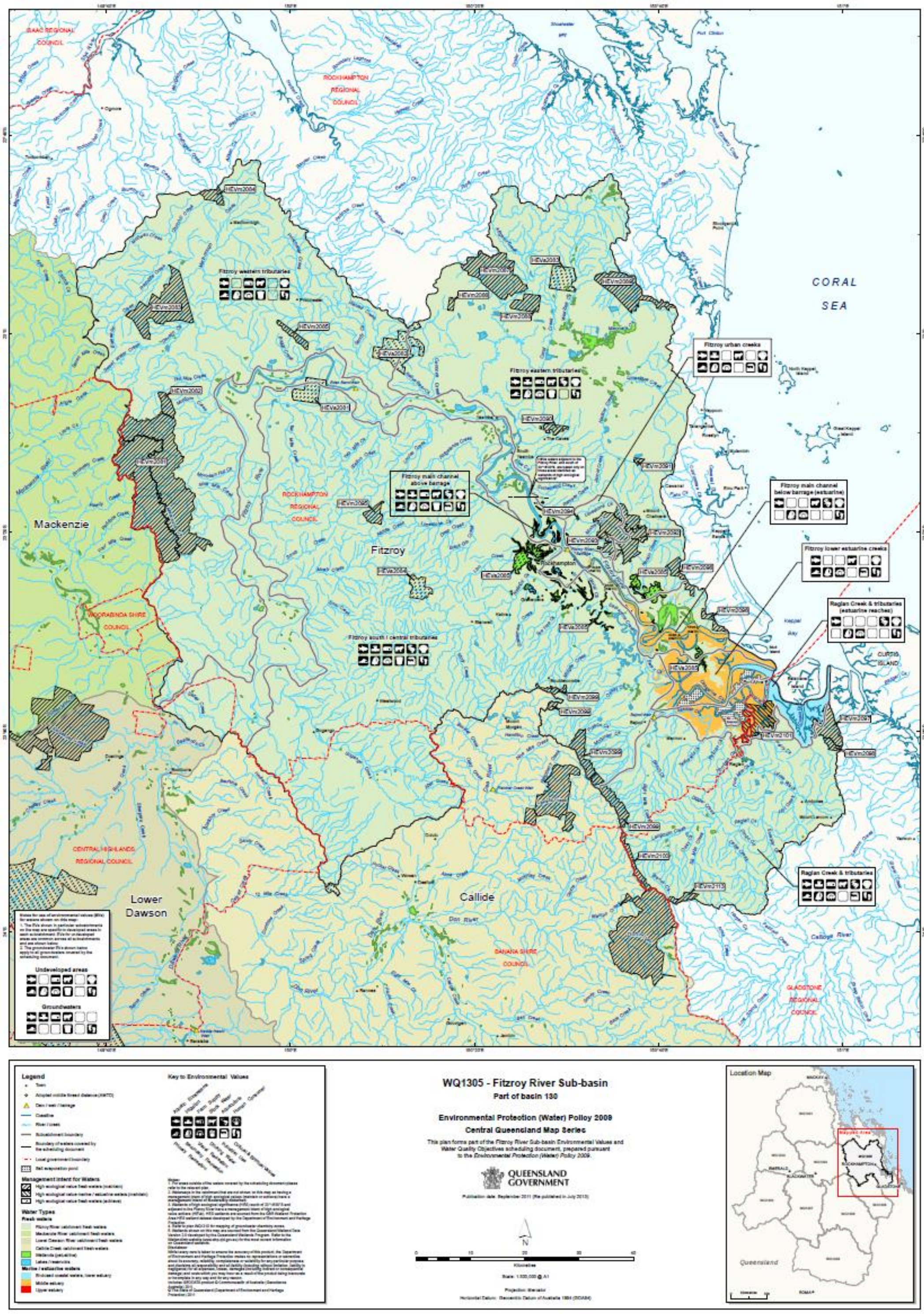

Figure 5.3: Fitzroy River waters as defined for the EVs and WQOs in Schedule 1 of the EPP Water. Source: Queensland Government Department of Environment and Heritage Protection[60].

[60] http://www.ehp.qld.gov.au/water/policy/pdf/plans/fitzroy_plan_300811.pdf Accessed May 2015.

5.3. GPC environmental management and offsets

Gladstone Ports Corporation operates in accordance with an EMS developed in 2006 and maintained based on the requirements of AS/NZSISO 14001:2004 (the international specification for environmental management)[61]. GPC's Environmental Commitment is to manage, develop and operate its ports in a manner which:

- "minimises environmental harm and preserves the inherent worth of the environment for future generations, through the adoption of leading practice environmental management;
- ensures continual improvement in its environmental performance; and
- ensures compliance with all relevant legislative requirements." (GPC 2014c)

The objectives are generally achieved through the EMS, and specifically addressed by a series of commitments including risk identification and management, environmental planning, documentation of operational procedures to prevent environmental impacts and identification of appropriate corrective and preventative actions to address environmental non-conformances (GPC 2014c).

For maintenance dredging activities, the "Long Term Monitoring and Management Plan for permit under the *Environment Protection (Sea Dumping) Act 1981* to dispose dredge material at sea: maintenance dredging" (LTMMP) forms part of GPC's EMS. The LTMMP is intended as a management document that ensures compliance with legislation and also environmental best practice during maintenance dredging and sea disposal of maintenance dredge spoil. It aims to do this by providing a works management program that implements measures to prevent and/or minimise the likelihood of environmental harm (GPC 2014b). The LTTMP is approved by State and Federal government environment departments prior to commencement of works.

The ERMP commenced in 2011 as a condition of approvals for the WBDDP, with an objective to "provide high level information on the health of Port Curtis and Port Alma ecosystems and observe and provide advice on any potential impacts caused by the dredging program and practices"[62]. The ERMP was developed and implemented by a panel of independent marine experts and has produced a long series of scientific reports including tier one reviews and monitoring studies[63] and tier two monitoring programs[64]. Only one of these is directly related to water quality ("Review of Water Quality Studies"; Hale 2013) although there are several other programs relating to species and ecosystems that could potentially be impacted by water quality issues, including marine turtle nesting populations, migratory shorebird populations, coral and benthos.

