Gladstone Healthy Harbour Partnership
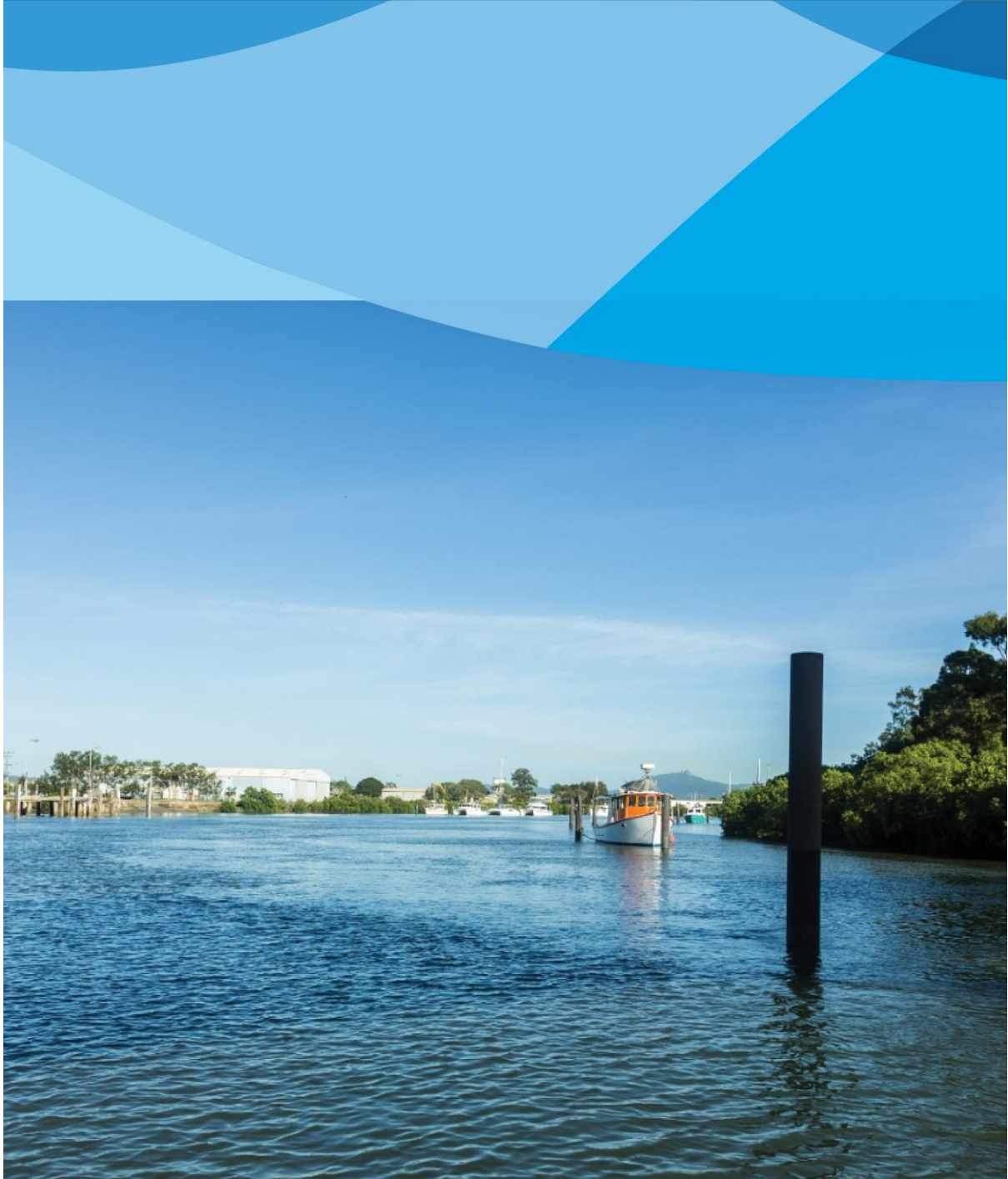
TECHNICAL REPORT | GLADSTONE HARBOUR PILOT REPORT CARD 2014

Acknowledgements

Disclaimer

The first Gladstone Harbour report card will be released in November 2015. A pilot report card was released a year in advance (December 2014), using a small subset of the data and the indicators that will be included in the first report card. The purpose of the pilot report card was to demonstrate the structure and format that the first report card will take, to test the methods for analysing data and developing indicators, and to provide an opportunity for stakeholders and the community to comment. This report provides the background, context and more detailed explanation of what is in the pilot report card.

While reasonable efforts have been made to ensure that the contents of this document are factually correct, measures and indicators included in the pilot report card are based on preliminary data analysis due to several data issues encountered, and the very short time available to generate the pilot scorecard. The methods used for the pilot report card are robust but reflect the current state of development of the methods. Great care should be taken in the interpretation of the pilot report card as it only includes a subset of the data and the indicators that will be used in the first report card in 2015. The pilot report card and this report have been released to demonstrate the approach that is planned for the first report card and not as an early summary of the condition of the Gladstone Harbour.

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Suggested citation

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GHHP partners

Australian Government, Australian Institute of Marine Science, Australian Pacific LNG, Boyne Smelters, CQG Consulting, Central Queensland University, CSIRO, Dhou Woolkoom, Fitzroy Basin Association, Gidarjil Development Centre, Gladstone Area Water Board, Gladstone Ports Corporation, Gladstone Regional Council, Gladstone Region Environmental Advisory Network, Griffith University, NRG, Orica, QGC, Queensland Alumina Limited, Queensland Government, QER, Rio Tinto Alcan, Santos GLNG Project, The University of Queensland, WICET.

List of Management Committee representatives

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Chair, Mr Paul Birch (Fitzroy Basin Association)
Mr Peter Brady (Gladstone Region Environmental Advisory Network)
Mr Peter Brockhurst (Gidarjil Development Corporation)

Government
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Councillor Col Chapman (Gladstone Regional Council)
Ms Peta Lane (Australian Government, Department of the Environment)

Industry
Mr Kurt Heidecker (Gladstone Industry Leadership Group)
Mr John Sherriff (Gladstone Ports Cooperation)
Mr Gary Scanlan (Santos – Gladstone Liquefied Natural Gas)

Research
Mr John Gunn (Australian Institute of Marine Science)

Executive Summary

GHHP

The Gladstone Healthy Harbour Partnership (GHHP) is a forum to bring together parties including community members, Traditional Owners, industry groups, science agencies, national, state and local government and harbour managers to maintain, and where necessary, improve the health of Gladstone Harbour. The GHHP vision is that "Gladstone has a healthy, accessible, working harbour." The guiding principles of the Partnership are open, honest and accountable management, annual reporting of the health of Gladstone Harbour and the provision of actionable management advice based on rigorous science and strong stakeholder engagement to ensure the ongoing and continuous improvement to the health of the harbour.

The establishment of the partnership is a Queensland Government initiative and currently has 25 partners comprising 13 industry representatives, five research and monitoring agencies, Commonwealth, state and local government representatives and four community groups including Traditional Owners.

The GHHP is advised by an Independent Science Panel (ISP) whose role is to ensure that the environmental, social and economic challenges of policy, planning and actions to achieve the vision of GHHP are supported by credible science through the provision of independent scientific advice, review and direction.

Pilot report card

The 2014 pilot report card was designed to trial report card indicators, statistical methods, and approaches to communicating the report card results. The goal of this pilot report card was to demonstrate the planned approach into the future and to receive feedback to incorporate into the first report card to be released at the end of 2015. The pilot report card includes only three of the four components of harbour health that will appear in the full report cards and is based on indicators of water quality, social health and economic health relevant to the 2013-14 financial year. This is only a small subset of the data and the indicators that will be included in the first report card which will also include a cultural component.

Report card grades and scores

The social, economic and environmental health of the Gladstone Harbour was reported on an A to E scale. As presented below each grade was also associated with a range of scores from 0 to 1.

A	**Very good (≥ 0.85)**
B	**Good (≥ 0.65, < 0.85)**
C	**Satisfactory (≥ 0.5, < 0.65)**
D	**Poor (≥ 0.25, < 0.50)**
E	**Very poor (0, < 0.25)**

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For water quality, a score of 0.50 indicated that the measure under consideration was equal to the relevant water quality guidelines presented in the Capricorn Curtis Coast Water Quality Objectives (DEHP 2014a). The objectives were set using historical data from a range of sources and provide locally refined and relevant guidelines. These guidelines have recently included a guideline concentration of 24 ug/L for dissolved aluminium based on the recommendation of Golding *et al*. (2014). If a particular measurement met the relevant guideline, it received a grade of A, B or C depending on how far within the guideline the measurement was. If a measurement did not meet the relevant guideline level, it received a score of D or E depending on how far outside the guideline it was.

For the social and economic indicators, a C grade did not necessarily indicate passing or failing a guideline. Rather it indicated a satisfactory state of social or economic health related to the relevant benchmark or baseline which are identified in the social and economic sections below.

Environmental (Water quality)

In the 2014 pilot report card the only environmental indicator assessed was water quality. The full Gladstone Harbour report cards to be released from 2015 will include the following additional environmental indicator groups: sediment quality, connectivity, habitats (seagrass, mangroves and coral) and fish and crabs.

All water quality data used to determine water quality scores and grades for the 2014 pilot report card were obtained from the Port Curtis Integrated Monitoring Program (PCIMP). Data supplied by PCIMP came from 53 water quality monitoring sites across thirteen harbour zones (Figure 1.6).

The overall grade for water quality in the 2014 Gladstone Harbour pilot report card was a C, and the overall score was 0.58. Nine of the thirteen Gladstone Harbour zones received an overall environmental scores of greater than 0.50. 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 lowest scores were recorded in Auckland Inlet (0.41), Boat Creek (0.47), Boyne Estuary (0.47) and Calliope Estuary (0.48).

Very good scores for dissolved oxygen were recorded across all harbour zones and very good scores for copper were recorded in all but one harbour zone, Rodds Bay which received a good score. Scores for aluminium ranged from poor in one zone (Boyne Estuary) to very good in four harbour zones—Inner Harbour, South Trees Inlet, Colosseum Inlet and Rodds Bay. Scores for nitrogen and phosphorus were generally low across all harbour zones, as were the scores for turbidity with only three zones—the Inner Harbour, South Trees Inlet and the Outer Harbour receiving a score of greater than 0.50 for this indicator.

Social

The overall grade for the social component of the 2014 Gladstone Harbour pilot report card was a C**.** The grade for social health was mainly determined through a community survey of 400 people from the Gladstone Local Government Area that was conducted in August 2014. Survey respondents were asked to respond to a range of questions on a 10 point agree/disagree scale. Report card scores were calculated based on these responses. The three indicators assessed to determine this grade were harbour access, liveability/wellbeing and harbour usability.

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Harbour access received a score of 0.61 with most survey respondents satisfied with their level of access to the harbour, their most recent trip to the area and the quality of boat ramps and facilities. Liveability and Wellbeing received a score of 0.64 with most people agreeing that the harbour improves their liveability and wellbeing. Harbour usability received a score of 0.60. This grade was affected by measures related to the harbour safety, i.e., marine pollution and marine safety incidents.

Economic

The overall grade for the economic component of the 2014 Gladstone Harbour pilot report card was a B. The three indicators assessed to determine this grade were, economic stimulus, economic performance and economic value.

The economic stimulus indicator group consisted of two indicators, employment and socio-economic status. The grade for employment was based on unemployment statistics for the Gladstone Local Government Area which were compared with unemployment rates in all Queensland Local Government Areas.

The score for socio-economic status was derived using the Australian Bureau of Statistics (ABS) economic measure known as the Index of Economic Resources (IER). This was calculated using Australian census data for the Gladstone region, and then estimates were fine-tuned using the information collected in the community survey. Of the three indicator groups, economic stimulus received the highest score of 0.87. This was attributed to the comparatively high socio-economic status of the Gladstone community and high levels of employment.

The economic performance indicator group consisted of three indicators: tourism (hotel occupancy), commercial fishing and the level of shipping activity. These were selected to reflect the key industries using the harbour, and weighted according to economic activity and a survey of local industry and community leaders. The overall score for the economic performance indicator group was 0.83. This reflected strong results for the shipping sector dominating mixed results from commercial fishing and a moderate result for hotel occupancy due to recent changes in the construction industry.

The indicator group economic value was assessed in terms of non-market values of recreation and received a score of 0.75. This score was largely driven by land-based and beach-based recreational activities, and was also affected by recreational fishing.

Iconic Species

Gladstone Harbour and its associated water bodies and islands provide important habitat, breeding sites and roosting locations for a number of iconic marine species and migratory shorebirds. This includes marine mega fauna such as the dugong and two species of dolphins (Indo-Pacific humpback dolphin: the Indo-Pacific humpback and bottlenose dolphins). Six species of marine turtles have been recorded within the harbour although only the flatback turtle nests annually with most nesting recorded on the south end of Curtis Island. Nesting has been recorded within the harbour for loggerhead and green turtles but not on an annual basis. While hawksbill, olive ridley and leatherback turtles have also been recorded in Gladstone Harbour no nesting has been observed. Up to 20 species of migratory shorebirds have been recorded within the Gladstone Harbour area. Future report card technical reports may include trends on population or significant findings related to these species. However as there can be a considerable lag between an environmental impact and a response in these species they have not been included in report card grades.

The GHHP website

The GHHP report card website is the primary interface to access all levels of report card information, including information on GHHP, high level summaries of report card results, trend data, explanations of the report card indicators and all GHHP publications. The website will also provide access to technical reports upon which the report card is based.

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Contents

1. Introduction

Gladstone Harbour, located in Central Queensland about 530 km north of Brisbane, is the largest multi-commodity port in Queensland and the fourth largest in Australia. The harbour comprises large, open bodies of water as well as a system of rivers, inlets and channels, containing diverse habitats. It is bounded by areas of natural vegetation as well as urban and industrial land and areas of reclaimed land (e.g. Fisherman's Landing), and contains extensive port infrastructure. Gladstone Harbour is part of the Great Barrier Reef World Heritage Area, and is adjacent to the Great Barrier Reef Marine Park.

The port facilities in Gladstone Harbour are managed and operated by the Gladstone Ports Corporation Ltd. (GPC) on behalf of the Queensland Government. The port handles more than 30 industrial products including coal, alumina, bauxite, cement and liquid ammonia, and has recently commenced export of Liquefied Natural Gas (LNG). More than 75 million tonnes of total product move through the port on an annual basis (Greer & Kabir 2013).

Gladstone Harbour is also culturally significant with at least 16 known indigenous cultural sites present on Curtis Island (McCabe & James 2013). There is a long history of commercial fishing in and around Gladstone Harbour, and recreational fishing is an integral part of the region's way-of-life. Over 61,000 people reside in the Gladstone Local Government Area, which covers one million hectares.

Rapid industrial development in and around Gladstone Harbour, an outbreak of fish disease in 2011, and UNESCO's consideration of the Great Barrier Reef's World Heritage Area status have contributed to public concern about the health and ongoing management of Gladstone Harbour. This concern prompted the formation of the Gladstone Healthy Harbour Partnership.

1.1. The Gladstone Healthy Harbour Partnership

1.1.1. Overview

The Gladstone Healthy Harbour Partnership (GHHP) is a forum that brings together parties including community members, Traditional Owners, industry groups, science agencies, national, state and local government and harbour managers to maintain, and where necessary, improve the health of Gladstone Harbour. The GHHP vision is that "Gladstone has a healthy, accessible, working harbour." The guiding principles of the Partnership are open, honest and accountable management, annual reporting of the health of the Gladstone Harbour and management advice. Actions are based on rigorous science and strong stakeholder engagement to ensure the ongoing and continuous improvement of the health of Gladstone Harbour.

The partnership is a Queensland government initiative and currently has 25 partners comprising 13 industry representatives, five research and monitoring agencies, Commonwealth, state and local government representatives and four community groups including Traditional Owners. The Gladstone Healthy Harbour Partnership was formally launched on 6 November 2013 at the Gladstone Marina Parklands where partner representatives agreed to work together to achieve the GHHP vision GHHP vision.

The GHHP is advised by an [Independent Science Panel](#) (ISP) whose role is to ensure that the environmental, social and economic challenges of policy, planning and actions to achieve the vision of GHHP are supported by credible science through the provision of independent scientific advice, review and direction.

1.1.2. *Moving from a vision to objectives and indicators of harbour health*

The GHHP vision is *Gladstone has a healthy, accessible, working harbour*, and was developed by the Gladstone community and GHHP stakeholders. The vision includes detailed statements relating to environmental, social, cultural and economic aspects of the health of Gladstone Harbour. It was developed by the local Gladstone community, including Traditional Owner groups (Gooreng Gooreng, Taribelang Bunda, Bailai and Gurang tribal groups), community members, and industry including commercial fishers, government, research organisations, conservation groups and recreational fishers.

The ISP developed a set of 'report card objectives' from the GHHP vision that were accepted by the GHHP Management Committee on behalf of the Partnership. The objectives are the measurable goals that underpin the GHHP monitoring and reporting program. They were grouped into environmental, social, cultural and economic categories and used by the ISP to guide the selection of the specific indicators to be measured and reported against. This was done in consultation with the GHHP partners (Figure 1.1).

The ISP commissioned a review of the international and national use of report cards (Connolly et al. 2013), a review of the available data relevant to Gladstone (Llewellyn et al. 2013) and reports to assist in selecting social, cultural and economic indicators (Greer & Kabir 2013) and environmental indicators (Dambacher et al. 2013). The ISP used the recommendations from these reports and consideration of local issues to guide the final selection of indicators to develop and trial in the pilot year prior to the final selection of indicators to be used in the first report card scheduled for 2015. These reports are available on the GHHP website.

GHHP Vision Statement

GHHP Vision Statement   **Report Card Objectives**   **Indicator Groups**

Has the functioning and interconnectivity of key ecosystems, ecosystem services and its biodiversity

Supports a sustainable population of marine species (including megafauna-dolphins, dugongs and turtles)

Has natural tidal and seasonal variations of water quality parameters which are defined, understood and measured

Identifies, acknowledges and protects the Outstanding Universal Values of the Great Barrier Reef World Heritage Area within the Gladstone Port Curtis area

Uses leading environmental practise for the activities in the harbour (and associated catchments) and ensures the activities maintain the resilience of the coastal-marine ecosystem

1. Maintain/improve habitat function and structure of key ecosystems

2. Maintain/improve connectivity of water within and between Gladstone Harbour, related rivers, estuaries and adjacent waters

3. Maintain suitable populations of fauna species reliant on the harbour and waterways

4. Maintain water and sediment quality at levels compliant with the appropriate guidelines

Improvements in management of more systematic governance of and, increased community involvement and empowerment in waterways health issues

Habitats

Connectivity

Fish and Crabs

Water and Sediment Quality

ENVIRONMENT

Is a suitable place to hunt

Has fishing exclusion zones

Includes traditional owners in decision making

Preserves the cultural heritage and cultural heritage sites e.g. bunda holes and middens

5. Registered cultural heritage sites associated with the harbour and waterways are protected

6. The Gladstone community's sense of identity and satisfaction with the condition of the harbour is increased

Cultural heritage

Sense of place

CULTURAL

Is a place in which the community has civic and community pride and continues to support a sense of community e.g. friendliness, easy access, personal relationships and lifestyle

Is a place where perceptions about the health of Gladstone Harbour reflect reality

Has infrastructure in place that allows citizens to easily and safely use, access and enjoy the harbour and foreshore for recreational activities (such as boating, fishing, crabbing, picnicking and swimming)

Is a safe and healthy place for all users

Improve information flows about and engagement with the Gladstone community over harbour and waterway health issues

7. Maintain/improve easy access to the harbour waters and foreshore for recreation and community uses

8. Maintain/improve a safe harbour for all users (e.g. swimming, boating and foreshore activities)

Community access and use

SOCIAL

Is a working harbour that is vital for Gladstone, Queensland and Australia

Continues to support existing and new industries e.g. fishing, tourism, manufacturing, export

Returns benefits to the whole community

Balances economic benefits with community expectations

Is sustainable in the long term

Contributes to a positive diverse economic future

9. The Gladstone Harbour is managed to support shipping, transport and a diversity of industries

10. Economic activity in the Gladstone Harbour continues to generate social and economic benefits to the regional community

Economic performance

Economic stimulus to community

ECONOMIC

Figure 1.1: The Gladstone Harbour report card objectives and indicator groups were developed from the GHP Vision Statements for the Environmental, Cultural, Social and Economic components of Gladstone Harbour health.