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[61] ISO 14000 – Environmental management: http://www.iso.org/iso/home/standards/management-standards/iso14000.htm. Accessed April 2015.
[62] GPC Ecosystem Research and Monitoring Program: http://www.westernbasinportdevelopment.com.au/ermp. Accessed April 2015.
[63] GPC ERMP Environmental Reports: http://www.westernbasinportdevelopment.com.au/ermp-environmental-reports-tier-1. Accessed April 2015.
[64] GPC ERMP Environmental Reports: http://www.westernbasinportdevelopment.com.au/ermp-environmental-reports-tier-2. Accessed April 2015.

GPC's BOS was also a condition of approvals for the WBDDP and was developed in 2013 with the objective to "provide for long-term conservation of threatened and migratory species, including their habitats that may be impacted by activities associated with the Western Basin Dredging and Disposal Project". The BOS has funded (and continues to fund) a variety of environment projects including one water quality project ("Identification and development of a water quality improvement and monitoring program for the major catchments supplying Port Curtis"; Hale 2014) and others including some that may act to influence, or themselves be influenced by, water quality:

- Signage and education
- Assessment of marine traffic
- Habitat enhancement and restoration actions
- Stormwater pollution control
- Distribution, maintenance and monitoring of TAngler bins
- Coral mapping and restoration
- Integrated map of all protected areas and sensitive habitats in the region and the wider bioregion
- Integrated environmentally friendly moorings (EFMs) program
- Acquisition of high value ecological land to protect from development
- Water quality improvement and monitoring in the Boyne and Calliope Rivers, and
- Declared fish habitat area (FHA) investigations in the Central Queensland region.[65]

6. Discussion and knowledge gaps

6.1. Discussion

The Port of Gladstone and the Port of Rockhampton, while managed under the same frameworks, are vastly different in scale — with 16 wharves and six main wharf centres, the Port of Gladstone is one of Queensland's largest multi-commodity ports, while the Port of Rockhampton is much smaller with only three wharf facilities. Consequently, the extent of various pressures on water quality and the level to which they are monitored differs between the two ports.

A similarity between the two ports is their placement within the GBRWHA, a characteristic which is shared with other large northern Queensland ports including Hay Point, Queensland's largest port (by total throughput). The Australian Government's independent review of the Port of Gladstone noted that the location of the port within the WHA made environmental management particularly important because of the potential to contribute to the values of the entire world heritage property (SEWPaC 2013).

As a result of their estuarine locations, catchment inputs to the Ports of Gladstone and Rockhampton (see Section 3.2 of this report) are higher than would be the case if they were situated

[65] GPC Biodiversity Offset Strategy: http://www.westernbasinportdevelopment.com.au/biodiversity-offset-strategy. Accessed April 2015.

on non-estuarine coastline. The Australian Government's independent review of the Port of Gladstone highlighted the importance of catchment influences on water quality (SEWPaC 2013). The influence of the Fitzroy River estuary on water quality in the Port of Rockhampton is higher still, as a result of the large size and level of catchment modification of the Fitzroy Basin. The influence of the estuaries complicates the management of port water quality as no one agency has jurisdiction over all of the various sources, and potential sources, of pollution.

Along with catchment and urban influences, water quality in both the Port of Gladstone and the Port of Rockhampton is influenced by shipping, ports activities, port-side industries and marine industries to different extents given the different scales of the two ports (see Section 3 of this report). Shipping, ports activities and port-side industries are all far more prevalent in the Port of Gladstone than the Port of Rockhampton. Both ports have recreational fishing activity, but relatively small commercial fishing fleets in comparison to other Queensland ports such as the Port of Townsville and the Port of Brisbane. The relative contributions of port-related sources of pollution, in comparison to catchment, urban, natural resuspension and (to a lesser extent) oceanic sources of pollution, is not well known or understood in either port.

Aside from the gaps in knowledge (discussed further in Section 6.2 below) there are some process gaps in the two Fitzroy region ports that may limit effective water quality management. The first of these is the jurisdictional complexity of water quality management in the ports, as described above in terms of relative contributions. The second is data availability and data sharing between sectors. In conducting this study some data were difficult to retrieve, and the report authors are aware of data that could not be included as they were inaccessible (e.g. details of water quality monitoring undertaken by some industries, and detailed vessel collision/incident reports post-2007). For the Port of Gladstone, some duplication of monitoring and research effort was identified between the various groups — for example social, economic and cultural values in Gladstone Harbour were recently studied simultaneously by separate projects; and research activities conducted under the Gas Industry Social and Environmental Research Alliance (GISERA) have similarities to some of the work conducted under the ERMP.

6.2. Knowledge gap identification

The scale of shipping and industrial activity in the Port of Gladstone, in combination with its proximity to the GBRWHA, means that it is well monitored in comparison to other stretches of coastline in regional Queensland. Water quality is comprehensively monitored by PCIMP for far-field and locally monitored by the port and industries for near-field under the conditions of their Environmental Authorities, and some monitoring is also conducted by research and community groups (see Section 4 of this report). Although PCIMP monitoring data have historically not been publicly available, they are provided to GHHP for analysis and some data are used in the production of GHHP's annual report card[66]. Marine ecosystem research in the port has recently been boosted by research and monitoring undertaken by GPC as conditions on their environmental approvals through

[66] Reports available at: http://rc.ghhp.org.au/

the ERMP[67] and the BOS[68] (described in Section 5 of this report). Additional marine environmental research is conducted by CQUniversity (including through student research projects), industry (mostly for specific water quality issues) and GHHP when developing and piloting indicators of harbour health.

In contrast to the Port of Gladstone, which is one of the most well monitored stretches of water in Queensland, water quality in the Port of Rockhampton is much less well understood. This is a reflection of the much lower level of shipping and industry in and around the Port of Rockhampton. A suite of publications on both Port Curtis and the Fitzroy Delta arose from the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management during the early 2000s, and the recent proposals for coal export terminal development in the Fitzroy Delta included some recent data collection for environmental impact statements. Aside from these, intermittent issue-focused research has been conducted by the Queensland Government and by universities. Ongoing monitoring is limited to several Queensland Government stations and two monitoring sites funded by GPC. As the Delta of the largest seaward draining river basin on the east coast of Australia and to the GBRWHA the lack of monitoring in the Fitzroy estuary represents a very significant gap, although it is recognised that this need is not driven by port activities.

CQUniversity and GPC workshopped knowledge gaps in relation to water quality in the two ports at a meeting in Gladstone on 5 June 2015. Gaps were characterised by source and issue (Table 6.1) and were prioritised from 1 (highest) to 3 (lower) priority. The highest priority gaps identified relate to understanding the relative contributions of all known sources of sediment, nutrients and toxicants (e.g. pesticides, metals, metalloids, petrochemicals) into port water. This is rated as the highest priority because without this information it is difficult to predict the potential effectiveness of single-sectorial management actions designed to improve water quality. Source tracking was hence highlighted as a research gap at the workshop. The cumulative impact of increasing industrialisation is also flagged as an important knowledge gap, particularly with the likely increases in flooding, storm surges and tropical storms with climate change. Little is currently known about the potential environmental impact of land-based disposal options for dredge material, and this may become increasingly important in the Port of Gladstone as a result of the Queensland Government's Sustainable Ports Development Bill 2015, which includes a prohibition on sea disposal of capital dredge spoil material in the GBRWHA[69].

To produce a full Ports Water Quality Improvement Plan for the Fitzroy, it would be necessary to have a better understanding of sources and their relative influence on water quality and ecosystem processes. Completion of current research projects, for example the GHHP stewardship project that will use a reporting framework to assess the current management of ports and industry sectors, would also be beneficial and incorporation of these results may significantly reduce the requirements for completion of a Ports Water Quality Improvement Plan.

[67] Reports available at: http://www.westernbasinportdevelopment.com.au/ermp
[68] Reports available at: http://www.westernbasinportdevelopment.com.au/biodiversity-offset-strategy
[69] http://www.statedevelopment.qld.gov.au/industry-development/sustainable-port-development.html Accessed July 2015.

Table 6.1: Knowledge and information gaps on water quality in the Port of Gladstone and the Port of Rockhampton, and ranked priority (1 = highest priority; 2 = medium priority; 3 = lower priority). Filling priority 1 gaps would improve the ability to predict the effectiveness of water quality management actions. Filling priority 2 and 3 gaps would also improve predictions, but are less critical.

Category	Issues	Knowledge gap to be filled			Priority
Catchment	**Agricultural chemicals**	Evaluation / assessment of impact	Impacts on non-coral species and non-reef habitats in ports area *(international research but no local data)*		1
Urban	**Development, litter and pollutants**	Effectiveness of litter reduction strategies for reducing litter in ports area *(some research has commenced)*	Hotspot management for litter and pollutants	Habitat loss and degradation caused by urban development and expansion	1
Shipping	**Oil, litter, pollutants**	Cumulative impacts on species / ecosystems and proportionate increase with increasing shipping activity	Impacts of freight transfer spills / emissions (e.g. loading coal onto ships) on reef water quality offshore		1
	Ballast water	Availability / accessibility of data			2
	Biosecurity	Invasive species – most important vectors, and regular assessment for establishment *(survey recently commenced to identify any invasive species incursions)*			2
	Sediment resuspension	Potential for fine sediment resuspension by ship movements and berthing			3
	Incidents [relates to all boating activities]	Understanding impacts of incidents and ecosystem resilience; and how this differs between high	Proportion of incidents reported		3

Category	Issues	Knowledge gap to be filled			Priority
		numbers of minor incidents vs. small numbers of major incidents			
Industry	**Pollutant loads**	Hotspot management	Effects of cumulative industrial impacts (and maximum allowable impacts) on ecosystems and species	Impacts on marine water quality of air-borne pollution	1
Ports development and construction activities	**Habitat loss/ degradation**	Effects on water quality of coastal habitat removal. Negative feedback loops.	Effects on water quality of remedial actions. Positive feedback loops.		1
	Cross harbour boating/ferries	Impact of increased boating movements during construction periods on pollutants (e.g. antifoul, petrochemicals, marine debris)	Potential for fine sediment resuspension by boat movements		2
	Dredging	Impacts of sea and land based maintenance spoil disposal (and relative contributions)	Spatial maps of erosion/ sedimentation and understanding of the drivers	Local impacts of sedimentation and sediment-bound pollutants, and understanding movement/fate of dredged material	1
	Management – industry	Review of individual industry environmental management activities/standards in ports area	Best management practices for port side industry		1
	Reclamation of mangroves and wetlands	Extent of impact on habitats *(some research through ERMP)* and hydrology	Effects of acid sulfate soils		2
Tourism/ recreation	**Water quality impacts**	Water quality impacts (garbage and toxicants) of non-fishing recreation	Invasive species / hull fouling from international vessels		3
	Marine debris and beach	Quantification *(baseline research*			2

Category	Issues	Knowledge gap to be filled			Priority
	pollution /boating/urban foreshore footprint	*available)* and assessing changes following introduction of cruise ships to Gladstone			
	Design of recreational facilities (eg boat ramps, jetties)	Redesigned for particular qualities (e.g. fish habitat) vs new installations	Hotspots for petrochemical and nutrient pollution from recreational and commercial vessels		3
Fishing	**Discarded catch**	Nutrient inputs	Hotspots		2
	Oil, litter, pollutants	Quantification and impacts	Hotspots		1
	Resuspension of sediments	Potential for fine sediment resuspension by boat movements	Resuspension on trawl grounds from fishing activity		2
Ocean sources (of pollution)	**Marine debris**	Understanding the sources, and proportion of marine debris of various size classes that is collected/ recorded (as a sample of the total volume)			2
Cross-cutting issues	**Climate change impacts on ports water quality**	Increased flooding with resulting increase in catchment and urban inputs	Increased intensity and possibly increased frequency and intensity of tropical storms Increased frequency of storm surges and resulting issues for outlets	Reduction in ecosystem resilience to other cumulative pressures	1
	Baselines of water quality in the two ports	Coral and sediment coring to establish environmental histories and local baselines			1
	Nutrients	Source tracking	Evaluation / assessment of relative contributions of all sources	Relationship between catchment inflows and	1

Category	Issues	Knowledge gap to be filled			Priority
				nutrient concentrations	
	Sediments	Source/sink tracking including anthropogenic and natural sources	Model validation	Relationship between sediment inputs and metals/nutrients	1
	Metals and metalloids	Source tracking			1

6.3. Conclusion

Ports activities and shipping occur directly within the marine environment and some influence on environmental conditions is unavoidable, although the extent of environmental impacts depends on a variety of port characteristics including location, size, types of activities conducted, port-side industry base, shipping volume and local conditions (e.g. geology and hydrography) (Darbra et al. 2005; Gómez et al. 2015). The water quality impacts of ports and shipping combine in coastal environments with the cumulative impacts of land use pressures (e.g. port-side industries, agriculture and urban development), other marine uses (e.g. commercial and recreational boating, tourism) and oceanic and climate influences (e.g. marine debris, ocean acidification and floods).