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### 1.1.3. The four areas of harbour health

The Gladstone Harbour report card will be the first report card in Australia that will report on environmental, social, cultural and economic health (Figure 1.2). Those four components were identified as being important to the community through stakeholder and community consultation. All four components will be reported on an annual basis starting with the first Gladstone Harbour report card in 2015. The 2014 pilot report card reports on three of the four components, as indicators for the cultural component require further development.
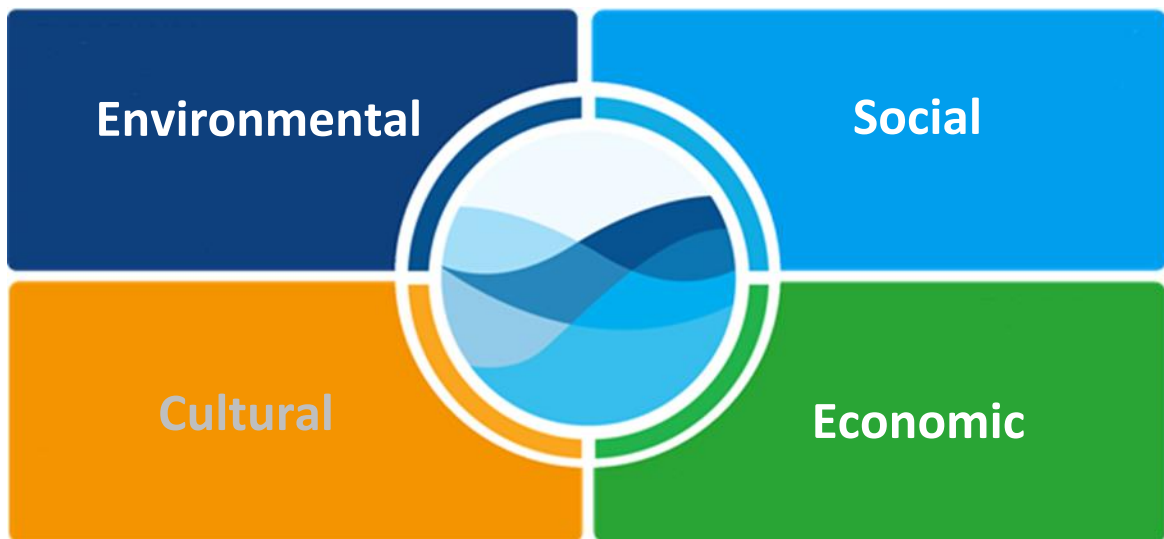
Figure 1.2: The four components of harbour health as defined by the GHHP vision.

1.2 The science program

The GHHP Science program has three distinct phases: the design (2013), pilot (2014) and operational phase (from 2015 onwards) (Figure 1.3).
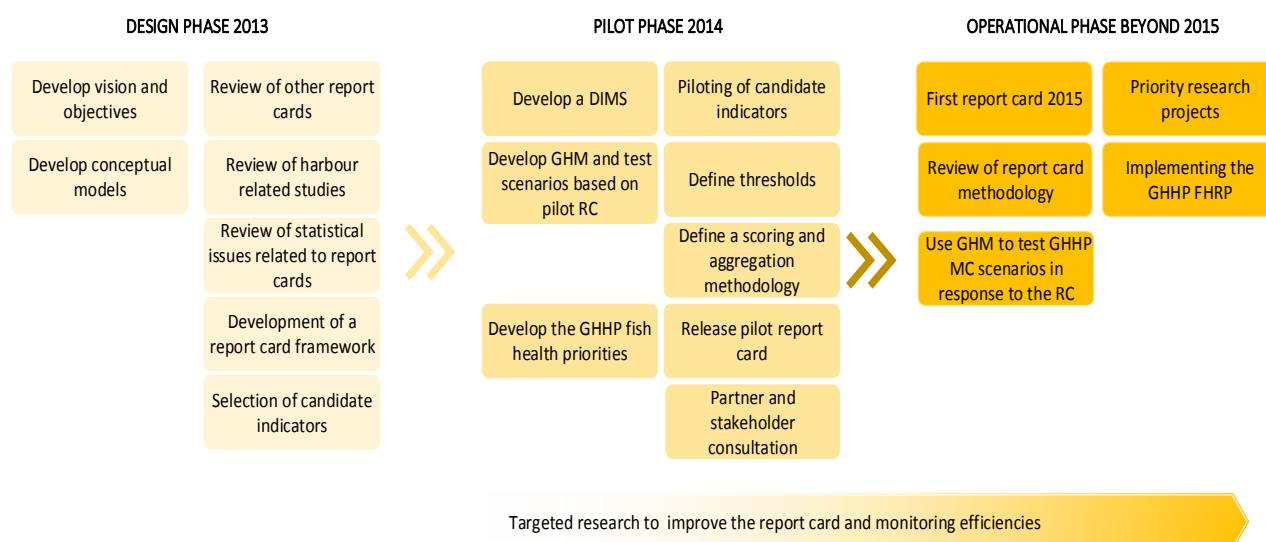
Figure 1.3: The three phases of the GHHP science program. (DIMS = Data and information Management System, GHM = Gladstone Harbour model; RC = report card; MC = Management Committee).

The ISP with the agreement of the GHHP Management Committee developed a program of coordinated research projects to be conducted in each of the three phases to help in the design and implementation of the GHHP report card and its ongoing improvement. When completed the final reports from each of these projects will be downloadable from the GHHP website.

Table 1.1 presents a list of completed projects from the design phase, completed and ongoing projects from the pilot phase and ongoing and new projects from the operational phase. Projects completed in the design phase include:

- Identification of existing monitoring programs and research to avoid duplication of effort.
- Mapping and synthesis of existing data for Gladstone Harbour and the development of the GHHP e-portal.
- Review of existing report cards.
- Report card indicator selection studies.
- Selection of indicators for the Gladstone Harbour report card.
- Development of a framework for the Gladstone Harbour report card.

Projects conducted in the pilot phase included:

- Development of monitoring projects and statistical methods that are required to develop a scientifically robust monitoring program to be delivered annually from 2015 through the Gladstone Harbour report card, GHHP website and associated technical reports.

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- The development of a Digital Information Management System (DIMS). When fully functional this system will allow the upload of data from monitoring programs and will automatically generate report cars scores and grades. Through the GHHP e-portal the public will be able to view past and present report cards and to search for technical and other reports relevant to the health of the harbour.
- The Gladstone Harbour Model, this model currently being developed by CSIRO, will be a tailored decision support tool. When completed it will integrate a wide range of environmental, social, cultural and economic information in a common framework. It will provide a mechanism to 'road test' management strategies before implementing them in reality, allowing users to investigate the likely effectiveness and cost of different actions to maintain or restore the health of the system.

Programs to be conducted in the operational phase from 2015 onwards include:

- The ongoing development of the monitoring and reporting programs that commenced in 2014.
- The ongoing development of the Gladstone Harbour Model including testing potential management scenarios developed in conjunction with the Management Committee.
- The ongoing development of the Digital Information Management System.
- The development of priority research areas for identifying the causality of fish health issues observed within Gladstone Harbour in 2011 and the development of approaches for the early detection of fish health issues in the future.

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Table 1.1: The GHHP Science program including past, present and planned future projects.

Phase	Project title	Conducted by	Completion date
Design phase	Port Curtis monitoring and research programs and the Gladstone Harbour report card (GHRC): Potential contributions and avoiding duplication	GHHP Internal Report	August 2013
	Mapping and synthesis of data and monitoring in Gladstone Harbour	Australian Institute of Marine Science (AIMS)	August 2013
	Review of the use of report cards for monitoring ecosystem and waterway health	Griffith University, CQU and The University of Queensland (UQ)	November 2013
	Guidance for the selection of social, cultural and economic indicators for the development of the GHHP report card	CQU	November 2013
	Models and indicators of key ecological assets in Gladstone Harbour	CSIRO	December 2013
	Gladstone Harbour report card framework recommendation	GHHP Internal Report	March 2014
Pilot phase	Development of social, cultural and economic indicator scores and grades for the Gladstone Healthy Harbour Partnership report card	CSIRO, CQU, James Cook University (JCU)	November 2014
	Development of connectivity indicators for the Gladstone Harbour report card	CSIRO, UQ	December 2014
	Gladstone Healthy Harbour Partnership seagrass pilot report card	JCU	December 2014
	Statistical assessment of fish indicators and scores for the 2015 report card	Dr Bill Venables, CSIRO Post-retirement Research Fellow in collaboration with Infofish	December 2014
	Pilot report card	GHP	December 2014
	Development of a data and information management system for the GHHP report card monitoring data	AIMS	January 2015

Table 1.1 (cont.): The GHHP Science program.

Phase	Project title	Conducted by	Completion date
Pilot phase	Provision of statistical support during the development of the Gladstone Harbour report card	Queensland University of Technology (QUT)	January 2015
	Fish health workshop, to identify research priorities	GHHP	March 2015
	Developing the cultural indicators for the Gladstone Healthy Harbour Partnership report card	To be determined	To be determined
Operational phase	Operational Gladstone Harbour Model to support scenario analysis	CSIRO	February/ March 2015
	First Gladstone Harbour report card	GHHP	November 2015
	Monitoring technology improvement plan	To be determined	June 2016
	Development of a Gladstone Harbour model to support the Gladstone Healthy Harbour report card	CSIRO, UQ	June 2016
	Gladstone fish health research program	GHHP, Fisheries Research and Development	2020

1.3   The 2014 pilot report card

Limitations of the 2014 pilot report card

This report has been released to demonstrate the approach that is planned for the first report card and not as an early summary of the condition of the Gladstone Harbour. The scores and grades described in this report are indicative only, and not a definitive outcome. However the methods used for the pilot report card are robust and reflect the current state of development of the methods. The first Gladstone Harbour report card will be released in November 2015.

Report cards provide an effective and increasingly popular way to disseminate the findings of long-term monitoring programs, historically focusing on environmental attributes, but moving towards including social, cultural and economic monitoring in the future. Report cards measure performance and progress in the form of grades or scores and can be used to synthesise and summarise complex, systematically collected scientific information from multiple sources into a small number of grades around distinct

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themes. Report cards have become key communications strategies in aquatic ecosystem-health programs both within Australia and internationally. Examples include the:

- Fitzroy Partnership for River Health report card,
- South-east Queensland Healthy Waterways report card, and
- Great Barrier Reef report card.

The Gladstone Harbour report card will provide the scientific information and understanding necessary to evaluate the social, cultural, economic and environmental health of Gladstone Harbour and assess progress towards the desired long-term goals encapsulated in the GHHP vision. While the health of the Gladstone Harbour will be of interest to a broad range of stakeholders at the local, regional, state and international level, the primary audience of the report card is the Gladstone community and stakeholders involved in managing the harbour.

The 2014 pilot report card was released in December 2014 (Its purpose is to trial report card indicators, statistical methods, and approaches to communicating the report card results. The goal is to demonstrate the planned approach into the future and to receive feedback to incorporate into the first report card to be released in November 2015. The pilot report card includes only three of the four components of harbour health that will appear in the full report cards and is based on indicators of water quality, social health and economic health relevant to the 2013-14 financial year. This is only a small subset of the data and the indicators that will be included in the first full report card in 2015 (Table 1.2).

The Port Curtis Integrated Monitoring Program (PCIMP) provided the water quality data for three sampling periods that were analysed for the pilot report card—December 2013, March 2014 and June 2014. The Gladstone Healthy Harbour Partnership (GHHP) collected the social and economic data.

This pilot report card demonstrates the structure and format that the first report card will take, tests the methods for analysing and combining data to obtain report card scores, and provides an opportunity for stakeholders and the community to comment on its content and approach.

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Table 1.2: A comparison of the components and indicator groups included in the 2014 pilot report card and those to be included in the 2015 report card.

Component and Indicator Group	2014 Pilot	2015
ENVIRONMENTAL (Overall Grade)	✔	✔
Water quality	✔	✔
Sediment quality		✔
Connectivity		✔
Fish and Crabs		✔
Habitats (Including mangroves, seagrass and coral)		✔
SOCIAL (Overall Grade)	✔	✔
Harbour access	✔	✔
Liveability / wellbeing	✔	✔
CULTURAL (Overall Grade)		✔
Sense of place		✔
Cultural heritage		✔
ECONOMIC (Overall Grade)	✔	✔
Economic values	✔	✔
Economic stimulus	✔	✔
Economic performance	✔	✔

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Structure and indicators

A common terminology has been developed to describe the hierarchy of scores for each component of harbour health which can comprise up to five levels of aggregation: sub-component, indicator group, indicator and measures (Figure 1.4). Definitions of each of the terms in this hierarchy are presented in Table 1.3. This structure was designed to derive component scores from raw measurements.
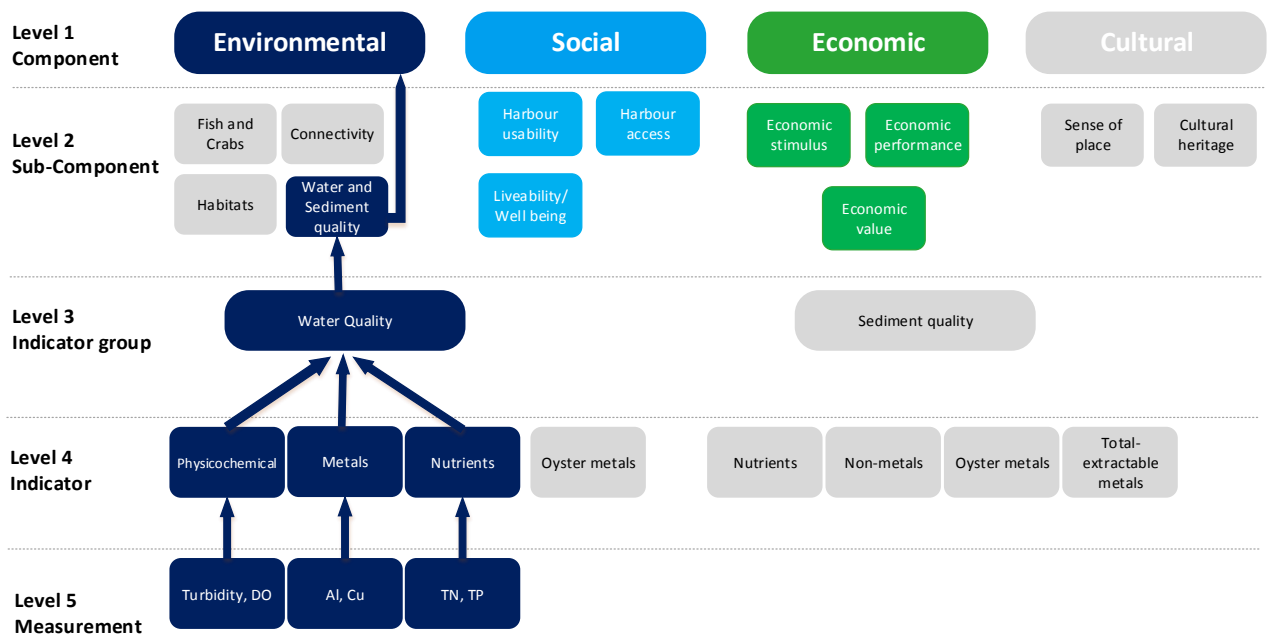
Figure 1.4: The five levels of aggregation that will be used to determine grades in the full report card. Grey coloured boxes denote items not included in the pilot report card. The Environmental component has been expanded to illustrate what was measured at each level. (DO = Dissolved Oxygen, Al= Aluminium, Cu = Copper, TN = Total Nitrogen, TP = Total Phosphorus).

Table 1.3: Explanation of the five levels of aggregation that will be employed to determine an overall grade for the Gladstone Harbour report card.

Name	Explanation	Examples
Level 1 Component	Highest level of aggregation	Environmental, social, cultural & economic
Level 2 Sub-component	The primary areas that make up each component	Water and sediment quality, habitats
Level 3 Indicator group	Each indicator group consists of several indicators	Water quality, sediment quality, seagrass, mangroves, corals
Level 4 Indicator	An aspect of a system that can be used to indicate its condition. These may comprise a single measurement, or an aggregation of several measurements or modelled outputs	Physical/chemical, nutrients, metals, seagrass biomass
Level 5 Measurement	Lowest level of detail, pertaining to data and numerical values	Dissolved oxygen, turbidity, total nitrogen, aluminium

1.3.1   Reporting periods and zones

Reporting Period

The reporting period for the 2014 pilot report card was July 2013 to June 2014. However for the social and economic components some data collected prior to the 2013-14 financial year were used as they were the most up-to-date data available. The first full Gladstone Harbour report card to be delivered in 2015 will report on the period from July 2014 to June 2015. This timing was adopted as it does not break up the significant environmental changes that occur in the wetter summer months where water quality may change rapidly with major rainfall events. (Figure 1.5).