In Australia, the potential impacts of ports, shipping and industries are closely regulated under a wide variety of legislation at both the State and Federal levels of government and through international agreements. This report summarised factors that may influence water quality and the characteristics of the two ports in the Fitzroy region — the Port of Gladstone and the Port of Rockhampton — and synthesised information on water quality monitoring and management in these ports. The study identified a variety of factors with the potential to impact on water quality and found that while water quality in the Port of Gladstone in particular has been well monitored and researched, there remain some research and knowledge gaps relating to water quality in the ports. Addressing these gaps would further improve understanding of port water quality and provide a stronger information base for decision making to mitigate regional ecosystem-level effects. It is hoped that this synthesis will help to direct future research and to frame communication to add to the efficiency of current research and monitoring activities.

7. References

Alquezar, R. and Stratford, P. (2007). *Rosslyn Bay boat harbour marine audit and assessment of dredge related impacts*. A report to the Fitzroy Basin Association and Queensland Transport. Centre for Environmental Management, CQUniversity, Gladstone, Queensland.

Anastasi, A. (2015). Ecological Risk Assessment of Manganese in the Subtropical Estuarine Harbour of Port Curtis, Queensland, Australia. PhD thesis, Central Queensland University, Rockhampton, Queensland.

Angel, B.M., Jarolimek, C.V., King, J.J., Simpson, S.L., Jung, R.F., and Apte, S.C. (2012). *Metals in the waters and sediments of Port Curtis, Queensland.* CSIRO Wealth from Oceans Flagship, Cleveland, Queensland.

Andersen, L. (2003). A study into the epidemiology of the mud crab (*Scylla serrata*) shell disease. Masters thesis, Central Queensland University, Rockhampton, Queensland.

Andersen, L. (2004). I*mposex in the city: a survey to monitor the effects of TBT contamination in Port Curtis, Queensland*. Project CP20. Cooperative Research Centre for Coastal Zone, Estuary & Waterway Management, Technical Report, Technical report No.16. Gladstone, Queensland.

Andersen, L., Melville, F., and Jolley, D. (2008). An assessment of an oil spill in Gladstone, Australia – impacts on intertidal areas at one month post-spill. *Marine Pollution Bulletin* **57:** 607-615.

ANZECC/ARMCANZ (2000). *Australian and New Zealand guidelines for fresh and marine water quality: Volume 1 – the guidelines.* Available at: http://www.environment.gov.au/water/quality/publications/australian-and-new-zealand-guidelines-fresh-marine-water-quality-volume-1

Apte, S.C., Duivenvoorden, L., Johnson, R., Jones, M., Revill, A., Simpson, S., Stauber, J.L. and Vicente-Beckett, V. (2005). *Contaminants in Port Curtis: Screening Level Risk Assessment*. Cooperative Research Centre for Coastal Zone, Estuary & Waterway Management, Technical Report No.25. Gladstone, Queensland.

Apte, S.C., Andersen, L.E., Andrewartha, J.R., Angel, B.M., Shearer, D., Simpson, S.L., Stauber, J.L. & Vicente-Beckett, V. (2006). *Contaminant pathways in Port Curtis: final report*. CRC for Coastal Zone, Estuary and Waterway Management. Gladstone, Queensland.

Bartley, R., Speirs, W.J., Ellis, T.W., and Waters, D.K. (2012). A review of sediment and nutrient concentration data from Australia for use in catchment water quality models. *Marine Pollution Bulletin* **65**: 101-116.

BITRE [Bureau of Infrastructure, Transport and Regional Economics]. (2014). *Australian sea freight 2012–13*, Australian Government, Canberra.

Borja, Á., Elliot, M., Carstensen, J., Heiskanen, A.s., and van de Bund, W. (2010). Marine management – towards an integrated implementation of the European Marine Strategy Framework and the Water Framework Directives. *Marine Pollution Bulletin* **60**: 2175-2186.

Brodie, J. (2014). Dredging the Great Barrier Reef: Use and misuse of science. *Estuarine, Coastal and Shelf Science* **142:** 1-3.

Bryant, C.V., Jarvis, J.C., York, P.H., and Rasheed, M.A. (2014). *Gladstone Healthy Harbour Partnership Pilot Report Card: ISP011 Seagrass Final Report – October 2014*. Centre for Tropical Water and Aquatic Ecosystem Research Publication 14/53 James Cook University, Cairns, Queensland.

Bureau of Meterology [BOM] (2015). Average annual, seasonal and monthly rainfall: Queensland. Accessed June 2015.
http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp?period=an&area=qd#maps

Burns, K.A. (2014). PAHs in the Great Barrier Reef Lagoon reach potentially toxic levels from coal port activities. *Estuarine Coastal and Shelf Science* **144**: 39-45.

Burns, K.A., and Brinkman, D.L. (2011). Organic biomarkers to describe the major carbon inputs and cycling of organic matter in the central Great Barrier Reef region. *Estuarine Coastal and Shelf Science* **93**: 132-141.

Cagnazzi, D. (2010). Conservation status of Australian snubfin, *Orcaella heinsohni* and the Indo-pacific humpback dolphin, *Sousa chinensis*, in the Capricorn coast, Central Queensland. PhD thesis, Southern Cross University, Lismore, New South Wales.

C&R Consulting. (2005). *Calliope River Basin Draft Water Resource Plan Ecological Assessment Report*. Report to Department of Natural Resources and Mines, Queensland.

Carter, A.B., Davies, J.D., Bryant, C.V., Jarvis, J.C., McKenna, S.A. and Rasheed, M.A. (2015). *Seagrasses in Port Curtis and Rodds Bay 2014: Annual long-term monitoring, biannual Western Basin, and updated baseline survey,* Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication 15/06, James Cook University, Cairns, Queensland.

Connolly, R.M., Currie, D.R., Danaher, K.F., Dunning, M., Melzer, A., Platten, J.R., Shearer, D., Stratford, P.J., Teasdale, P.R., and Vandergragt, M. (2006). *Intertidal wetlands of Port Curtis. Ecological patterns and processes and their implications.* Technical Report 43. CRC for Coastal Zone, Estuary and Waterway Management, Gladstone, Queensland.

Curry, D., and Small, K. (2005). Macrobenthic community structure in the Fitzroy River Estuary, Queensland. In: Nobel, B, Bell, A, Verwey, & Tilden, J (eds), *Fitzroy in focus: coastal science for the Fitzroy region.* Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Indooroopilly, Queensland.

DAFF [Australian Department of Agriculture Fisheries and Forestry] (2011). *Australian Ballast Water Management Requirements, version 5.* Seaports Program. Australian Government, Canberra.

DAFF [Queensland Department of Agriculture Fisheries and Forestry]. (2012). *Commercial catch of key species Gladstone (2006-2011)*. Queensland Government, Brisbane, Queensland. Available at: https://www.daf.qld.gov.au/__data/assets/pdf_file/0017/52505/gladstone-catch-report-20April12.pdf

Dafforn, K.A., Lewis, J.A. and Johnston, E.L. (2011). Antifouling strategies: History and regulation, ecological impacts and mitigation. *Marine Pollution Bulletin* **62**: 453-465.

Darbra, R.M., Ronza, A., Stojanovic, T.A., Wooldridge, C., and Casal, J. (2015). A procedure for identifying significant environmental aspects in sea ports. *Marine Pollution Bulletin* **50**: 866-874.

DEHP [Department of Environment and Heritage Protection] (2012). *Analysis of Water Quality in Relation to Fish Health in Gladstone Harbour and Waterways September 2011 – September 2012*. Queensland Government, Brisbane, Queensland.

DERM [Department of Environment and Resource Management] (2009). *Queensland Water Quality Guidelines*. Queensland Government, Brisbane, Queensland.

Devlin, M., Wenger, A., Waterhouse, J., Romero, J., Abbott, B., Bainbridge, Z. and Lewis, S. (2011). *Reef Rescue Marine Monitoring Program: Flood Plume Monitoring Annual Report Incorporating results from the Extreme Weather Incident Response program*, ACTFR REPORT 11/x. James Cook University, Townsville, Queensland.

DNRM [Department of Natural Resources and Mines] (2014). *Boyne River Basin Water Resource Plan and Resource Operations Plan*. Consultation Report January 2014, Queensland Government, Brisbane, Queensland. Available online at: https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0005/123674/boyne-consultation-report.pdf

DNRW [Department of Natural Resources and Water] (2007). *Calliope River Basin water resource plan consultation report*. Queensland Government, Brisbane, Queensland. Available at: https://www.dnrm.qld.gov.au/__data/assets/pdf_file/0003/109065/calliope-wrp-consultation.pdf

Dougall, C., McCloskey, G.L., Ellis, R., Shaw, M., Waters, D., and Carroll, C. (2014). *Modelling reductions of pollutant loads due to improved management practices in the Great Barrier Reef catchments – Fitzroy NRM region, Technical Report, Volume 6*. Queensland Department of Natural Resources and Mines, Rockhampton, Queensland.

Dougall, C., Packett, R., Carroll, C. (2005). Application of the SedNet model in partnership with the Fitzroy Basin community. In: Zerger, A., Argent, R.M. (Eds.), *MODSIM 2005 International Congress on Modelling and Simulation*. Modelling and Simulation Society of Australia and New Zealand, December 2005.

DSITIA [Department of Science, Information Technology, Innovations and the Arts] (2013). *Post-flood Water Quality Monitoring in Gladstone Harbour and Waterways*. Queensland Government, Brisbane, Queensland.

DTMR [Department of Transport and Main Roads] (2012a). *Port Procedures and information for Shipping Port of Gladstone.* Queensland Government.

DTMR [Department of Transport and main Roads] (2012b). *Annual Report 2011-12, Volume 1 of 2.* Queensland Government.

DTMR [Department of Transport and Main Roads] (2013a). *Queensland's Maritime Regions, December 2013.* Available at: http://www.msq.qld.gov.au/~/media/msqinternet/msqfiles/home/about%20us/right%20to%20information/queenslandmaritimeregions.pdf Accessed June 2015.

DTMR [Department of Transport and Main Roads] (2013b). *Standard for Marine Construction Activities in Gladstone Harbour.* Queensland Government.

DTMR [Department of Transport and Main Roads] (2014). *Trade Statistics for Queensland Ports for the five years ending 30 June 2013*. Queensland Government.

EHP [Department of Environment and Heritage Protection] (2011). *State of the Environment Queensland 2011*. Queensland Government, Brisbane, Queensland.

EPA [Environmental Protection Agency] (2008). *State of the Environment Queensland 2007*. Queensland Government, Brisbane, Queensland.

Erftemeijer, P.L.A., Riegl, B., Hoeksema, B.W., Todd, P.A. (2012). Environmental impacts of dredging and other sediment disturbances on corals: A review. *Marine Pollution Bulletin* **64**: 1737-1765.

Erftemeijer, P.L.A., and Lewis, R.R. (2006). Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin* **52**: 1553-1572.

Evans, S.M., Leksono, T. & McKinnell, P.D. (1995). Tributyltin pollution: a diminishing problem following legislation limiting the use of TBT-based anti-fouling paints. *Marine Pollution Bulletin* **30:** 14-21.

FPRH [Fitzroy Partnership for River Health] (2014). *The Partnership Program Design for the Development of Report Cards. Phase 2, Version 3.* Fitzroy Partnership for River Health, Rockhampton, Queensland.

Fryda-Blackwell, S. (2014). Ports Australia response to the Marine Pest Biosecurity System Issue Paper. Available at: http://www.agriculture.gov.au/SiteCollectionDocuments/animal-plant-health/pests-diseases-weeds/marine-pests/submissions/11-ports.docx

Gallen, C., Devlin, M., Thompson, K., Paxman, C., Mueller, J. (2014). *Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2013 - 2014).* The National Research Centre for Environmental Toxicology, The University of Queensland, Brisbane, Queensland.

GBRMPA [Great Barrier Reef Marine Park Authority] (2010). Water Quality Guidelines for the Great Barrier Reef Marine Park, Townsville, Queensland.

GBRMPA [Great Barrier Reef Marine Park Authority] (2013). Fitzroy basin assessment: Fitzroy Basin Association Natural Regional Management, Townsville, Queensland.

GBRMPA [Great Barrier Reef Marine Park Authority] (2014). *Great Barrier Reef Outlook Report 2014*, Townsville, Queensland.

Goldsworthy, L. and Galbally, I.E. (2011). Ship engine exhaust emissions in waters around Australia - an overview. *Air Quality and Climate Change*, **45**: 24-32.

Gómez, A.G., Ondiviela, B., Puente, A. and Juanes, J.A. (2015). Environmental risk assessment of water quality in harbor areas: A new methodology applied to European ports. *Journal of Environmental Management* **155**: 77-88.