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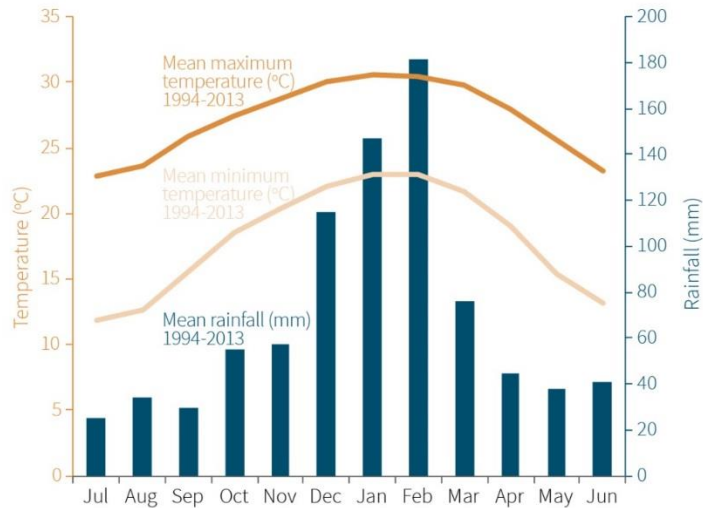
Figure 1.5: Mean monthly rainfall and temperature recordings for 1994 – 2013 from the Bureau of Meteorology monitoring station at Gladstone Airport**.**
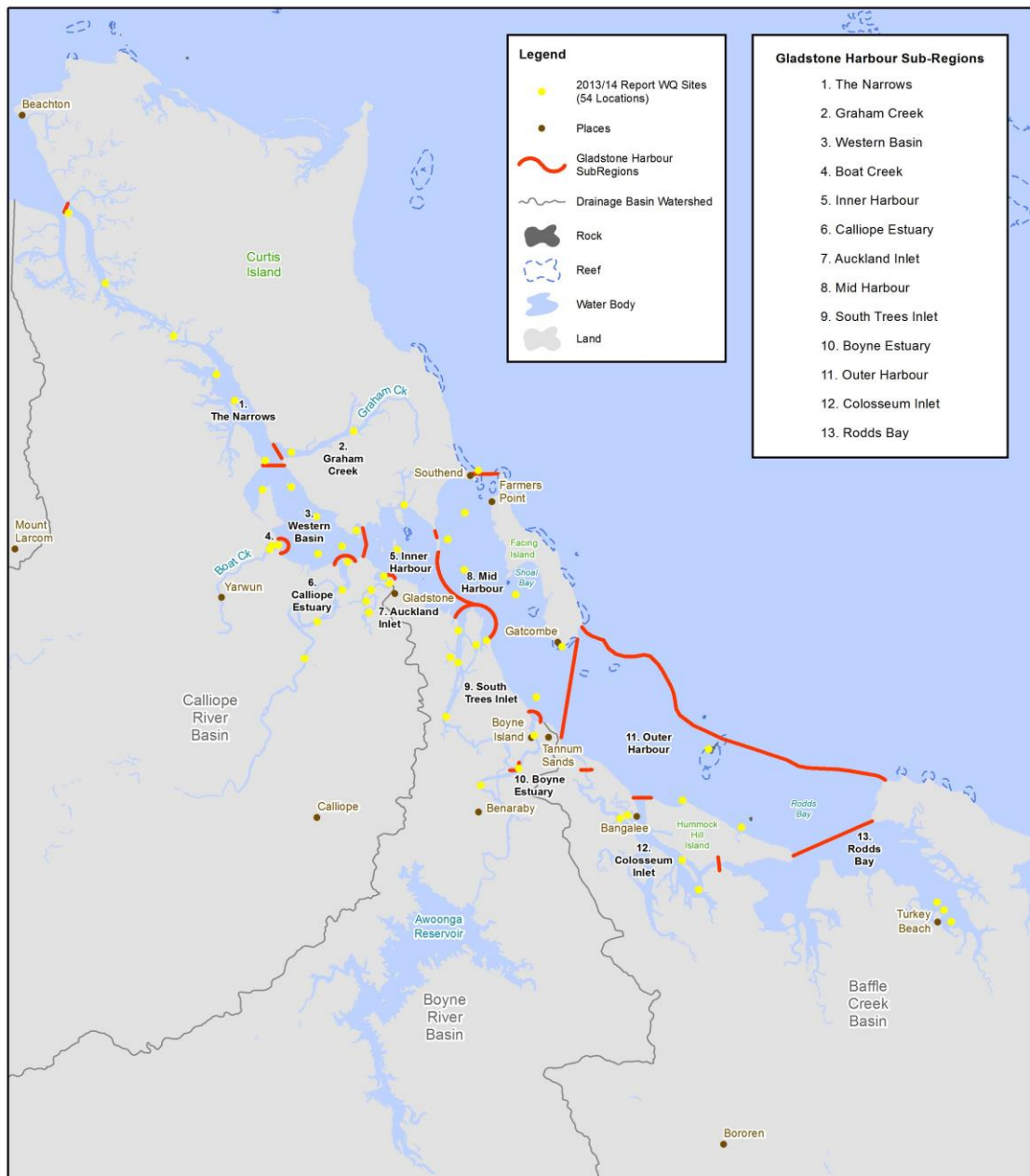
Reporting Zones

The current sub-regions or zones in Gladstone Harbour have developed over time from an initial seven zones proposed by Jones et al. (2005) in a risk assessment for contaminants in Gladstone Harbour. In their 2007 Port Curtis Eco Card PCIMP increased the number of zones to nine by including oceanic and estuarine reference sites (Storey et al. 2007). However these two reference zones were combined in the Port Curtis Eco Card 2008 – 2010 (PCIMP 2010) resulting in eight zones.

The current thirteen zones have been developed through an agreement between PCIMP and the Queensland Department of Environment and Heritage Protection (DEHP) (Figure 1.6). That agreement was part of a larger project to develop regionally specific water quality objectives for the Capricorn Coast (DEHP 2014a).

As part of the development of the pilot report card, GHHP commissioned a statistical support project which (amongst other things) reviewed the zoning of Gladstone Harbour for the assessment of water and sediment quality. This investigation concluded that the number of zones could be reduced based on statistical considerations. However the report went on to say that alternative zones derived on purely empirical grounds may be met with scepticism and confusion and would lead to backward compatibility issues and thus a potential loss of information. Additionally the existing zonation was developed through consultation between government and industry and is proposed to be included in state legislation.

Most social and economic grades were determined for the Gladstone Local Government Area (LGA) (Figure 1.7). However data for determining some economic scores, including those for shipping, commercial fishing and tourism (hotel occupancy) do not conform to the LGA boundaries. Shipping data were obtained from GPC and were limited to the Port of Gladstone; commercial fishing data were limited to the area within Queensland Fisheries S30 Grid which includes Gladstone Harbour and the open coastal waters immediately adjacent to the harbour (Figure 1.8). Hotel occupancy rates were for the Gladstone District Council area.

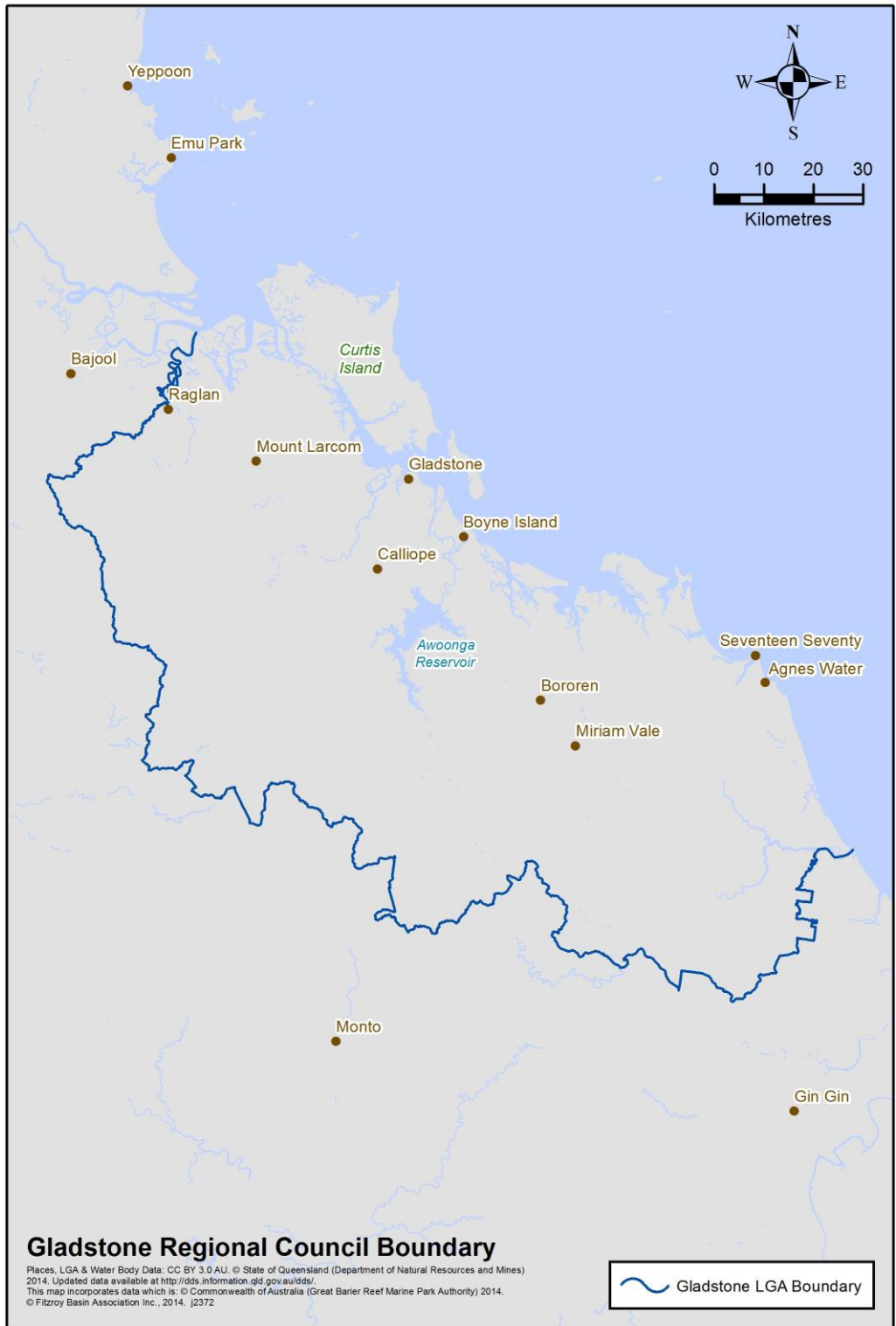**Figure 1.6:** The 13 Gladstone Harbour sub-regions zones for which water quality was measured for the 2014 pilot report card.

Figure 1.7: The Gladstone Local Government Area Boundary.

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Figure 1.8: The Queensland Fisheries S30 Grid.

2. Reporting Methodology

2.1 Data collection

2.1.1 Water quality

Water quality data used to determine water quality scores and grades for the 2014 pilot report card were obtained from the Port Curtis Integrated Monitoring Program (PCIMP). These data were collected from 53 sites across thirteen harbour zones (Figure 1.6). PCIMP water quality data collection usually occurs on a quarterly basis (September, December, March and June), but data from just three sampling periods were used for the pilot report card (December 2013, March 2014 and June 2014).

Turbidity (NTU), dissolved oxygen (%), total nitrogen (ug/L), total phosphorus (ug/L), dissolved aluminium (ug/L) and dissolved copper (ug/L) parameters were assessed for the 2014 pilot report card. Standard sampling methods, field treatment and preservation techniques were employed as outlined in the Water Quality Sampling Manual (DEHP 2009) and followed guidelines in AS/NZS 5667.1: 1998 'Water Quality, Sampling, Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples'.

Physicochemical parameters (turbidity and dissolved oxygen) were measured using a Hydrolab DS5 multi-parameter water meter. Measurements were recorded at 0.5m intervals throughout the water column until the seabed was reached. Water samples for nutrients (nitrogen and phosphorus) and metals (dissolved aluminium and copper) analysis were collected from a depth of about 0.5m using a Teflon Kemmerer sampler. Water samples were analysed at the Australian National Measurement Institute (NMI). NMI is the Australian Government's peak measurement body responsible for biological, chemical, legal, physical and trade measurement. For quality control purposes duplicate samples were collected from eleven randomly selected sites and triplicate samples were collected from five randomly selected sites. The triplicate samples were analysed at independent contract laboratories that were ISO/IEC 17025 accredited and recognised by the National Association of Testing Authorities, Australia (NATA) for good laboratory practice. Those laboratories were Advanced Analytical Australia Pty Ltd and ALS Global in Brisbane, and Envirolab Services Pty Ltd in Sydney (PCIMP 2010).

2.1.2 Social indicators

The key indicators for social health of Gladstone Harbour were defined by McIntosh et al. (2014) (Table 2.1). Measures to evaluate those indicators were developed through a social, cultural and economic project workshop and a survey of social scientists (Pascoe et al. 2014). The measures, which took the form of specific questions related to the indicators, were used to design a community survey of local residents. This survey was pre-tested and fine-tuned via a focus group discussion on 5 August 2014 involving eight Gladstone residents (four males and four females) aged from 18 to 65 years who had lived in the region for periods of between 2 and 65 years. The survey included 75 questions relating to the GHHP social, cultural and economic objectives. Although the questions were largely qualitative in nature, they were designed to be answered on a 10-point agree-disagree scale to produce quantifiable results. This also ensured that answers would be comparable to other studies such as the Social and Economic Long Term Monitoring Program (SELTMP) for the Great Barrier Reef and will enable elicitation of trends over time (Pascoe et al. 2014).

Primary data to assess the social measures were collected using a Computer Assisted Telephone Interview survey (CATI) of 400 local residents undertaken in August 2014. Participants were contacted using a random dialling technique of households in the Gladstone LGA. The survey respondents were evenly divided by gender (51% male and 49% female) and the age of respondents ranged from 18 to 65 plus years. The survey was administered by trained research interviewers and monitored for quality control.

In addition to the CATI survey a range of secondary data sources were also used to derive measures for both the social and economic components of the pilot report card. Those data sources included Gladstone Regional Council (GRC), the Australian Bureau of Statistics (ABS), Gladstone Ports Corporation Limited (GPC), the Queensland Department of Agriculture, Fisheries and Forestry (DAFF), the Office of Economic and Statistical Research and Tourism and Events Queensland. The 2014 pilot report card was based on data for 2013-14 or the most recent data available (Pascoe et al. 2014).

Table 2.1: Sub-components, indicators and measures used to determine the social grade and scores for the 2014 pilot report card. Measures refer to specific questions in the community CATI survey.

Sub-component	Indicators	Measures
Harbour usability	Satisfaction with harbour recreational activities	How satisfied with last trip
		Quality of boat ramps and facilities
	Air and water quality	Water quality satisfaction
		Air quality satisfaction
		Water quality does not affect use of the harbour
	Harbour safety	Marine safety incidents
		Oil spills
		Safety at night
		Happy to eat seafood
Harbour access	Satisfaction with access to the harbour.	Fair access to harbour
		Input into management
	Satisfaction with ramps and public spaces	Frequency of use
		Number of boat ramps
		Access to public spaces
	Perceptions of harbour health	Great condition
		Optimistic about future health
		Improved over the last 12 months
	Barriers to access	Marine debris a problem
		Marine debris affects access
		Shipping reduced use
		Recreational boats reduced use
Liveability and wellbeing	Liveability and wellbeing	Makes living in Gladstone a better experience
		Participate in community events

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Word Cloud

Word clouds enable the visual identification of key recurring issues or themes in an area. At the start of the community CATI surveys participants were asked "when you think of the Gladstone Harbour area, what are the first three words that come to mind?" The preparation of words for analysis involved the following steps. Responses with two or more words were hyphenated to create one word, all entries of the word 'none' were removed as they indicated a respondent would not or could not give three words. The word 'none' was recorded twice for the first word, 16 times for the second word and 54 times for the third word. All spelling errors were corrected and some words were revised for consistency for example Ships and Industrial Ships were altered to Shipping. Some prepositions were also removed e.g. Nice-to-be-on became Nice. These words were analysed using the web-based application *Wordle* to produce the word clouds (see www.wordle.net). This analysis gives greater prominence to words that appear most frequently. Two word clouds were produced. The first used just the first word supplied and the second was based on all three word supplied. The word clouds are presented in Section 3.2.

2.1.3   Economic indicators

The Sub-components, indicators and measures used to determine the overall economic grade for the pilot report card are presented in Table 2.2. These key areas were suggested by GHHP (McIntosh et al. 2014).

In comparison to the measures developed for the social component of the pilot report card the majority of economic measures were more quantitative and different approaches were required. However some economic data were collected via the community CATI survey. This included a section of the survey that was devoted to demographic and household economics including income and home ownership, and a section on the non-market economic values of recreation in the Gladstone Harbour area. Those values were determined using the Travel Cost Method (TCM), which assesses the value of using a recreational site based on the investment that people have made to do so, including travel costs, travel time and other access and site costs.

A range of secondary data were collected to derive other economic measures. These included Australian Bureau of Statistics 2011 census data, unemployment statistics at the local government area level for Queensland, turnover of harbour based industries data obtained from the Queensland Office of Economic and Statistical Research, monthly shipping movement data provided by GPC, commercial fishing data from the QFish data base, and tourism data for the Gladstone District Council area from economy.id.

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Table 2.2: Sub-components, Indicator groups and indicators assessed to determine the economic grade for the Gladstone Harbour 2014 pilot report card. Data are for the 2013-14 financial year unless otherwise indicated.

Sub-component	Indicators	Measures
Economic performance	Tourism (hotel occupancy)	Expenditure on hotel accommodation (2012-13 financial year)
	Shipping activity	Monthly shipping movements by cargo type (2012-13 financial year)
	Commercial fishing	Estimated total value of fish and crustaceans harvested from QFish zone S30 in four fishery sectors, trawl, pot, line & net
Economic stimulus	Employment	Unemployment statistics for the Gladstone Local Government Area (December quarter, 2013-14)
	Socio-economic status	Index of economic resources derived from 2011 ABS census and updated using the community CATI survey (September 2014)
Economic value (Recreation)	Beach recreation	Travel cost data derived from the community CATI survey (September 2014)
	Recreational fishing	Travel cost data derived from the community CATI survey (September 2014)
	Land-based recreation	Travel cost data derived from the community CATI survey (September 2014)

Economic performance

The economic performance indicator group consisted of three indicators; tourism (hotel occupancy), commercial fishing and the level of shipping activity. These were selected to reflect the key industries using the harbour, and weighted according to economic activity and a survey of local industry and community leaders. All economic data were adjusted for inflation into 2014 dollar values, and then aggregated into a grade for each of the three indicators.

Tourism (Hotel occupancy)

The report card grade for tourism was based on expenditure on hotel accommodation in the Gladstone Region, in comparison with 10 year average expenditure (2002 to 2011). The data were provided by the Australian Bureau of Statistics and were based on the 2012-13 financial year as those were the most up-to-date data available. Hotel occupancy is a standard measure of tourist activity, and usually includes business travel. In the Gladstone region, hotel occupancy in recent years has been strongly influenced by LNG plant

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construction and other industrial activity, so provides an indicator of overall economic activity encompassing more than recreational travel alone.

Commercial Fishing

The report card grade for commercial fishing was based on fishing effort and the value of the landed catch in four fishery sectors: the net, line, pot (mud crab) and otter trawl fisheries. Commercial fishers operating in Queensland's state-managed fisheries are required to complete daily catch and effort logbooks. These logbooks detail where, when and how fishing took place, and what was caught. Catch and effort information are available from the Queensland Department of Agriculture, Forestry and Fisheries scaled to standard 30 x 30 nautical mile grids. Data for the 2013-14 financial year were collected from the area within Queensland Fisheries Grid S30 only. Fishing activity collected from within the S30 Grid over the period 1990-91 to 2012 was used as the basis for comparison. This grid includes Gladstone Harbour and the open coastal waters immediately adjacent to the harbour. The net, line and pot fishery data reported for S30 is inside Gladstone Harbour. The otter trawl fishery occurs inside and outside the harbour. The fishers involved in all four fisheries are primarily based in Gladstone. The total value of fish and crustaceans caught in Queensland Fisheries Grid S30 in 2013-14 was estimated based on catch by fishing method data from the Qfish data base and average prices for different species derived from ABARES fisheries statistics (Skirtun et al. 2013).

Shipping

Data on monthly shipping movements by cargo type, destination and origin were provided by the Gladstone Ports Corporation. The report card grade for shipping activity was based on capacity utilisation (current level of activity relative to potential level of activity). Data for the 2012-13 financial year were used in this pilot report card as that was the most recent year for which financial statistics were available. Shipping activity from 2006-07 to 2011-12, and potential future shipping activity related to developments on Curtis Island and at Fisherman's Landing were used as the basis for comparison.

Economic stimulus

The economic stimulus indicator group consisted of two indicators, employment and socio-economic status.