GPC [Gladstone Port Corporation] (2011a). *Port Alma Shipping Terminal Port Information Handbook 2010.* Gladstone, Queensland. Available at: http://www.gpcl.com.au/Portals/0/pdf/Handbook/Port_Alma_Info_Handbook_2011.pdf

GPC [Gladstone Port Corporation] (2011b). *Port of Gladstone Information Handbook 2011*. Gladstone, Queensland. Available at: http://www.gpcl.com.au/Portals/0/pdf/Handbook/Port_of_Gladstone_Information_Handbook_November_2011.pdf

GPC [Gladstone Port Corporation] (2012). *50 year strategic plan for Gladstone Ports Corporation*. Gladstone, Queensland. Available at: http://www.gpcl.com.au/Portals/0/pdf/50%20yr%20plan/GPC_50yr_strategic_plan_2012_update.pdf

GPC [Gladstone Port Corporation] (2014a). Annual Report 2013-14. Available at: http://www.gpcl.com.au/Pages/Annual-Report.aspx

GPC [Gladstone Port Corporation] (2014b). Long term monitoring and management plan for permit under the *Environment Protection (Sea Dumping) Act 1981* to dispose of dredge material at sea. Maintenance dredging. Gladstone Ports Corporation, Gladstone, Queensland.

GPC [Gladstone Port Corporation] (2014c). Our Environmental Commitment. Craig Doyle, Chief Executive Officer, January 2014. Available at: http://www.gpcl.com.au/environment

GPC [Gladstone Ports Corporation] (2015). Origin & Destination of Cargoes: Totals for Financial Year 2014. Accessed May 2015. Available at: https://content1.gpcl.com.au/ViewContent/CargoComparisonsSelection/CargoOriginDestination.aspx?View=P&Durat=F&Key=2014

Grech, A., Bos, M., Brodie, J., Coles, R., Dale, A., Gilbert, R., Hamann, M., Marsh, H., Neil, K., Pressey, R.L., Rasheed, M.A., Sheaves, M., and Smith, A. (2013). Guiding principles for the improved governance of port and shipping impacts on the Great Barrier Reef. *Marine Pollution Bulletin* **75**: 8-20.

Gregg, D., and Greiner, R. (2008). *The direct impact of recreation on water quality in the Great Barrier Reef Marine Park.* Report prepared for the Great Barrier Reef Marine Park Authority. River Consulting, Townsville, Queensland.

Hale, J. (2013). *CA120020: Review of water quality studies*. Gladstone Ports Corporation ERMP report. Aquatic Ecology Consulting.

Hale, J. and Box, P. (2014). *Identification and development of a water quality improvement and monitoring program for the major catchments supplying Port Curtis*. A report for Gladstone Ports Corporation's Biodiversity Offset Strategy.

Herzfeld, M., Parslow, J., Andrewartha, J., Sakov, P., and Webster, I. (2004). *Hydrodynamic Modelling of the Port Curtis Region.* Technical Report No.7. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Brisbane, Queensland.

Holton, (2011). *Acid sulphate soil management plan western basin dredging and offshore/onshore disposal project, Gladstone, Queensland*. (Report no: 10524_ASSMP_REH5F.docx). Gilbert and Sutherland. Robina, Queensland.

Houston, W., Black, R., Elder, R., Black, L., & Segal, R. (2012). Conservation value of solar salt ponds in coastal tropical eastern Australia to waterbirds and migratory shorebirds. *Pacific Conservation Biology* **18**: 100-122.

Jones, M-A. (2002). Assessing the risk from chemical contaminants in the Port Curtis Estuary, Australia. Masters thesis, Central Queensland University, Rockhampton, Queensland.

Jones, M.A., Stauber, J., Apte, S., Simpson, S., Vicente-Beckett, V., Johnson, R., and Duivenvoorden, L.J. (2005). A risk assessment approach to contaminants in Port Curtis, Queensland, Australia. *Marine Pollution Bulletin* **51**: 448-458.

Jones, A. (2009). Physiological Trade-offs to Thermal Acclimation by Symbiont Community Change in the Reef Coral *Acropora millepora.* PhD thesis, Central Queensland University, Rockhampton, Queensland.

Kabat, P., Bazelmans, J., van Dijk, J., Herman, P.M.J., van Oijen, T., Pejrup, M., Reise, K., Speelman, H., and Wolff, W.J. (2012). The Wadden Sea Region: Towards a science for sustainable development. *Ocean & Coastal Management* **68:** 4-17.

Kroon, F.J., Kuhnert, P.M., Henderson, B.L., Wilkinson, S.N., Kinsey-Henderson, A., Abbott, B., Brodie, J.E. & Turner, R.D.R. (2012). River loads of suspended solids, nitrogen, phosphorus and herbicides delivered to the Great Barrier Reef lagoon. *Marine Pollution Bulletin* **65**: 167-181.

Lewis, J.A. and Gillham, A.C. (2007). *Antifouling paint patch trial project – Final report*. Report for Australian Government Department of Defence and the Australian Shipowners Association. Available at: http://asa.com.au/wp-content/uploads/Paint-patch-trials-Final-Report.pdf

Lewis, S., Hewitt, C., and Melzer, A. (2001). *Port survey for introduced marine species Port Curtis – Final report*. Centre for Environmental Management Centre for Land and Water Resource Management. CQUniversity, Gladstone, Queensland.

Lohrer, A.M. and Wetz, J.J. (2003). Dredging-induced nutrient release from sediments to the water column in a southeastern saltmarsh tidal creek. *Marine Pollution Bulletin* **46:** 1156-1163.

Low, T. (2003). *Ballast invaders: the problem and response*. Prepared for Invasive Species Council.

McCook, L.J., Schaffelke, B., Apte, S.C., Brinkman, R., Brodie, J., Erftemeijer, P., Eyre, B., Hoogerwerf, F., Irvine, I., Jones, R., King, B., Marsh, H., Masini, R., Morton, R., Pitcher, R., Rasheed, M., Sheaves, M., Symonds, A., Warne, M.St.J. (2015). *Synthesis of current knowledge of the biophysical impacts of dredging and disposal on the Great Barrier Reef: Report of an Independent Panel of Experts*, Great Barrier Reef Marine Park Authority, Townsville, Queensland.

MSQ [Marine Safety Queensland] (2014). *Marine incident annual reports (Years 2001-2013)*. Available online: http://www.msq.qld.gov.au/About-us/Marine-incident-annual-reports.aspx Accessed May 2015.

MSQ [Maritime Safety Queensland] (2015a). *Registered commercial vessels, Queensland, by region and length*. Available at: http://www.msq.qld.gov.au/~/media/msqinternet/msqfiles/home/about%20us/right%20to%20information/published%20information/lists%20and%20registers/commercialregistration.pdf Accessed March 2015.

MSQ [Maritime Safety Queensland] (2015b). *Registered recreational vessels, Queensland, by region and length*. Available at: http://www.msq.qld.gov.au/~/media/msqinternet/msqfiles/home/about%20us/right%20to%20information/published%20information/lists%20and%20registers/recreationalregistration.pdf Accessed March 2015.

Newman, M.C., and McIntosh, A.W. (Eds.) (1991). *Metal ecotoxicology concepts and applications*. Lewis Publishers Inc. Chelsea, Michigan.

Packett, R., Dougall, C., Rohde, K. & Noble, R. (2009). Agricultural lands are hot-spots for annual runoff polluting the southern Great Barrier Reef lagoon. *Marine Pollution Bulletin* **58:** 976-986.

Petus, C., and Devlin, M. (2012). *Using satellite maps to document the extent of sediment plumes associated with dredging activity in Gladstone Port's western basin.* Catchment to Reef Research Group, James Cook University, Townsville, Queensland.

Ports Australia (2015). *Trade statistics for 2012/2013*. Accessed June 2015. Available at: http://www.portsaustralia.com.au/aus-ports-industry/trade-statistics/

Queensland Government (2009). *Queensland Land Use Mapping Program*. Available at: https://www.dnrm.qld.gov.au/

Queensland Government (2014). *Summary of oil spills and other marine pollution events reported to Maritime Safety Queensland from 2002 to 2013*. Available at: https://data.qld.gov.au/dataset/marine-oil-spills-data/resource/280b7e6e-61b5-4502-b365-96bafea2950a Accessed May 2015.

QRC [Queensland Resources Council] (2015). *Economic Contribution for Fitzroy Region*. Accessed August 2015. Available at: https://www.qrc.org.au/01_cms/details.asp?ID=3466

Robins, J.B. and Courtney, A.J. (1998). Status report on bycatch within the Queensland trawl fishery. In: C. Buxton and S. Eayrs. (Eds.), *Establishing meaningful targets for bycatch reduction in Australian fisheries* (pp. 24-45). Hobart: Australian Society for Fish Biology Workshop Proceedings, 22-24 September 1998.

Ross, D.J. (2004). *Acid sulphate soils Tannum Sands – Gladstone area Central Queensland Coast*. (Report no: QNRM04285). Department of Natural Resources and Mines, Rockhampton, Queensland.

Sawynok, B., Platten, J., Parsons, W., and Sawynok, S. (2014). *Gladfish: Gladstone recreational fishing project. Assessing trends in Recreational Fishing in Gladstone Harbour and Adjacent Waterways.* InfoFish Australia, Rockhampton, Queensland.

SEWPaC [Department of Sustainability, Environment, Water, Population and Communities] (2013). *Independent Review of the Port of Gladstone: Report on Findings*. Australian Government, Canberra, Available at: http://www.environment.gov.au/system/files/resources/ae7cbcf9-2963-47d7-9029-3aa1a065db51/files/gladstone-review-initial-report.pdf

Sheehan, C. and Harrington, J. (2012). Management of dredge material in the Republic of Ireland – A Review. *Waste Management* **32**: 1031-1044.

Smith, S.D.A, and Rule, M.J. (2001). The effects of dredge-spoil dumping on a shallow water soft-sediment community in the Solitary Islands Marine Park, NSW, Australia. *Marine Pollution Bulletin* **42**: 1040-1047.

Stobutzki, I., Blaber, Brewer, D., Fry, G., Heales, D., Jones, P., Miller, M., Miller, D., Salini, J., Van der Velde, T., Wang, Y-G. and Wassenberg, T. (1996). *Ecological sustainability of bycatch and biodiversity in prawn trawl fisheries.* CSIRO, Cleveland, Queensland.

Taylor S., Webley, J., and McInnes, K. (2012). 2010 *Statewide Recreational Fishing Survey*, Department of Agriculture, Fisheries and Forestry (DAFF), Brisbane, Queensland.

Tourism Research Australia. (2014). *SGBR Regional snapshot year ending June 2014*. Available at: http://www.gladstoneregion.info/Portals/3/Business%20Centre/Tourism%20Services/SGBR%20Regional%20Snapshot%20June%202014.pdf

UK Marine Special Areas of Conservation (2001). *TBT-based antifouling paints. Copper-based antifouling paints*. Available at: http://www.ukmarinesac.org.uk/activities/ports/ph4_3_1.htm

UNCTAD (2014). *Review of Maritime Transport 2014*. UNITED NATIONS PUBLICATION (UNCTAD/RMT/2014).

Vincente-Beckett, V., Shearer, D., Munksgaard, N., Hancock, G., and Morrison, H. (2006). *Metal and polycyclic aromatic hydrocarbon contaminants in benthic sediments of Port Curtis*. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management.

Wilson, S.P. (2009). *Status of Imposex from tributyltin contamination in Port Curtis*. Centre for Environmental Management, CQUniversity, Gladstone, Queensland.

Wilson, S.P. (2013) *Marine debris tracking on the Capricorn Coast region*. Report to Greening Australia. CQUniversity, Marine Debris Research Lab, Gladstone, Queensland.

Wilson, S.P. (2014a). *Gladstone Region debris tracking study*. Gladstone Ports Corporation Biodiversity Offset Strategy Report. CQUniversity, Marine Debris Research Lab, Gladstone, Queensland.

Wilson, S.P. (2014b). *Gladstone Region TAngler Bin assessments*. Gladstone Ports Corporation Biodiversity Offset Strategy Report. CQUniversity, Marine Debris Research Lab, Gladstone, Queensland.

Wilson, S.P. and Cartraud, A. (2014). *Gladstone region shoreline debris survey final report*. School of Medical and Applied Sciences, CQUniversity, Gladstone, Queensland.

Wilson, S.P. and Hansler, M. (2014). *Gladstone catchment care marine debris - Final report for 2013/2014*. School of Medical and Applied Sciences, CQUniversity, Gladstone, Queensland.