Employment

The report card grade for employment was based on statistics for the Gladstone Local Government Area provided by the Australian Bureau of Statistics (ABS). The most recent ABS data were for the 2013 December quarter. Unemployment in the Gladstone LGA was compared with unemployment rates in all Queensland LGA's

Socio-economic status

The report card grade for socio-economic status was derived using the Australian Bureau of Statistic's Index of Economic Resources (IER) based on the financial aspects of relative socio-economic advantage and disadvantage. It includes variables related to income and wealth but excludes variables related to education and occupation as these are not direct economic measures. It does not include data on savings or equities as these were not collected in the ABS 2011 census. This method takes into account income extremes (both high and low) in a population, as well as household ownership, costs of living and other

indicators relevant to economic wellbeing in the community. A low score indicates a relative lack of access to economic resources and a high score indicates a greater level of access to economic resources. The IER was calculated using ABS 2011 census data and revised for the Gladstone region in 2013-14 using the information collected in the community survey.

Economic value (Recreation)

The recreational value was assessed through three indicators; land based recreation, beach recreation and recreational fishing. The scores for these indicators were based on data collected on the frequency of three types of recreational activity (i.e. recreation based on mainland beaches, land-based recreation other than beach activities and boat-based recreational fishing). Land-based recreation other than beach activities included activities such as walking, running, cycling, shore-based fishing, picnicing or relaxing on the harbour shore.

Most information on the recreational values of harbour-based recreational activities was collected through a community survey of 400 people within the Gladstone LGA conducted in August 2014. Travel cost data were collected for the type of activity the survey respondent undertook most frequently.

2.2   Development of indicators and grades

The pilot report card demonstrated the structure and format that the first report card will take and tested the methods for analysing and combining data to obtain report card scores and grades. The analytical methods supporting the report card are due to be finalised by the end of March 2015.

Outstanding issues that remain to be resolved include the following.

1. Weighting of Harbour Zones – equal weighting was used for the pilot report card, but this will be reviewed for future report cards.

2. Weighting of indicators – the pilot report card analysis used equal weighting but this will be reviewed for future report cards.

3. Treatment of missing data.

4. Sample design – the PCIMP water quality sample design is not balanced (e.g., zones have anywhere between two and six sample sites).

5. Treatment of extreme weather events (e.g. floods) in the analysis of the data.
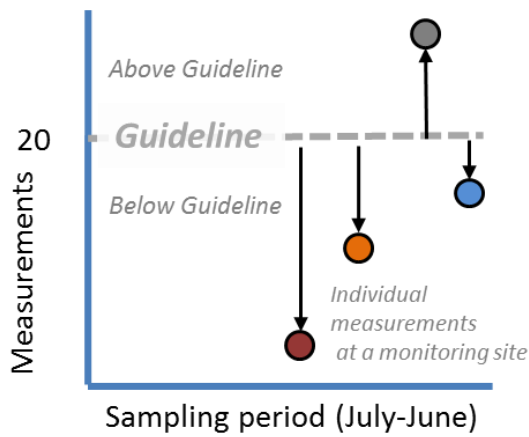
2.2.1   Water Quality Indicators

A hundred candidate water quality parameters were suggested by the ISP as potential indicators of the water quality of Gladstone Harbour. A sub-set of those parameters (Turbidity (NTU), dissolved oxygen (%), total nitrogen (ug/L), total phosphorus (ug/L), dissolved aluminium (ug/L) and dissolved copper (ug/L), see Section 2.1.1) was selected for the 2014 pilot report card by the statistical support team commissioned by GHHP. For the 2014 pilot report card the DEHP water quality objectives for the Capricorn Curtis Coast Region (DEHP 2014a) were used as a baseline for all parameters, with the exception of dissolved aluminium for which a concentration of 24 µg/L was recommended by DEHP based on the recommendation of Golding *et al*. (2014).
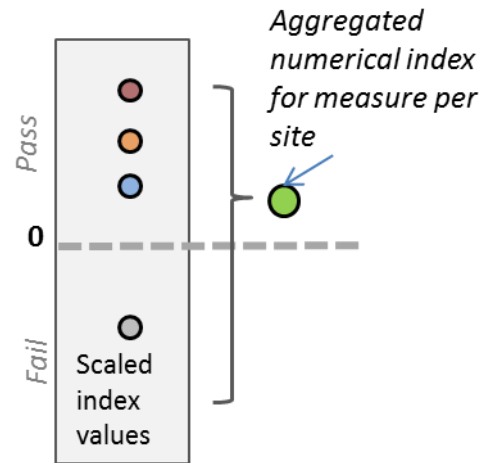
The index score for each indicator per site was then calculated using modified amplitude (scaled) method. This method is based on the distance from the guideline values (Connolly et al., 2013 and Fox 2013). For the pilot report card, the modified amplitude method index was calculated as log2 of the ratio of the site average to the guideline value, and this was then scaled to ensure that the values fell within the range of -1 to +1. These scaled values were then mapped to a grade (A to E) using a control chart with equal boundaries between -1 and +1.

The general approach that was used to determine the scores and grades for water quality measures, indicators, indicator groups, sub-components and the environmental component of the Gladstone Harbour pilot report card is illustrated in the following sequence of diagrams (Figure 2.1).
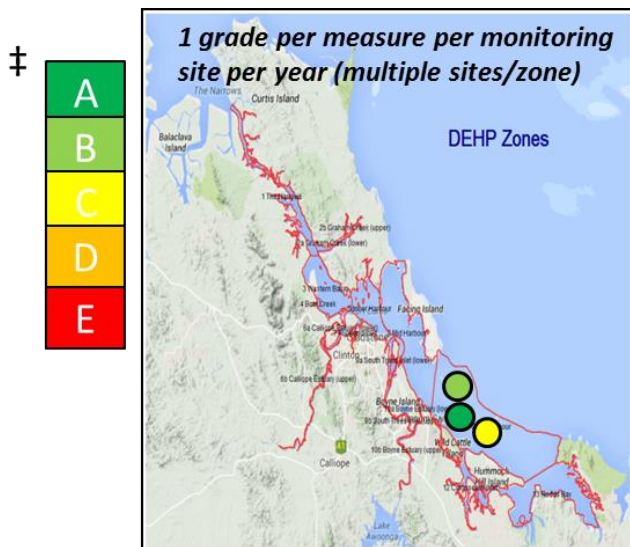
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| **1.** Collected raw water quality data from monitoring sites & compared to water quality objectives.	**2.** Created indexed data as an expression of the degree of difference from the objective using the modified (scaled) amplitude method.
3. Converted numerical index into data bins: A – E (categorical data) (e.g. using Control Charts with equal boundaries).	**4.** Calculated grade proportions per measure per zone per year & added to node probability tables in the Bayesian network.
‡ Equal intervals: A(100-80),B(80-60),C(60-40),D(40-20),E(20-0)	
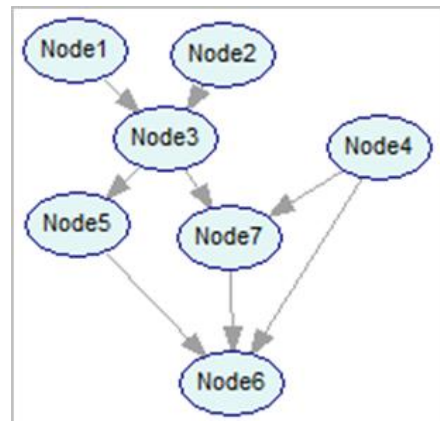
Figure 2.1a: Statistical approach used to generate scores and grades for the pilot report card (Steps 1 – 4 of 10 steps). See text below for a more complete explanation.

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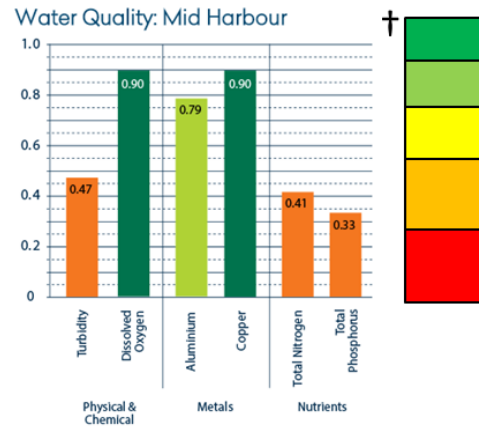| **5.** Aggregated measures to generate indicator scores for each zone (e.g. measures of total nitrogen (TN) and phosphorous (TP) were aggregated into a Nutrients score).	**6.** Report card grades thus determined for each indicator for each zone (e.g. Mid Harbour zone, indicator Total Nitrogen as "D" with a score of 0.41).
	  † Unequal intervals: A(100-85),B(85-65),C(65-50),D(50-25),E(25-0)
7. Aggregated indicator scores (Physicochemical, Metals, Nutrients) into indicator group score (Water Quality) for each zone.	**8.** Report card grades thus determined for Water Quality for each zone (e.g. Mid Harbour zone, Water Quality was grade "C" with a score of 0.63).
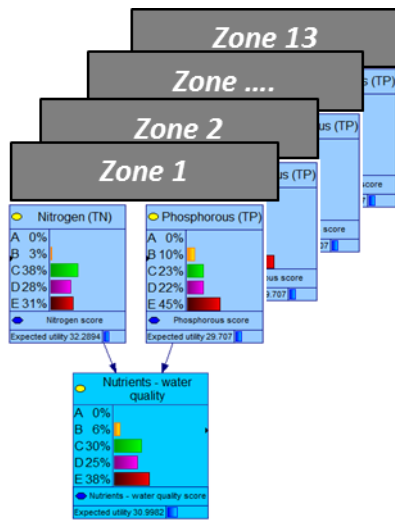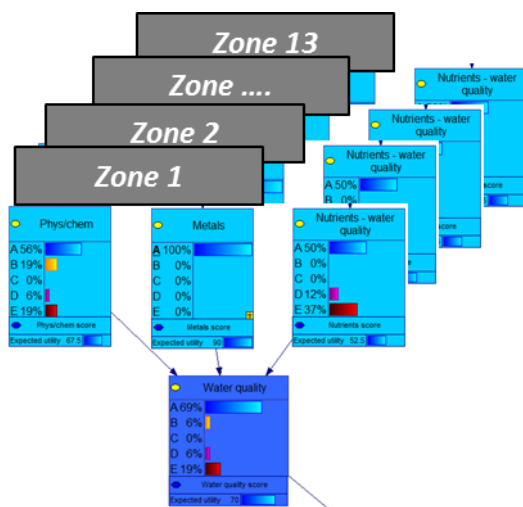
Figure 2.1b: Statistical approach used to generate scores and grades for the pilot report card (Steps 5 – 8 of 10 steps). See text below for a more complete explanation.

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9. Water quality was used as the report card grade for the Environmental component for each zone (e.g. Environmental component for Mid Harbour zone was graded "C" with a score of 0.63).

10. Summarised pilot report card component grades for Gladstone Harbour.
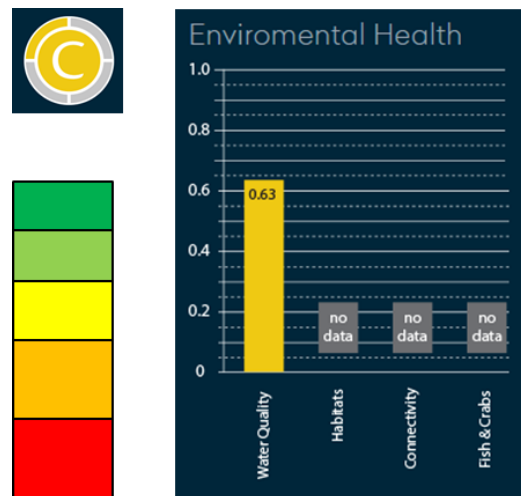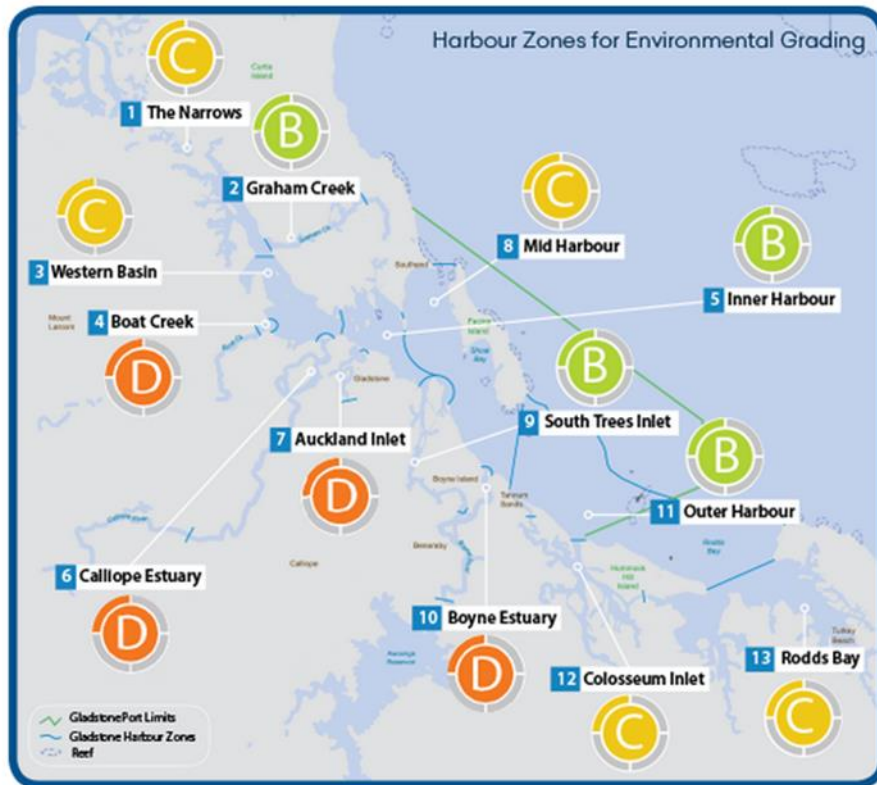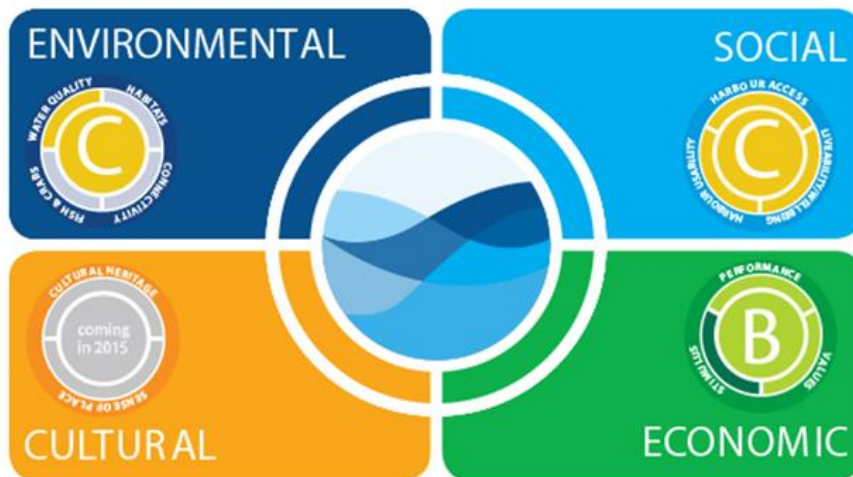

Figure 2.1c: Statistical approach used to generate scores and grades for the pilot report card (Steps 9 – 10 of 10 steps). See text below for a more complete explanation.

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Table 2.3 demonstrates how raw data for Total Nitrogen in Mid Harbour (Zone 8) were converted to data bins.

Table 2.3: Example raw data for Total Nitrogen (TN) measure for Mid Harbour (Zone 8)

	Raw Data (ug/L)			Average of 3 data points (ug/L)	Modified amplitude (scaled)	Bin
Site	Dec 2013	Mar 2014	Jun 2014	2014	2014	2014
B7	140	130	200	156.7	-0.2147	D
C9	150	130	120	133.3	0.0179	C
P4	220	150	185	185.0	-0.4546	D
P5	200	150	110	153.3	-0.1837	C
P6	160	180	100	146.7	-0.1196	C
P7	120	150	130	133.3	0.0179	C
Q1	150	160	160	156.7	-0.2147	D

Averages were calculated for each monitoring site in the Mid Harbour zone (sites B7, C9, P4, P5, P6, P7 and Q1). Deviations from the guideline value for Total Nitrogen (TN), 135, were quantified using the modified amplitude indexation technique, the values were scaled to fall within the range of +1 to -1, and then mapped to grades using control charts.

For this example, the average was compared to the guideline value, which is 135 for TN. Therefore the modified amplitude index value for site B7 was $log_2\left(\frac{135}{156.7}\right) = -0.2147$. As can be seen in Table 2.3, all site averages fell within the range of -1 to +1, so no further scaling was required. Using a control chart with equal boundaries (A: +1.0 − +0.6, B:+0.6 − +0.2, C:+0.2 - -0.2, D: -0.2 - -0.6, E: -0.6 - -1.0), the data bin assigned to TN for site B7 was D.

The next step was to populate a node probability table in the Bayesian network model to show the proportion of sites falling into each of the grades (A to E), for each zone of a measure. For Mid Harbour the proportions for TN grades were: 0 for grades A, B and E; $\frac{3}{7} = 0.43$ for grade D, and $\frac{4}{7} = 0.57$ for grade C (Figure 2.5). The Bayesian Network model used 'expected utility' nodes to calculate scores from the probabilities of each node. It used the mid-point of each grade, i.e. A: 0.9, B: 0.7, C: 0.5, D: 0.3, E: 0.1, to calculate the score. For this example the score for the TN measures in zone 8 was $(0.9*0) + (0.7*0) + (0.5*0.57) + (0.3*0.43) + (0.1*00) = 0.41$. Based on the grade intervals for the pilot report card, A(100-85),B(85-65),C(65-50),D(50-25),E(25-0), this value means that a grade of D was assigned to TN in Mid Harbour.

Measures were combined into indicators, and in this example TN and Total Phosphorus (TP) quantified the Nutrients indicator. The resulting proportions for the grades were an unweighted average of the two measures. Figure 2.2 shows the result of combining TN and TP for the Mid Harbour Zone. A similar procedure was followed to translate the proportion of grades into a score and then the score was mapped to a grade. As can be seen in Figure 2.3, the score for Nutrients in zone 8 was 0.37, so Nutrients had a grade of D (Note: nutrient grades/scores were not captured/published in the pilot report card)

The Nutrients indicator was aggregated with two other indicators: Metals and Physicochemical to calculate a score for the Water quality indicator group. As outlined above, the expected utility node generated a score for the indicator group, which for Mid-Harbour zone, was 0.63, which means it was graded as a C in the pilot report card.

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The process described above was for a specific zone, and this was repeated for all the other Gladstone Harbour zones. Finally, the overall grades and scores for all the zones were combined into an overall harbour grade and score. In the absence of evidence to the contrary, all zones contributed equally to the overall grade and score. This may be varied for the 2015 and subsequent report cards should there be credible reasons to consider certain zones as more 'important' or more indicative of harbour health.
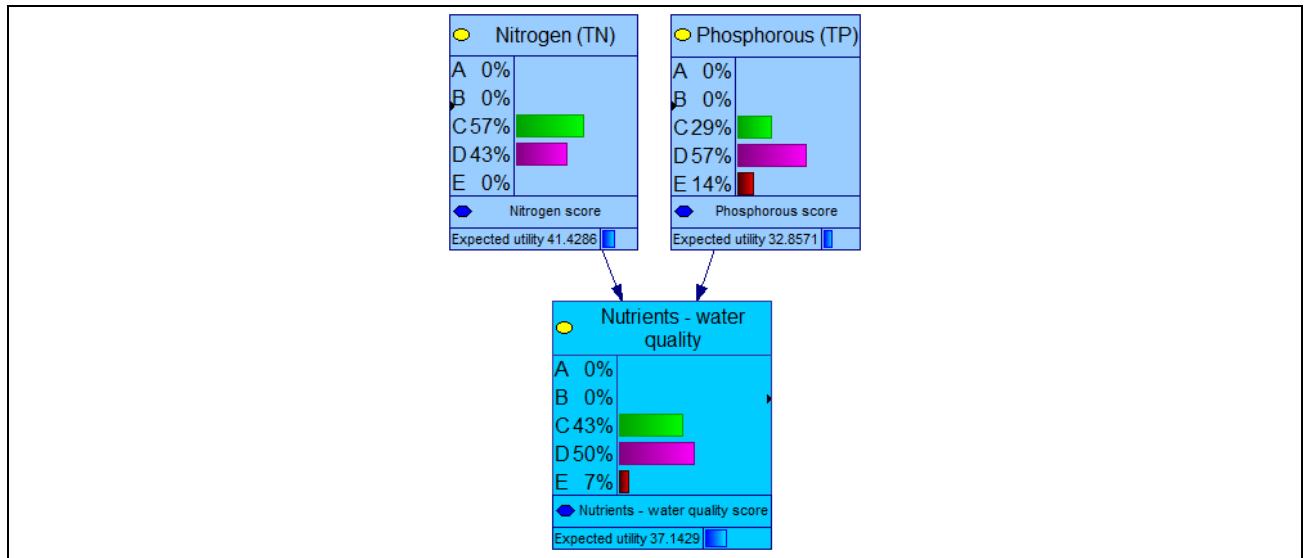
Figure 2.2: Node probabilities for nutrient measures total nitrogen and total phosphorous for Mid Harbour, zone 8
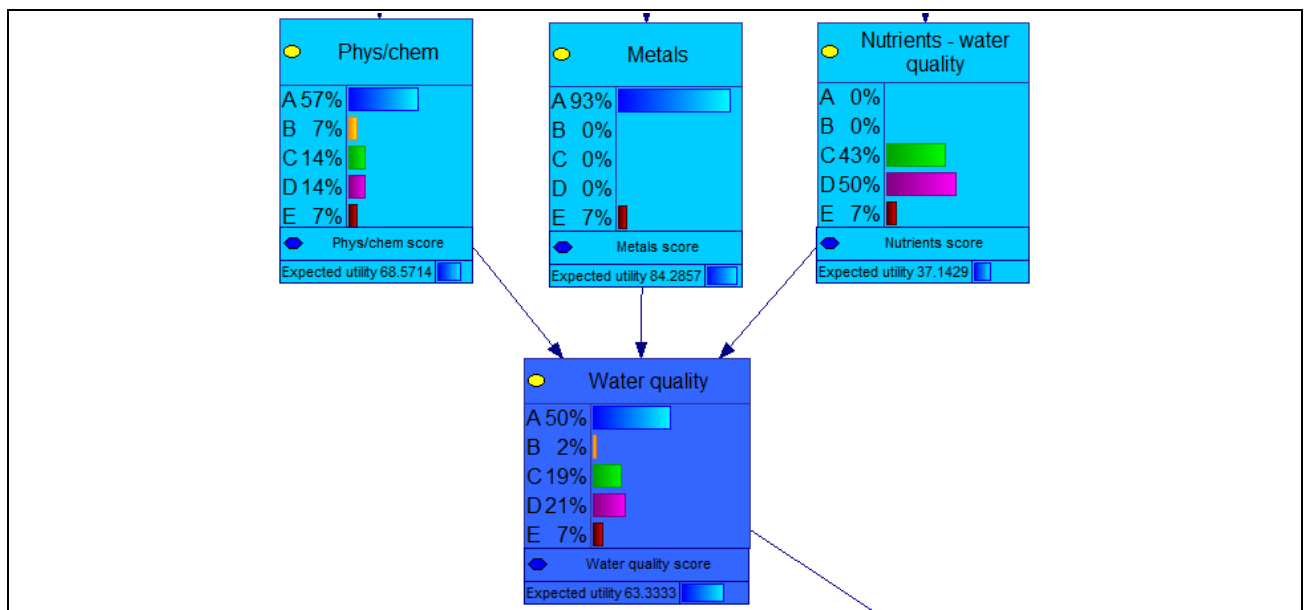
Figure 2.3: Three water quality indicators aggregated into the indicator group water quality (Mid Harbour – zone 8).

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2.2.2 Social indicators

The process through which social indicator scores were determined is outlined in Figure 2.5. Social data and a portion of the economic data were collected using a Computer Assisted Telephone Interview (CATI) of 400 respondents from the Gladstone LGA and a range of other data sources (see Section 2.1). The interview questions were designed to elicit a response on a ten point agree/disagree scale.

Indicator weighting was determined via online surveys of 200 of the respondents from the CATI survey and 31 community leaders. A range of weighting techniques including simple ranking methods, scoring based methods and Analytic Hierarchy Processes were considered when determining the final weights. Inputs from 19 marine or coastal-social scientists were used to develop the relationships between measures, indicators and indicator groups.

Two methods were used to derive grades for indicators. Most indicator results were directly converted to A to E grades (A = 9-10, B=7-8, C=5-6, D=3-4, E=1-2 on the satisfaction scale) from the CATI survey responses.

As the final step, a BBN model was developed linking all levels of indicators. This model was used to obtain the probability of an outcome rather than to produce a deterministic outcome. Through the model (using conditional probability distributions) a mean outcome and confidence interval were also determined. The final grade for each indicator was the most probable grade after the relevant weighting had been being applied and a final score was applied to the grades at all levels.

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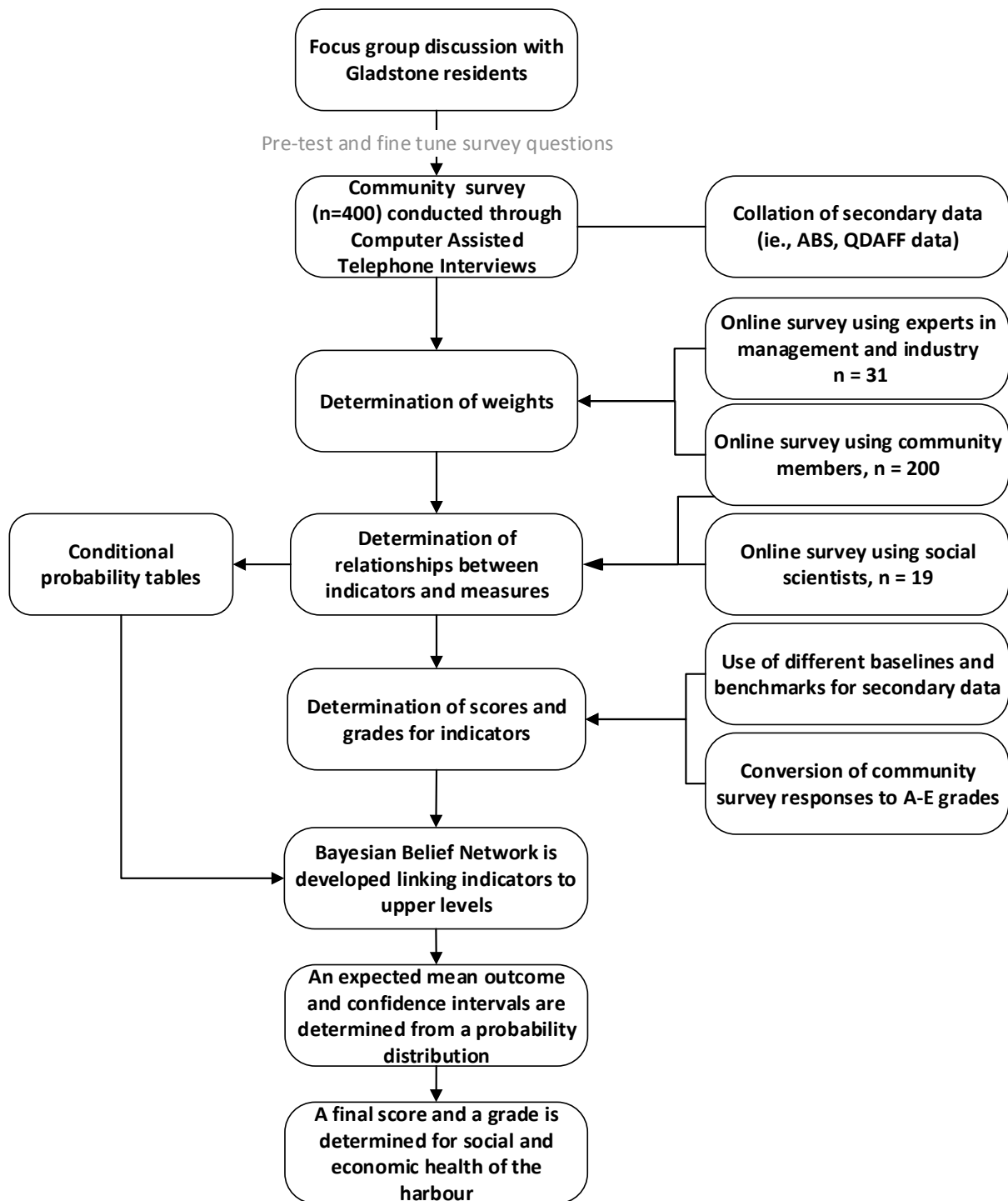
Figure 2.5: Schematic diagram indicating the development of social indicators, scores and grades from a series of community, community-leader and social scientist surveys.

2.2.3 Economic indicators

While some economic data were collected via the CATI survey outlined above, the majority came from secondary data sources, including:

- Gladstone Regional Council (GRC),
- Australian Bureau of Statistics (ABS),
- Gladstone Ports Corporation (GPC),
- Queensland Department of Agriculture, Fisheries and Forestry (DAFF),
- Queensland Office of Economic and Statistical Research,
- Tourism and Events Queensland.

When using secondary datasets, baselines and benchmarks were used. The secondary data were compared to a comparable dataset to generate a distribution of potential outcomes and the comparison used to produce a score. The indicators, measures, data source and baseline / benchmark for each economic sub-component are shown in Table 2.7. For economic performance indicator group a modelling approach was used to derive report card scores.

Table 2.6: Data sources and baselines used for economic indicators of the 2014 pilot report card.

	Indicator	Measure	Data source	Baseline / Benchmark
Economic performance	Commercial fishing	Productivity of line, net, trawl and pot fisheries	Queensland Fishing, Queensland Department of Agriculture, Fisheries and Forestry	Time series data from 1990-1991 and 2013-2014
	Shipping activity	Shipping activity productivity	Gladstone Ports Corporation Limited (GPC)	Time series data from 2007-2014
	Tourism related sectors	Tourism related sectors expenditure	economy.id.com.au and Australian Bureau of Statistics	Last 10 year average
Economic stimulus	Employment	Employment	Queensland Office of Economic and Statistical Research	Queensland 2013 distribution
	Socio-economic status	Socio-economic status (Index of Economic Resources)	CATI survey, Australian Bureau of Statistics 2011 census	Australian 2011 distribution
Economic value	Beach recreation	Beach recreation satisfaction	CATI survey, Gladstone Regional Council	10 point scale
	Recreational fishing	Recreational fishing satisfaction	CATI survey, InfoFish Australia	10 point scale
	Land based recreation	Land based recreation satisfaction	CATI survey	10 point scale

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3. Results

The social, economic and environmental health of the Gladstone Harbour was reported on an A to E scale with A being very good and E being very poor (Figure 3.1). Each grade was associated with a range of scores (Figure 3.1).

For water quality, a score of 0.50 indicated that the measure under consideration was equal to the relevant water quality guidelines presented in the Capricorn Curtis Coast Water Quality Objectives (DEHP 2014a). The objectives were set using historical data from a range of sources and provide locally refined and relevant guidelines. These guidelines have recently included a guideline concentration of 24 ug/L for dissolved aluminium based on the recommendation of Golding *et al*. (2014). If a particular measurement met the relevant guideline, it received a grade of A, B or C depending on how far within the guideline the measurement was. If a measurement did not meet the relevant guideline level, it received a score of D or E depending on how far outside the guideline it was.

However for the social and economic indicators, a C grade did not necessarily indicate passing or failing a guideline. Rather it indicated a satisfactory state of social or economic health related to the relevant benchmark or baseline (see Table 2.7).

A	**Very good (≥ 0.85)**
B	**Good (≥ 0.65, < 0.85)**
C	**Satisfactory (≥ 0.5, < 0.65)**
D	**Poor (≥ 0.25, < 0.50)**
E	**Very poor (0, < 0.25)**
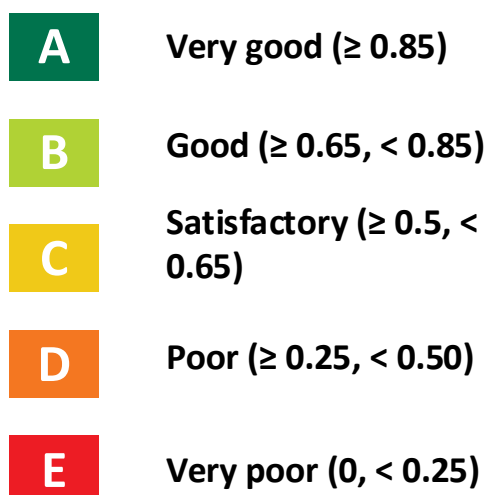
Figure 3.1: Grades and associated scores used in the 2014 pilot report card.

3.1 Water quality

For the 2014 pilot report card the physical and chemical measures were turbidity and dissolved oxygen, the metals measures were, dissolved aluminium and dissolved copper, and the nutrient measures were total phosphorus and total nitrogen.

The overall grade for water quality in the 2014 Gladstone Harbour pilot report card was a C (0.58). Nine of the thirteen Gladstone Harbour zones (Figure 1.5) received an overall environmental score of greater than 0.50. Auckland Inlet received the lowest score of 0.41 (Table 3.1).

Very good scores for dissolved oxygen were recorded across all harbour zones and very good scores for copper were recorded in all but one harbour zone, Rodds Bay, which received a good score. Scores for aluminium ranged from poor in one zone, Auckland Inlet, to very good in four harbour zones, with nine zones being graded as moderate or better. 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). The lowest scores for water quality were recorded in Auckland Inlet (0.41), Boat Creek (0.47), Boyne River (0.47) and Calliope River estuary (0.48) primarily as a result of low scores for nitrogen, phosphorus and turbidity.

Scores for nitrogen and phosphorus were generally low across all harbour zones, as were the scores for turbidity with only three zones—the Inner Harbour, South Trees Inlet and the Outer Harbour receiving a score of greater than 0.50 for this indicator. Table 3.2 provides a summary of the water quality scores for the whole of harbour and individual harbour zones.

Table 3.1: Overall water quality grades and scores for the whole of harbour and the 13 individual harbour zones.

Water Quality		Grade	Score
Whole of Harbour		C	0.58
Zone 1	The Narrows	C	0.57
Zone 2	Graham Creek	B	0.68
Zone 3	Western Basin	C	0.54
Zone 4	Boat Creek	D	0.47
Zone 5	Inner Harbour	B	0.74
Zone 6	Calliope River Estuary	D	0.48
Zone 7	Auckland Inlet	D	0.41
Zone 8	Middle Harbour	C	0.63
Zone 9	South Trees Inlet	B	0.68
Zone 10	Boyne River Estuary	D	0.47
Zone 11	Outer Harbour	B	0.69
Zone 12	Colosseum Inlet	C	0.62
Zone 13	Rodds Bay	C	0.62

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Zone 1 – The Narrows: Six water quality monitoring sites.
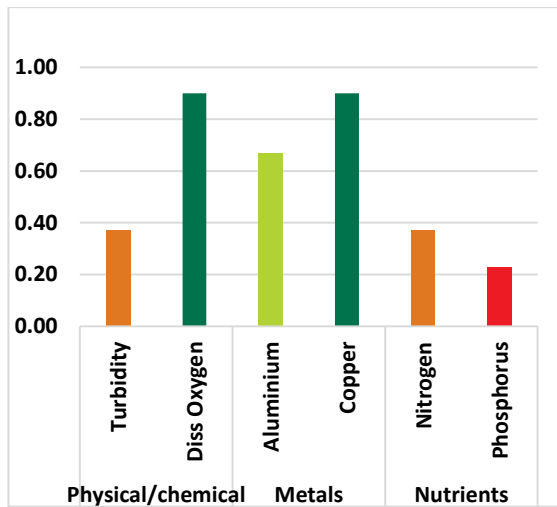
The Narrows is the northern outlet of the harbour which connects the harbour to the mouth of the Fitzroy River estuary and separates Curtis Island from the mainland. It is mangrove-lined and poorly flushed. The Narrows received a score of 0.57 (C) for water quality, which was about average for Gladstone Harbour in 2013-14. The Narrows received a very good score for dissolved oxygen (0.90), aluminium (0.67) and copper (0.90), poor scores for turbidity (0.37) and nitrogen (0.37) and very poor for phosphorus (0.23).

Zone 2 – Graham Creek: Two water quality monitoring sites.
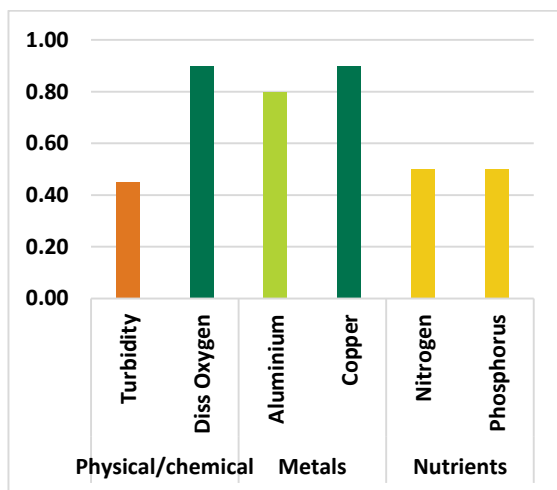
Graham Creek is a mangrove lined tidal inlet located at the southern end of Curtis Island that is connected to the Narrows. Graham Creek received a score of 0.68 (B) for water quality, which was the equal third highest score for Gladstone Harbour in 2013-14. Graham Creek received a very good score for dissolved oxygen (0.90) and copper (0.90) a good score for aluminium (0.80), satisfactory scores for phosphorus (0.50) and nitrogen (0.50) and a poor score for turbidity (0.45). Graham Creek was amongst the four harbor zones that received an overall score of greater than 0.65.