Yu, B., Joo, M. And Caroll, C. (2013). Land use and water quality trends of the Fitzroy River, Australia. In: Berit Arheimer et al. (eds). *Understanding Freshwater Quality Problems in a Changing World, Proceedings of H04, IAHS-IAPSO-IASPEI Assembly*. International Association for Hydrological Sciences. Available at: http://www98.griffith.edu.au/dspace/bitstream/handle/10072/58668/88048_1.pdf?sequence=1

Appendix: Supplementary data

Table A.1: Prosecutions for ship sourced garbage pollution Commonwealth and State legislation from 2007 to 2014 in Gladstone and Rockhampton[70]

Date of Prosecution	Date of Incident	Jurisdiction	Vessel name	Vessel type	Flag	Location	Type of garbage	Penalty
18/11/14	13/06/13	Townsville Magistrates Court	*Xin Tai Hai*	Bulk Carrier	Panama	~16 nm from the Port of Gladstone	Plastic, garbage and food waste.	Owner: $20,000 Master: $6,000 Both convicted
15/11/12	29/06/12	Commonwealth, S26F(3) of the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. Cairns Magistrates Court	*Hope Star*	Bulk Carrier	Panama	QLD waters within nearest land and GBRMP. 22.30º S 153.00º E	Garbage	Owner: $5,000 Master: $300 Both convicted
23/05/07	24/3/06 to 7/4/06	Commonwealth Gladstone Magistrates court S26F(3)	*Azul Libero*	Bulk carrier	Singapore	QLD waters within nearest land and GBRMP ~4 nm off the coast.	Food waste	Owner: $5,000 Master: $1,200
5/12/06	28/09/04	Commonwealth Rockhampton Magistrates Court	*Loch Maree*	Bulk carrier	Hong Kong	QLD waters within nearest land, ~15 nm from coast	Food waste	Owner: $6,000 Master: $500

Table A.2: Boat ramps and jetties in the Gladstone and Rockhampton regions. Note that this list includes facilities beyond the limits of the Ports of Gladstone and Rockhampton (Source: MSQ[71]).

Facility Location	Type	Lanes/berth
Gladstone		
Tannum Sands, Boat Ramp Road	Boat ramp	1
Tannum Sands, Blackwell Street (Ibis park)	Boat ramp	1
Boyne Island, Alexander Street	Boat ramp	1
Boyne Island, Wyndham Road (David Bray Park)	Boat ramp	3
Toolooa, Gladstone - Benaraby Road	Boat ramp	2
Gladstone, Morgan Street	Boat ramp	2
Gladstone, Goondoon Street	Boat ramp	3
Gladstone, Hanson Road	Boat ramp	4

[70] https://www.amsa.gov.au/environment/legislation-and-prevention/prosecutions/garbage/table.asp Accessed March 2015

[71] http://www.msq.qld.gov.au/~/media/msqinternet/msqfiles/home/waterways/boating%20infrastructure/boating%20facilities/pdf_boatramp_central_qld.pdf Accessed April 2015.

Curtis Island, Wyndham Avenue	Boat ramp	1
Calliope River, Bruce Highway	Boat ramp	1
The Narrows, south of Ramsay Crossing	Boat ramp	1
The Narrows, Ramsay Crossing	Boat ramp	1
Gladstone Marina*	Boat ramp	5
Rockhampton		
Port Alma, Port Alma Road	Boat ramp	2
Rockhampton, Derby Street	Jetty	
Rockhampton, Larcombe Street	Boat ramp	2
Rockhampton, via Huet Street (Ski Gardens)	Boat ramp	2
Rockhampton, Reaney Street	Boat ramp	2
Nerimbera, St Christopher's Chapel Road	Boat ramp	2
Keppel Sands, Limpus Avenue (upstream)	Boat ramp	1
Keppel Sands, Limpus Avenue (downstream)	Boat ramp	1
Keppel Sands, Taylor Street	Boat ramp	2
Coorooman Creek, Svendsen Road	Boat ramp	2
Emu Park, Hill Street	Boat ramp	1
Mulambin, Yeppoon-Emu Park Road	Boat ramp	1
Rosslyn Bay, Vin E. Jones Drive	Wharf	
Rosslyn Bay, Vin E. Jones Drive	Jetty	
Rosslyn Bay, Vin E. Jones Drive (commercial jetty #2)	Jetty	
Rosslyn Bay, Vin E. Jones Drive (Lay-up maintenance jetty #1)	Jetty	
Rosslyn Bay, Anchor Drive (southern)	Boat ramp	4
Rosslyn Bay, Breakwater Drive (western)	Boat ramp	4
Yeppoon, Emu Park Road (Fig Tree Creek)	Boat ramp	1
Corbetts Landing, Corbetts Landing Road	Boat ramp	1

* Not listed by MSQ (constructed in 2011, MSQ data are from 2009)

Table A.3: Most important commercial fish species by weight for Gladstone harbour (Grid S30). Data are for all years 1990–2014 in total (Source: DAF[72]).

Species	Fishing Method	Licences	Days	Weight (t)
Crab – mud	Pot	179	58,005	2,054.68
Prawn - banana	Otter trawl	117	7,413	1,370.19
Scallop - saucer	Otter trawl	275	5,675	531.44
Barramundi	Net	84	4,715	493.11
Mullet - unspecified	Net	128	7,082	384.97
Shark - whaler unspecified	Net	48	3,098	372.16
Mackerel - grey	Net	50	2,422	351.17
Threadfin - blue	Net	131	8,485	245.46
Shark - unspecified	Net	106	4,416	234.23
Total for key sp.			**101,311**	**6,037.42**

Table A.4: Summary of key commercial fishing species (1990–2014) for Rockhampton (Grid R30) (Source: DAF[73]).

Species	Fishing Method	Licences	Days	Weight (t)
Crab – mud	Pot	165	56,205	1,457.59
Prawn – banana	Beam trawl	53	16,905	638.10
Barramundi	Net	102	10,974	449.94
Threadfin – blue	Net	141	7,235	295.21
Threadfin – king	Net	139	12,481	470.70
Total for key sp.			**103,800**	**3,311.54**

[72] Query results for grid region S30 for commercial fishing effort. Retrieved from http://qfish.daff.qld.gov.au/Query/ViewResults?CubeId=7&PredefinedQueryId=2d38a533-02cb-41a5-88d7-46700c7ee480&ViewKind=Pivot May 2015.
[73] Query results for grid region R30 for commercial fishing effort Port Alma. Retrieved from http://qfish.daff.qld.gov.au/Query/ViewResults?CubeId=7&PredefinedQueryId=107accd9-edf6-4611-acfd-2c1e7b92eef3&ViewKind=Pivot May 2015.

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Fitzroy Basin Association Incorporated
PO Box 139, Rockhampton QLD 4700
Phone: (07) 4999 2800
Fax: (07) 4921 2860

www.fba.org.au

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