Zone 3 – Western Basin: Six water quality monitoring sites
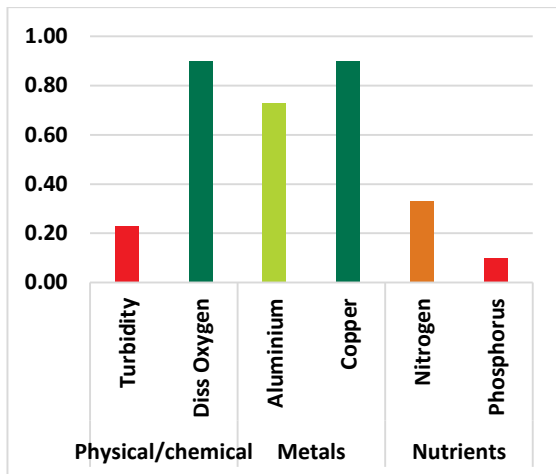
The Western Basin is located near the north-western end of Gladstone Harbour and was the location of the Western Basin Dredging and Disposal Program (WBDDP) from May 2011 until September 2013. The Western Basin received a score of 0.54 (C) for water quality which was a slightly below average water quality score for Gladstone Harbour in 2013-14. The Western Basin received very good scores for dissolved oxygen (0.90) and copper (0.90), a good score for aluminium (0.73) a poor score for nitrogen (0.33) and very poor scores for turbidity (0.23) and phosphorus (0.13).

Zone 4 – Boat Creek: Three water quality monitoring sites.
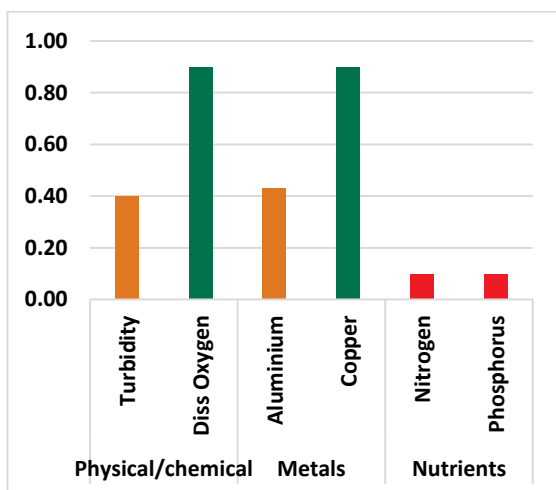
Boat Creek is a small mangrove lined estuary connected to the western side of the Western Basin. It is a long and narrow water body that is not well flushed during regular tides.

Boat Creek's overall score was 0.47 (D) for water quality and this was the third lowest water quality score for Gladstone Harbour in 2013-14. Boat Creek received very good scores for dissolved oxygen (0.90) and copper (0.90), poor scores for aluminium (0.43) and turbidity (0.40) and very poor scores for phosphorus (0.10) and nitrogen (0.10).

Zone 5 – Inner Harbour: Two water quality monitoring sites.
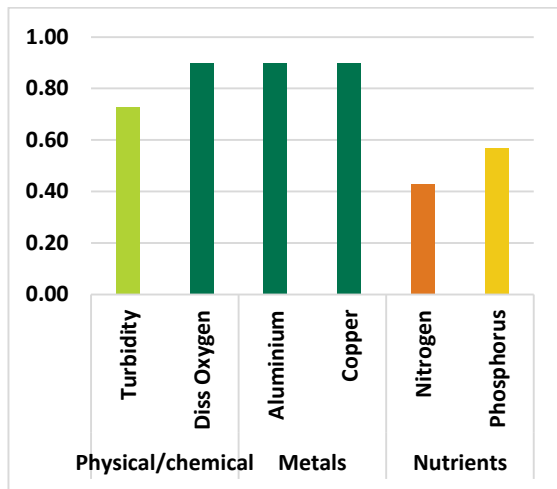
The Inner Harbour is located immediately to the east of the Western Basin and is bounded by a mangrove dominated intertidal system on Curtis Island and the town of Gladstone on the southern edge. The Inner Harbour received a score of 0.74 (B) for water quality and this was the highest water quality score for Gladstone Harbour in 2013-14. The Inner Harbour received very good scores for dissolved oxygen (0.90), copper (0.90) and aluminium (0.90), a good score for turbidity (0.73), a satisfactory score for phosphorus (0.57) and a poor score for nitrogen (0.43).

Zone 6 – The Calliope River Estuary: Four water quality monitoring sites.
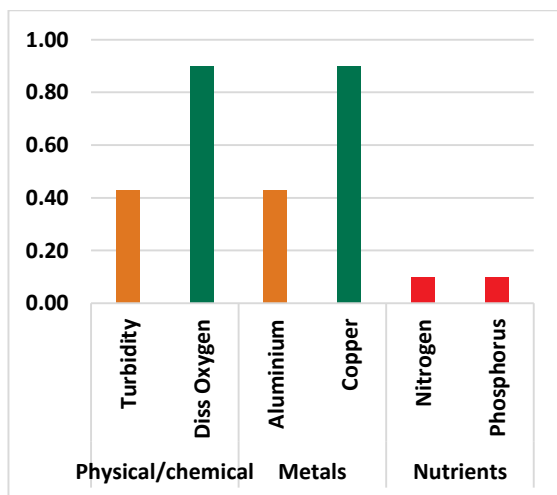
The Calliope River is fed by Gladstone Harbour's largest freshwater catchment. The estuary, which flows into the Western Basin, is a source of turbid fresh water during floods or other high flow events.

The Calliope River estuary received a score of 0.48 (D) for water quality which was the fourth lowest water quality score for Gladstone Harbour in 2013-14. The Calliope River estuary received very good scores for dissolved oxygen (0.90) and copper (0.90), poor scores for aluminium (0.43) and turbidity (0.43) and very poor scores for phosphorus (0.10) and nitrogen (0.10).

Zone 7 – Auckland Inlet: Five water quality monitoring sites.
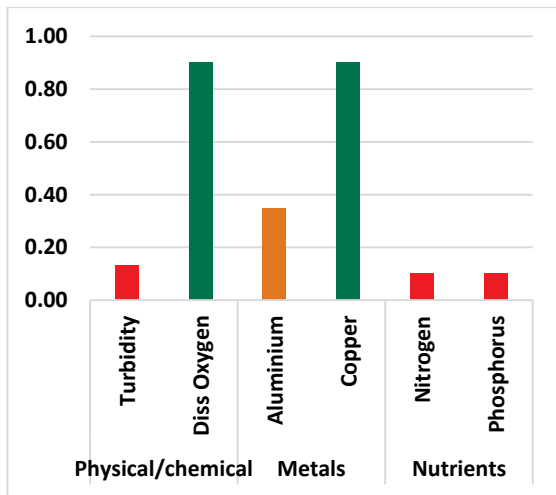
Auckland Inlet is a tidal inlet that connects to the Inner Harbour zone. The Auckland Inlet wharf facilities and Barney Point Terminals are located at the mouth of this inlet. Auckland Inlet received a score of 0.41 (D) for water quality which was the lowest water quality score for Gladstone Harbour in 2013-14. Auckland Inlet received very good scores for dissolved oxygen (0.90) and copper (0.90), a poor score for aluminium (0.35) and very poor scores for turbidity (0.13), phosphorus (0.10) and nitrogen (0.10).

Zone 8 – Mid Harbour: Six water quality monitoring sites.
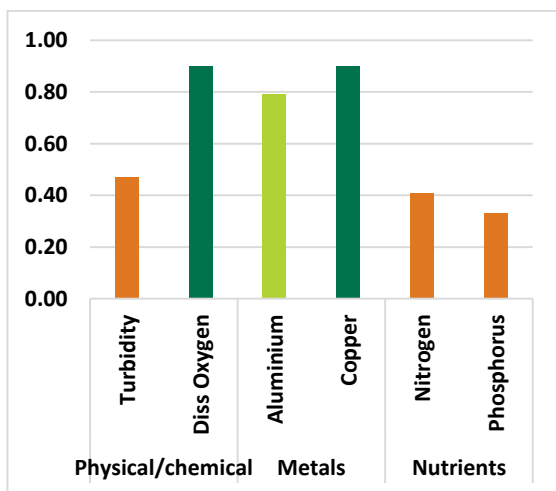
The Mid Harbour area is bounded by Facing Island to the north-east, Curtis Island to the north-west and the town of Gladstone and South Trees inlet to the south. The Mid Harbour zone received a score of 0.63 (C) for water quality, which was a slightly above average water quality score for Gladstone Harbour in 2013-14. Mid Harbour received very good scores for dissolved oxygen (0.90) and copper (0.90), a good score for aluminium (0.79) and poor scores for turbidity (0.47), phosphorus (0.33) and nitrogen (0.41).

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Zone 9 – South Trees Inlet: Six water quality monitoring sites.
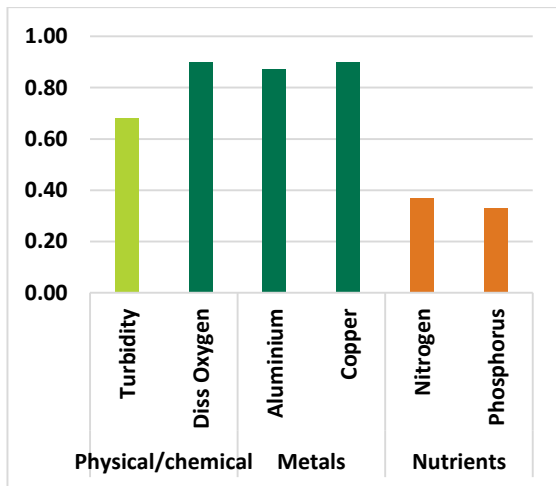
South Trees Inlet is a tidal inlet bordered on one bank by Queensland Alumina Ltd. alumina refinery. The area between the inlet and the Boyne River includes large areas of salt-flat and mangroves.   South Trees Inlet received a score of 0.68 (B) for water quality which was the fourth highest water quality score for Gladstone Harbour in 2013-14. South Trees Inlet received very good scores for dissolved oxygen (0.90), copper (0.90) and aluminium (0.87) a good score for turbidity (0.68) and poor scores for phosphorus (0.33) and nitrogen (0.37).

Zone 10 – Boyne River estuary: Three water quality monitoring sites.
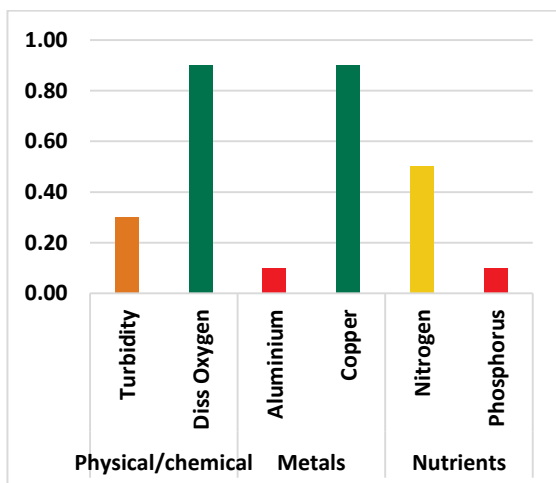
The lower Boyne River estuary area contains salt-flat and mangrove ecosystems. The Boyne River flows through residential communities before entering the harbour.   The Boyne River estuary received a score of 0.47 (D) for water quality which was the second lowest water quality score for Gladstone Harbour in 2013-14. The Boyne River estuary received very good scores for dissolved oxygen (0.90) and copper (0.90), a satisfactory score for nitrogen (0.50), a poor score for turbidity (0.30) and a very poor scores for phosphorus (0.10) and aluminium (0.10).

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Zone 11 – Outer Harbour: Three water quality monitoring sites.
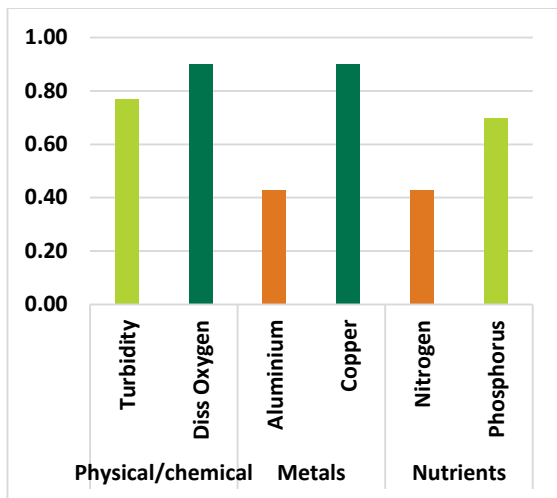
The Outer Harbour zone lies between Facing Island and Rodds Bay, and is bordered by open coastal water. The Outer Harbour received a score of 0.69 (B) for water quality, which was the second highest water quality score for Gladstone Harbour in 2013-14. The Outer Harbour received very good scores for dissolved oxygen (0.90) and copper (0.90), good scores for turbidity (0.77) and phosphorus (0.70), and poor scores for aluminium (0.43) and nitrogen (0.43).

Zone 12 – Colosseum Inlet: Four water quality monitoring sites.
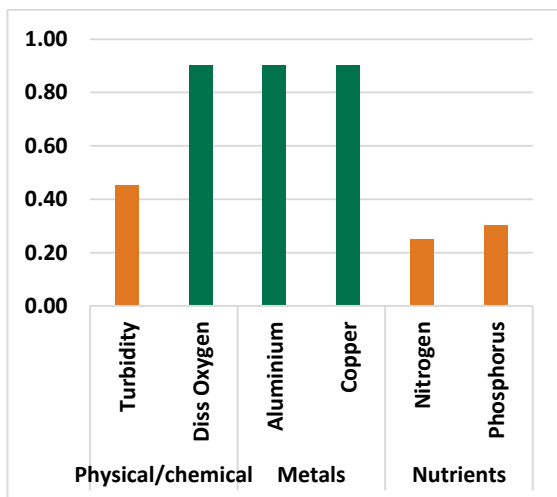
Colosseum Inlet is an estuarine zone that connects to the Outer Harbour and Rodds Bay. Colosseum Inlet received a score of 0.62 (C) for water quality, which was about average for Gladstone Harbour in 2013-14. Colosseum Inlet received very good scores for dissolved oxygen (0.90), aluminium (0.90) and copper (0.90), and poor scores for turbidity (0.45), phosphorus (0.30) and nitrogen (0.25).

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Zone 13 – Rodds Bay: Three monitoring sites.
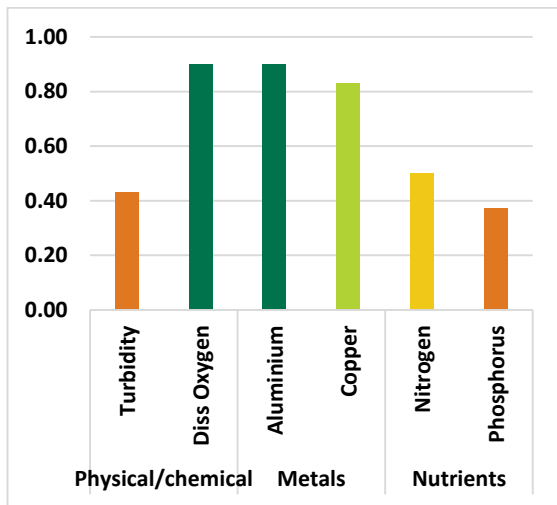
Rodds Bay is located to the south-east of the Outer Harbour and includes the Rodds Bay Dugong Protection Area. Sandy and Scrubby creeks each flow into the south of this bay. Rodds Bay received a score of 0.62 (C) for water quality which was about average for Gladstone Harbour in 2013-14 and gave this zone an overall environmental grade of C. Rodds Bay received very good scores for dissolved oxygen (0.90), and aluminium (0.90), a good score for copper (0.83), a satisfactory score for nitrogen (0.50) and poor scores for turbidity (0.43) and phosphorus (0.37).

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Table 3.2: Water quality scores for the whole of harbour and individual harbour zones.

Indicator Group	Physicochemical		Dissolved Metals		Nutrients	
Measure	Turbidity	Dissolved Oxygen	Aluminium	Copper	Nitrogen (TN)	Phosphorous (TP)
Whole of Harbour	0.45	0.90	0.63	0.90	0.34	0.30
The Narrows	0.37	0.90	0.67	0.90	0.37	0.23
Graham Creek	0.45	0.90	0.80	0.90	0.50	0.50
Western Basin	0.23	0.90	0.73	0.90	0.33	0.13
Boat Creek	0.40	0.90	0.43	0.90	0.10	0.10
Inner Harbour	0.73	0.90	0.90	0.90	0.43	0.57
Calliope Estuary	0.43	0.90	0.43	0.90	0.10	0.10
Auckland Inlet	0.13	0.90	0.35	0.90	0.10	0.10
Mid Harbour	0.47	0.90	0.79	0.90	0.41	0.33
South Trees Inlet	0.68	0.90	0.87	0.90	0.37	0.33
Boyne Estuary	0.30	0.90	0.10	0.90	0.50	0.10
Outer Harbour	0.77	0.90	0.43	0.90	0.43	0.70
Colosseum Inlet	0.45	0.90	0.90	0.90	0.25	0.30
Rodds Bay	0.43	0.90	0.90	0.83	0.50	0.37

3.2 Social indicators

The overall grade for the social component of the 2014 Gladstone Harbour pilot report card was a C. Of the three social health sub-components, Harbour access received a score of 0.61 with most survey respondents satisfied with their level of access to the harbour, their most recent trip to the area and the quality of ramps and facilities (Table 3.3). Liveability and wellbeing received a score of 0.64 with most people agreeing that the harbour improves their liveability and wellbeing. Harbour usability received a score 0.60, with the high score for recreational activities being brought down by issues related to harbour safety and perceptions about air and water quality (Table 3.3). Data on marine pollution and marine safety incidents also reduced the score for this sub-component.

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Table 3.3: Scores for the social health sub-components and indicators in the 2014 Gladstone Harbour pilot report card.

Social health sub-components		Score/ Grade	Social health indicator	Score
Social health (C)	Harbour accsess	0.61 C	Satisfaction with access	0.67
			Satisfaction with boat ramps	0.60
			Perceptions of harbour health	0.53
			Perceptions of barriers to access	0.64
	Liveability/Wellbeing	0.64 C	Liveability /Wellbeing	0.63
	Harbour usability	0.60 C	Perceptions of harbour safety	0.38
			Harbour recreational activities	0.70
			Perceptions of air and water quality	0.46

Key demographics of the CATI community survey respondents.

The survey respondents were evenly divided by gender, 51% male and 49% female, and while responses were obtained from all age groups fewer respondents were obtained from the younger age categories, 18 – 24 (<5% of respondents) and 25 – 34 (<10% of respondents). Eleven percent of participants identified themselves as Traditional Owners of the area.

Survey participants were from a broad range of income categories from less than $20,799 per annum to greater than $156,000 per annum. Across all categories the proportions of respondents were broadly consistent with the Australian Bureau of Statistics 2011 census data for the Gladstone LGA (Table 3.4). The majority of survey participants owned their homes without a mortgage (41%) or with a mortgage (41%), while 14% were renting. The vast majority (98%) of households owned a car.

Table 3.4: Comparison of household income distribution between the community CATI survey and Australian Bureau of Statistics 2011 census data from Pascoe et al. 2014).

Individual income		CATI survey (2014)	ABS census (2011)
Annual	**Weekly**		
Less than $20,799	Less than $399	12%	8%
$20,800 – $41,599	$400 – $799	13%	13%
$41,600 – $64,999	$800 – $1249	10%	12%
$65,500 – $77,999	$1250 – $1499	5%	7%
$78,000 – $103,999	$1500 – $1999	18%	15%
$104,000 – $129,999	$2000 – $2499	12%	11%
$130,000 – $155,999	$2500 – $2999	11%	16%
Greater than $156,000	Greater than $3000	20%	20%

Harbour usability

Of the survey respondents who had visited the Gladstone Harbour area for recreation most (89%) were satisfied with the trip. However perceptions of the usability and condition of the harbour were more

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variable. A majority (61%) believed that the harbour was in great condition and a slight majority (56%) were optimistic about the future health of the harbour, although only 48% believed that the health of the harbour had improved in the past year. Most participants were satisfied with the quality of boat ramps (71%) and 52% were not concerned about marine debris and litter. Only 33% were not concerned about water quality and only 28% were not concerned about air quality in the harbour area. A slight majority of respondents (56%) were happy to eat seafood caught in the harbour area and 61% felt safe being in the harbour area at night.

Harbour Access

Ninety nine percent of people surveyed had visited the harbour in the previous 12 months and most of these people (93%) had visited for recreational purposes. Most survey respondents believed they had fair access to the harbour and were also satisfied with the level of access to public spaces and the number of boat ramps. Most respondents (71%) agreed that the amount of shipping (71%) and recreational boating (81%) had not reduced their use of the harbour area. And most agreed that marine debris (82%) and water quality (59%) did not affect their access or frequency of use.

However, less than half of the people surveyed (42%) felt that they were able to have input into the management of Gladstone Harbour if they choose to.

Liveability and wellbeing

Ninety two percent of people surveyed believe that Gladstone Harbour is a key part of the Gladstone community. Eighty percent of people surveyed agreed that Gladstone Harbour makes living in Gladstone a better experience and 73% agreed that Gladstone Harbour improved their quality of life. However, only half the respondents regularly participated in community events in the harbour area.

Word Cloud

The first word response word cloud is presented in Figure 3.2 and the three word response word cloud is presented in Figure 3.3. The results suggest that while most people view the area positively as an area of beauty, negative attributes such as pollution, busy and dirty are also predominate features of the word clouds. Other dominant words such as fishing and shipping may be ambiguous as recreational anglers may view fishing as a positive attribute while others may see it as a part of the economic activity in the area without a positive or negative connotation. Similarly some may consider shipping as a negative feature while others may see it in a positive light as a major part of the economic activity of the harbour.

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Figure 3.2: First word response word cloud by CATI survey respondents (Pascoe et al. 2014).

Figure 3.3: Three word response word cloud by CATI survey respondents (Pascoe et al. 2014).

3.3   Economic indicators

The overall grade for the economic component of the 2014 Gladstone Harbour pilot report card was a B. Of the three economic health sub-components economic stimulus received the highest score (0.87). This

was driven by the high comparative socio-economic status of the Gladstone community and high levels of employment. The overall score for the economic performance indicator group was 0.83, a result of mixed grades across the indicator group. While commercial fishing (0.66) and shipping activity (0.83) received high grades, tourism occupancy only received a score of 0.60. This was influenced by lower occupancy rates in 2014 when compared to occupancy rates in preceding years. The final indicator group recreational value, which considered recreation in terms of non-market values, received a score of 0.75 with the annual value of recreational trips in Gladstone estimated at approximately $84 million.

Table 3.5: Grades and scores for the economic health component of the 2014 Gladstone Harbour pilot report card.

Economic health sub-components		Score/ Grade	Economic health indicator	Score/ Grade
Economic health (B)	Economic stimulus	0.87 A	Employment	0.72
			Socio-economic status	0.90
	Economic performance	0.83 B	Tourism occupancy	0.60
			Commercial fishing	0.66
			Shipping activity	0.83
	Recreational value	0.75 B	Land-based recreation	0.76
			Beach recreation	0.71
			Recreational fishing	0.67

Economic stimulus

The two indicators for the economic stimulus sub-component were the unemployment rate and the index of economic resources for the Gladstone Region

Unemployment in the Gladstone Local Government Area was compared with unemployment rates in all Queensland Local Government Areas. The unemployment rate of 4.8% was in the best 30 per cent in the State, giving a score of 0.72 for this indicator.

The score for socio-economic status was derived using an economic measure known as the Index of Economic Resources (IER). The IER is formally calculated using Australian census data. A revised estimate for the Gladstone region was calculated using information collected in the CATI community survey.

The high score for socio-economic status was primarily driven by the high proportion of residents who fall into high income groups (Table 3.4), the relatively high proportion of home ownership and the relatively large size of houses in the region.

Economic performance

The three economic performance indicators were tourism (hotel occupancy), commercial fishing, and shipping activity.

Tourism expenditure in the Gladstone LGA decreased markedly from 2005-06 to 2009-10, but has been relatively constant since then (Figure 3.4). The gross value of production (based on total expenditure) was $77 million in 2012-13. This was the last year for which data were available. Tourism expenditure also includes business travel expenditure which includes workers staying in hotels, motels and short term rentals. Thus the decline post 2005-06 may be due to a reduction in construction work in the region, such

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as work associated with the three LNG plants on Curtis Island, as well as workers moving into accommodation on Curtis Island.
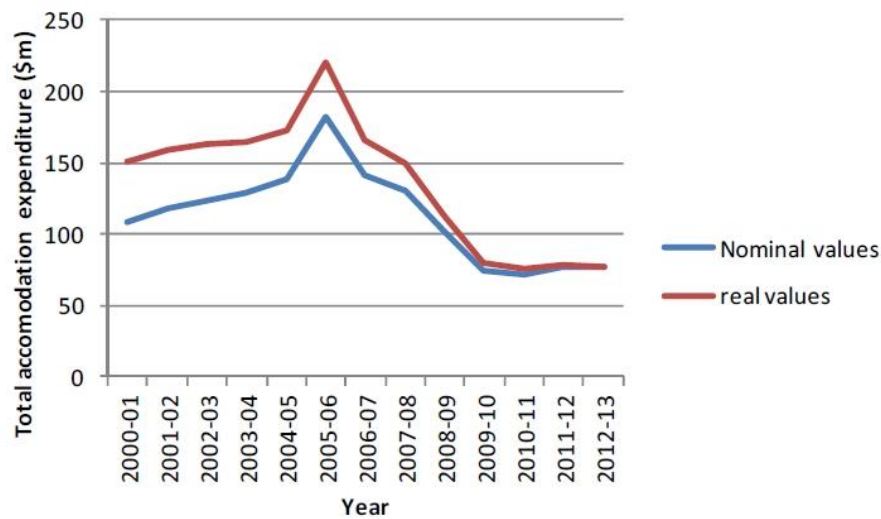
Figure 3.4: Total expenditure on tourist accommodation in the Gladstone LGA peaked in 2005-06, then declined sharply over the next five years. Source: (Pascoe et al. 2014).

The Gross Value of Production (GVP) for Gladstone Harbour fisheries in 2013-14 was $4.9 million, well above the long-term, inflation-adjusted average of $3 million. This was the second highest GVP on record for the area. However, each of the four sectors comprising the commercial fishery of Gladstone Harbour performed differently in 2013-14 (Figure 3.5). In general economic terms, the line and net sectors performed very poorly, while the trawl and pot (mud crab) sectors performed very well. Line fishing productivity in 2013-14 was virtually zero. Line fishing productivity in Gladstone Harbour has always been fairly low, and has been close to zero since 2010. Net fishing productivity in 2013-14 was about half of the long-term average for this sector. Net fishing productivity in Gladstone Harbour was fairly stable from 2005– 2008, then fluctuated considerably from 2009 – 2012 before the low productivity of the past two years. In contrast, productivity in the trawl and pot fisheries was higher in 2013-14 than in any other year over the past decade. Trawl fishing productivity in 2013-14 was about double the long term average for this sector, while pot fishing productivity in 2013-14 was about 25% higher than the long-term average for this sector. Combining the fishing effort and productivity data for the four sectors yielded a score of 0.66.
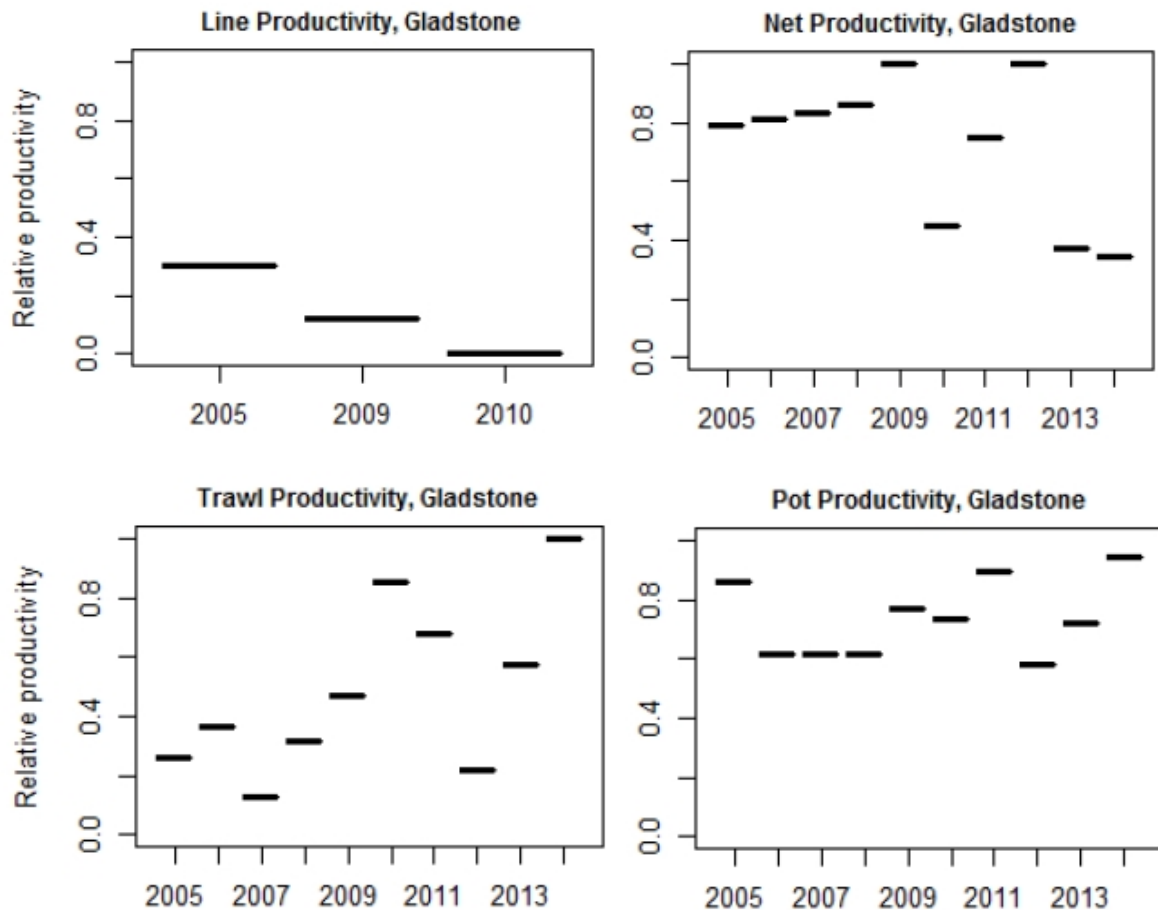
Figure 3.5: Relative productivity has varied considerably amongst the four fishery sectors in Gladstone Harbour. The line fishery has declined to virtually zero, while the net fishery has also performed poorly since peaks in 2010 and 2012. However, both the trawl and pot sectors had one of their best years in 2014. Source: Pascoe et al. (2014).

In 2012-13, the Gladstone Ports Corporation generated $889 Million in revenue. Coal exports accounted for around two thirds of export shipping and bauxite imports for the aluminium industry provided around half of the import shipping. The total quantity of ship movements was slightly higher in 2012-13 than in previous years, resulting from a steady increase in shipping movements that has occurred since 2006-07 and leading to a capacity utilisation high relevant to past years. When comparison with predictions of future shipping from the Curtis Island LNG plants and Fisherman's Landing was factored in, the capacity utilisation score was reduced, yielding an overall score of 0.83.

Recreational value

The average number of recreational trips to Gladstone Harbour in 2013-14 (including recreational fishing and trips to the beach, the harbour shoreline or out on the water) was approximately 33 trips/household for each of the 22,841 households in Gladstone. The average value of one of these trips was $104, giving a total value of recreational trips to Gladstone Harbour of $84 million in 2013-14. This does not include trips to the harbour by people from outside the Gladstone region.

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Land-based recreational activities such as walking, running or cycling along the harbour shores were undertaken by almost all respondents in 2013-14 (94%), with the most popular land-based activity being walking (83%). The relatively low trip value of land-based recreation led to it receiving an overall score of 0.75. In contrast to the land based recreation, only 33% people participated in boat-based recreational fishing, but the relatively high value of this activity still gave it a score of 0.66.

Tannum Sands was the most popular beach visited by survey participants and beach based recreation received a score of 0.70.

4. Iconic Species of Gladstone Harbour

Gladstone Harbour and its associated water bodies and islands provides important habitat, breeding sites and roosting locations for a number of iconic marine species such as dolphins, dugongs, marine turtles and migratory shorebirds. However these species are not necessarily the best indictors of harbour health year to year. In some instances there can be a considerable lag between an environmental impact and a response in these species. For example a decline in seagrass cover will provide a signal of change long before malnourishment or reduced sightings are detected in marine turtles or dugongs within the harbour. Additionally the range of most of these marine megafauna usually extends well beyond the confines of Gladstone Harbour making it difficult to associate change in their condition or population with impacts in the harbour. This may be even more difficult with migratory shorebirds as changes in numbers observed may be influenced to a greater extent by impacts in the northern hemisphere or other portions of their flyways.

However research on the distribution, population and trends and the use of the harbour by these species is vital for understanding and managing/mitigating potential impacts within Gladstone Harbour—both natural and anthropogenic. As these species are listed under the Environment Protection and Biodiversity Conservation Act (EPBC Act) there are also legislative requirements requiring the protection and mitigation of anthropogenic impacts on these species.

Dolphins

The Indo-Pacific humpback dolphin *Sousa chinensis*, the Bottlenose dolphin *Tursiops truncatus* and the Indo-Pacific (inshore) bottlenose dolphin *Tursiops aduncus*, have been observed in Gladstone Harbour (DEHP 2014b), The Indo-Pacific humpback dolphin is an EPBC listed migratory species and is listed as near threatened in Queensland under the *Nature Conservation Act 1992*. Cagnazzi (2013) reported that the Indo-Pacific humpback dolphins in Port Curtis was a distinct sub-population from other populations of this species. Surveys conducted from 2006 to 2008 estimated the Port Curtis population to be 115 individuals. In 2011 the abundance estimate for the Port Curtis sub-population was about 104 dolphins (Cagnazzi 2013).

Dugongs

The dugong *Dugong dugong* is an EPBC act listed marine and migratory species that is listed as vulnerable in Queensland under the Nature Conservation Act 1992. Dugongs are found throughout the western Indo-Pacific region (eastern Africa to eastern Australia) in tropical and subtropical waters. Within the Gladstone Harbour area, including Rodds Bay, dugongs are predominately associated with the seagrass meadows, which form the major component of their diet. A review of the status of the dugong population in the Gladstone area was conducted by Sobtzick et al. (2013) as a component of the Ecosystem Research and Monitoring Program currently being undertaken by GPC. This review found that the Port Curtis – Rodds Bay area provides important habitat for a relatively small population of dugongs. They indicated that as these areas overlap with areas of human use that the risk to dugongs from anthropogenic impacts may be substantial. This review also considered the seagrass meadows within the Gladstone area to be of regional significance as they may provide valuable connecting habitat between dugong populations in southern Queensland (Sobtzick et al. 2013).

Marine Turtles

Six species of marine turtles have been observed in the Port Curtis region. However nesting has only been recorded for three of these species: the loggerhead, green and flatback turtles. Sightings of the other three

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species are rare. The status of turtles within Gladstone Harbour has also been reviewed as a component of the Ecosystem Research and Monitoring Program currently being undertaken by GPC (Limpus et al. 2013):

- Loggerhead turtle *Caretta caretta*: EPBC status, endangered, marine, and migratory. Within the port limits of Port Curtis, isolated loggerhead turtle nesting has been recorded but not on an annual basis.
- Green turtle *Chelonia mydas*: EPBC status, vulnerable, marine and migratory. Within the port limits of Port Curtis, isolated green turtle nesting has been recorded but not on an annual basis.
- Hawksbill turtle *Eretmochelys* imbricata: EPBC status, vulnerable, marine and migratory. There are no records of this species nesting within a 500km radius of Port Curtis.
- Olive Ridley turtle *Lepidochelys olivacea*: EPBC status, endangered, marine and migratory. There has been no recorded nesting of this species in eastern Australia.
- Flatback turtle *Natator depressus*: EPBC status endangered, marine and migratory. The Flatback Turtles are the dominant species of nesting turtle recorded on the beaches of Port Curtis. Most nesting occurs on the south end of Curtis Island and low density nesting can be expected on seaward beaches within the port limits.
- Leatherback turtle *Dermochelys coriacea*: EPBC status, endangered, marine and migratory. leatherback turtles are rarely recorded in the waters of Port Curtis.

Migratory Shorebirds

Migratory shorebirds are EPBC Act listed migratory species. Surveys of migratory shorebirds have been conducted in the Gladstone area since 2011 as a component of the Ecosystem Research and Monitoring Program (ERMP) currently being undertaken by GPC. In shorebird surveys conducted at five locations in the Gladstone area in February 2014, a total of 11,590 migratory shorebirds of 20 species were counted during high tide roost surveys conducted at sites located in the areas of Port Curtis, Fitzroy Estuary, North Curtis, and Mundoolin Inlet/Colosseum Creek. This was a 5% increase over the number of birds recorded in 2013. Variation of this magnitude is well within the magnitude expected for migratory shorebirds (Wildlife Unlimited 2013). During the 2014 high tide roost surveys the greatest number of birds was recorded in the Fitzroy Estuary / North Curtis Island area and the nine most abundant species accounted for 95% of observations. These species were; bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Tringa brevipes*, great knot *Calidris tenuirostris*, red-necked stint *Calidris ruficollis*, grey plover *Pluvialis squatarola,* lesser sand plover *Charadrius mongolus* and greater sand plover *Charadrius leschenaultia*.

Current monitoring and research of Iconic species in the Gladstone Harbour region.

The majority of current iconic species monitoring projects are being conducted as part of the Port Curtis ERMP. The development, implementation and funding of this program is a requirement of the EPBC approval for The Port of Gladstone Western Dredging and Disposal Project. The ERMP requires research and monitoring commitments related to marine megafauna, migratory shorebirds and seagrasses. This program commenced in 2011. Where data is available this section of the Gladstone Harbour report card technical reports will outline any monitoring or research of the identified iconic species currently being undertaken in the Gladstone Harbour region.

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5. Guide to the infrastructure supporting the GHHP Report Card Website

The GHHP report card website is the primary interface to access all levels of report card information, including information on GHHP, high level summaries of report card results, trend data, explanations of the report card indicators and all GHHP publications. The website will also provide access to the report card and the technical reports upon which it is based.

The Gladstone Harbour report card Website will be linked to a Digital Information Management System (DIMS) from 2015. This system consists of three major components; the report card system, the repository system and the metadata system. These system and the linkages between system administrators, data providers and user groups are illustrated in Figure 5.1. When completed this system will:

- Allow report card data providers, GHHP Partners, and modelers to upload data sets and other information to an online repository.
- Contain an automated report card system which collates analyses data to generate a report card score including graphs and figures.
- Allow the public through the report card website and metadata system to view the current and past report cards and to search and view DIMS for reports and other information related to the health of Gladstone Harbour.
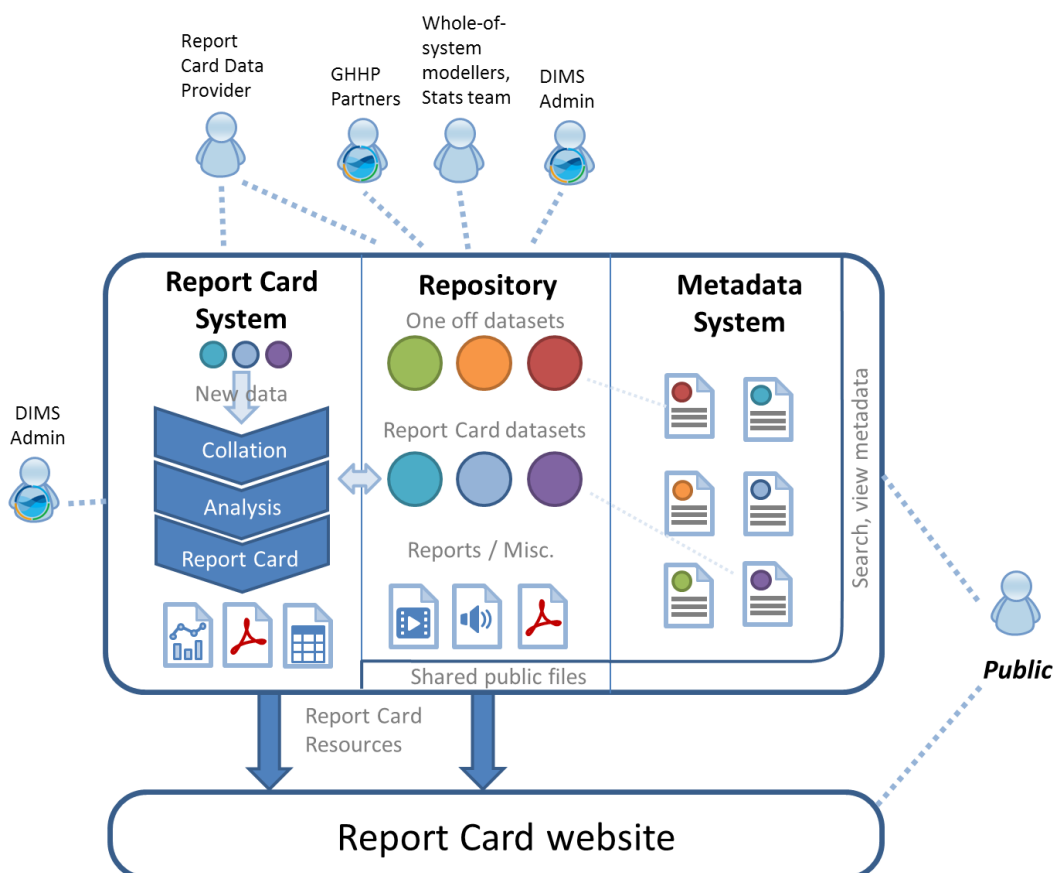
Figure 5.1: Conceptual model of the links between the report card website and the DIMS illustrating major components and primary inputs and outputs.

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6. References

AS/NZS 5667.1 (1998) Water quality, Sampling, Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples.   STANDARDS AUSTRALIA Homebush NSW. STANDARDS NEW ZEALAND, Wellington, New Zealand.

Bryant CV, Jarvis JC, York PH & Rasheed MA (2014) Gladstone Healthy Harbour Partnership Pilot Report Card: ISP011 Seagrass Draft Report – October 2014, Centre for Tropical Water & Aquatic Ecosystem. Research Publication 14/53 James Cook University, Cairns.

Buys, L., Mengersen, K., Johnson, S., van Buuren, N. & Miller, E. (2014) Triple Bottom Line Planning Tool for Measuring Sustainability: A systems approach to sustainability using the Australian dairy industry as a case study. Chartridge Books, Oxford

Commonwealth of Australia (2013) Independent review of the port of Gladstone- report on Findings. [Online] Available at: http://www.environment.gov.au/system/files/resources/ae7cbcf9-2963-47d7-9029-3aa1a065db51/files/gladstone-review-initial-report.pdf [Accessed 20 October 2014].

Cagnazzi D. (2013) Review of Coastal Dolphins in central Queensland, particularly Port Curtis and Port Alma region. Gladstone Port Corporation.

Connolly, R., Bunn, S., Campbell, M., Escher, B., Hunter, J., Maxwell, P., Teasdale, P. (2013) Review of the use of report cards for monitoring ecosystem and waterway health. Report to: Gladstone Healthy Harbour Partnership. November 2013. Queensland, Australia.

DEHP (2009) Monitoring and Sampling Manual 2009, Version 2, July 2013. State of Queensland, 2013.

DEHP (2014) Environmental Protection (Water) Policy 2009: Environmental Values and Water Quality Objectives Curtis Island, Calliope River and Boyne River Basins. Environmental Policy and Planning Division, Department of Environment and Heritage Protection, Queensland. November 2014, 96p.

DEHP (2014a) Final Draft Water Quality Objectives for Gladstone Harbour Zones. Department of Environment and Heritage Protection, Brisbane.

DEHP (2014b) Wildlife of Gladstone local government area, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 2 February 2015, <http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/wildlife/?AreaID=lga-gladstone>.

DSITIA (2014) Report on draft aquatic ecosystem water quality guidelines for the Capricorn Curtis Coast (draft released for public consultation) DSITIA, Queensland.

Fox, D.R. (2013) Statistical Issues Associated with the Development of an Ecosystem Report Card. Report prepared for GHHP by Environmetrics, Melbourne

Gladstone Ports Corporation, 2012. 50 Year Strategic Plan. [Online] Available at: http://www.gpcl.com.au/Portals/0/pdf/50%20yr%20plan/GPC_50yr_strategic_plan_2012_update.pdf [Accessed 20 October 2014].

Greer, L., & Kabir, Z. (2013) Guidance for the selection of social, cultural and economic indicators for the development of the GHHP Report Card, Report to the Gladstone Healthy Harbour Partnership, School of Human Health and Social Science, CQ University Australia, Rockhampton.

GPC (2011) Port Curtis and Port Alma Ecosystem Research and Monitoring Program (ERMP) LNG Document Number 629342[Accessed 22 October 2014]. http://www.westernbasinportdevelopment.com.au/media/pdf/ERMP%20Approval.pdf

Johnson, S., Logan, M., Fox, D. & Mengersen, K. (2015) Project ISP008: Statistical Support Draft Report. Report prepared for GHHP by Queensland University of Technology, Brisbane.

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

Limpus C.J., Parmenter C.J. and Chaloupka M. (2013a) Monitoring of Coastal Sea Turtles: Gap Analysis 1. Loggerhead turtles, *Caretta caretta*, in the Port Curtis and Port Alma Region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus C.J., Parmenter C.J. and Chaloupka M. (2013b) Monitoring of Coastal Sea Turtles: Gap Analysis 2. Green turtles, *Chelonia mydas*, in the Port Curtis and Port Alma Region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus C.J., Parmenter C.J. and Chaloupka M. (2013c) Monitoring of Coastal Sea Turtles: Gap Analysis 3. Hawksbill turtle, *Eretmochelys imbricata*, in the Port Curtis and Port Alma Region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus C.J., Parmenter C.J. and Chaloupka M. (2013d) Monitoring of Coastal Sea Turtles: Gap Analysis 4. Olive ridley turtle, *Lepidochelys olivacea*, in the Port Curtis and Port Alma Region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus C.J., Parmenter C.J. and Chaloupka M. (2013e) Monitoring of Coastal Sea Turtles: Gap Analysis 5. Flatback turtles, *Natator depressus*, in the Port Curtis and Port Alma Region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Limpus C.J., Parmenter C.J. and Chaloupka M. (2013f) Monitoring of Coastal Sea Turtles: Gap Analysis 6. Leatherback turtles, *Dermochelys coreacea*, in the Port Curtis and Port Alma Region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

Llewellyn, L., Wakeford, M. & McIntosh, E. (2013) *Mapping and synthesis of data and monitoring in Gladstone Harbour*. A report to the Independent Science Panel of the Gladstone Healthy Harbour Partnership, August 2013. Townsville: Australian Institute of Marine Science.

McCabe, J. & James, C. (2013) Natural, Cultural and World Heritage Values of Curtis Island, Queensland. Capricorn Conservation Council, Rockhampton.

McIntosh, EJ, Poiner, IR and ISP Members (2014) Gladstone Harbour Report Card Framework Recommendations- March 2014. Report prepared for the Gladstone Healthy Harbour Partnership Management Committee. Brisbane.

Pascoe, S., Cannard, T., Marshall, N., Windle, J., Kabir, Z., Flint, N. & Tobin R. (2014) Piloting of Social, Cultural and Economic Indicators for Gladstone Healthy Harbour Partnership Report Card. CSIRO Oceans and Atmosphere Flagship. Australia.

PCIMP (2010) Port Curtis Ecosystem Health Report 2008 – 2010. Gladstone Ports Corporation Ltd. Gladstone.

Skirtun, M., Sahlqvist, P. & Vieira, S. (2013) Australian Fisheries Statistics 2012, FRDC project 2010/208. ABARES, Canberra.

Sobtzick, S., Grech, A., Coles, R., Cagnazzi, D. and Marsh, H. (2013) Status of the dugong population in the Gladstone area. A Report for Gladstone Ports Corporation Limited for Project CA 120017: Monitoring of Dugongs, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Publication, James Cook University, Townsville.

Storey, A.W., Andersen, L.E., Lynas, J. & Melville, F. (2007) Port Curtis Ecosystem Health Report Card. Port Curtis Integrated Environmental Monitoring Program, Centre of Environmental Management, CQU.

Wildlife Unlimited (2014) Report for Migratory Shorebird Monitoring – Port Curtis and the Curtis Coast – February 2014. Report Prepared for GPC by Wildlife Unlimited Bairnsdale Vic.

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7. Glossary

Terms & acronyms	Definition
ABARES	Australian Bureau of Agricultural and Resources Economics and Science
ABS	Australian Bureau of Statistics
Asset	A particular feature of value to the GHHP for monitoring and reporting purposes, e.g. seagrass meadows or swimmable beaches.
Baseline	A point of reference from which to measure change
BBN	Bayesian Belief Nets
Component	The Gladstone Harbour report card will report on four components of harbour health, environmental, cultural, social and economic.
DEHP	Department of Environment and Heritage Protection
DIMS	Digital Information Management System
Ecosystem health	An ecosystem which is stable and sustainable, maintaining its organisation and autonomy over time and its resilience to stress. Ecosystem health can be assessed using measures of resilience, vigour and organisation. Source: http://www.biodiversity.govt.nz/picture/doing/nzbs/glossary.html
Environmental indicators	Metrics derived from observation used to identify indirect drivers of environmental problems (e.g. population growth), direct pressures on the environment (e.g. overfishing), environmental condition (e.g. contaminant concentrations), broader impacts of environmental condition (e.g. health outcomes), or effectiveness of policy responses. (de Sherbinin, Reuben, Levy, & Johnson, 2013).
ERMP	Ecosystem Research and Monitoring Program
GHHP	Gladstone Healthy Harbour Partnership
GPC	Gladstone Ports Corporation
GREAN	Gladstone Region Environmental Advisory Network
Guidelines and criteria	Science based numerical concentration limits or descriptive statement recommended to support a designated water use. Guidelines are not legally enforceable.
Indicator	Indicators are numerical values which provide insight into the state of the environment, or human health etc. As the environment is highly complex, indicators provide a simple, practical way to track changes in the state of the environment over time.

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IER	Index of Economic Resources
ISP	Independent Science Panel
Liveability	In this report, liveability is used to refer to a sense of place, quality of housing, provision of health services, recreation facilities, attraction of the urban environment, availability of services
MC	Management Committee
Metadata	"Data about data", the series of descriptors used to identify a particular dataset, e.g. author, date of creation, format of the data, location of the data points etc.
Model / Modelling	The creation of conceptual, graphical or mathematical models to describe, visualise or test abstract concepts and processes. Models help explain complex real world interactions and add to our ability to understand how human actions impact on ecosystems. Models can be used as scenario analysis tools to support management decision making.
PCIMP	Port Curtis Integrated Monitoring Program
Physicochemical	Physical and chemical forces that influence the environment and the biodiversity and people within e.g. temperature, salinity
Point source	A single, identifiable localised source of a release e.g. a stormwater outlet
QA/QC	Quality Assurance/Quality Control – the processes used to ensure the quality of a product (QA), and then to assess whether the product or services meet quality standards and correct where necessary (QC). Raw data may have errors or may be in formats that are not suitable for further analysis so appropriate quality control needs to be applied to assess and correct data.
Raw data	Raw data or primary data is defined as data that have not been subjected to processing or any other manipulation apart from QA/QC to ensure accuracy.
Reference condition	Recorded indicator values are compared against values from sites not impacted by human disturbance or alteration, or, which represent a control site considered to be 'healthy' (Connolly et al., 2013)
Standards	Legal limits permitted for a specific water body
TropWATER	Centre for Tropical Water and Aquatic Ecosystem Research (James Cook University)
WQO	Water Quality Objective

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Appendix 1: The GHHP science program

ISP 001 Mapping and synthesis of data and monitoring in Gladstone Harbour (Completed)

Australian Institute of Marine Science, Townsville

This study identified the current state of knowledge of Gladstone Harbour and identified knowledge gaps that if addressed could assist in the development of the Gladstone Harbour report card and the Gladstone Harbour Model. Environmental, social, cultural and economic data were considered and three primary outputs were produced:

- A report including a synthesis of available information relating to environmental, social, cultural and economic aspects of Gladstone Harbour.

- Identification of potential baseline or landmark studies.

- Development of a centralised online metadata repository (GHHP e-portal).

The report assessed potential information sources that were within the Gladstone Harbour Port limits, neighbouring locations that may influence the harbour and areas that the harbour itself may influence. Where possible the data was associated with sub-regions of Gladstone Harbour. A total of 100 data sources from universities, publically funded research organisations and government data bases and reports and readily available data holdings from stakeholder groups were identified.

There was a large volume of data related to water and sediment quality, iconic species including dolphins, turtles and dugongs and macroscopic flora particularly seagrass and to a lesser extent mangroves. A large portion of this data was considered to be of high quality although some gaps remain. In contrast large gaps remain in social, cultural and economic information particularly those that could be linked to the environmental condition of the harbour. In many cases data in these categories could only be associated with broader regions such as the Fitzroy catchment or the Gladstone Local Government Area.

The report identified 45 potential landmark or baseline studies across 19 topic areas although it was acknowledged that the potential baseline studies may not reflect the final choice of indicators for the report card selected by the Independent Science Panel.

The GHHP e-portal contains nearly 340 metadata records. As many records relate to multiple reports or data sets over 600 files have been include. Scientific reports and other published work owned by commercial entities were not included owing to copyright restrictions, however a separate bibliography with links to their abstracts is included.

Reports and Publications

Llewellyn, L., Wakeford, M. & McIntosh, E. (2013) Mapping and synthesis of data and monitoring in Gladstone Harbour. A report to the Independent Science Panel of the Gladstone Healthy Harbour Partnership, August 2013. Townsville: Australian Institute of Marine Science.

The GHHP e-portal can be viewed here

ISP 002 Review of the use of report cards for monitoring ecosystem and waterway health (Completed)

Central Queensland University, Griffith University, The University of Queensland

The effective communication of monitoring results and the free flow of relevant information is critical in supporting management decision concerning ecosystem health and ensuring that environmental management is achieving its stated goals. In this project a critical review of the use of report cards regionally, nationally and internationally with an emphasis on coastal marine areas including estuarine and tropical systems was conducted. The effectiveness of report cards in the communication of monitoring results to a wide range of audiences including the general public, industry groups, indigenous groups and various levels of government was assessed. The ability of a report card program to support management decisions concerning ecosystem health and the synthesis and communication of monitoring results and other scientific information was also considered. Fourteen report card programs were reviewed in this study.

The review found that report cards were an effective tool for communicating complex results in an easily understood format, that few programs report social, cultural and economic indicators and that challenges and opportunities are presented by new and emerging technologies. Particularly around online interactive report cards, data portals and visualisations and new tools for data collection, storage and analysis.

This review identifies five key elements critical to the successful implementation and ongoing effectiveness of a report card program. These are:

1) Setting clear goals
2) Strong links to all stakeholders
3) Flexibility in implementation
4) Effective communication
5) Rigorous science

The findings of this study continue to guide the development of The Gladstone Healthy Harbour Partnership program.

Reports and Publications

Connolly RM, Bunn S, Campbell M, Escher B, Hunter J, Maxwell P, Page T, Richmond S, Rissik D, Roiko A, Smart J, Teasdale P (2013). Review of the use of report cards for monitoring ecosystem and waterway health. Report to: Gladstone Healthy Harbour Partnership. November 2013. Queensland, Australia.

ISP 003 Models and Indicators of Key Ecological Assets in Gladstone Harbour (Completed)

CSIRO Wealth from Oceans Flagship, Hobart

To determine potential indicators for the Gladstone Harbour report card and monitoring program this project developed models of key ecological assets with in the Gladstone Harbour system. These models were developed to capture a conceptual understanding of cause and effect relationships between social, cultural and economic pressures on environmental and ecological components of the system. In essence these models provide a rigorous analytical framework to predict how a system will respond to disturbance and to identify key indicators that will allow the health of Gladstone Harbour to be tracked. The

development of models was strongly driven by stakeholder engagement, building upon the experience of GHHP stakeholders including community members, industry, scientists and regional managers through a series of workshops over three days in Gladstone.

The final set of assets selected for qualitative modelling by the Independent Science Panel were based on the GHHP vision statement and included non-migratory species resident in the harbour or were ecosystems that provided critical habitats or ecological services. These assets were: barramundi, yellow bream, mud crab, tidal wetlands, mangroves, mangrove ecosystems, coral reefs and seagrass ecosystems.

The results of this work have provided the information and conceptual understanding to determine key indicators that are relevant to community based values and consistent with the GHHP vision statement. The qualitative models developed during this project will be incorporated in to the Gladstone Harbour Mode, currently being developed (see ISP 006), and in the long-term predictions from the qualitative models will be tested against data from the monitoring program and will provide a sound platform for increasing our understanding of the key ecological assets in Gladstone Harbour.

Reports and Publications

Dambacher, J.M., K.B. Hodge, R.C. Babcock, E.A. Fulton, S.C. Apte, É.E. Plagányi, Warne, M. & Marshall, N.A. 2013. Models and Indicators of Key Ecological Assets in Gladstone Harbour. A report prepared for the Gladstone Healthy Harbour Partnership. CSIRO Wealth from Oceans Flagship, Hobart.

Dambacher, J.M., K.B. Hodge, R.C. Babcock, E.A. Fulton, S.C. Apte, É.E. Plagányi, Warne, M. & Marshall, N.A.. 2013. Précis for Models and Indicators of Key Ecological Assets in Gladstone Harbour. A report prepared for the Gladstone Healthy Harbour Partnership. CSIRO Wealth from Oceans Flagship, Hobart.

ISP 004 Guidance for the selection of social, cultural and economic indicators for the development of the GHHP Report Card (Completed)

CQ University, Rockhampton

The Gladstone Harbour report will card extend beyond environmental health and will include social, cultural and economic components. In the long-term it will consider the links between these four components. This project considered and made recommendations for the selection of social, cultural and economic indicators that measure progress towards the GHHP vision for Gladstone Harbour developed in conjunction with the community of Gladstone. These recommendations were based on reviews of the use of social, cultural and economic indicators in report cards and more specifically the use of these indicators in rural Queensland. The final report also considered appropriate frameworks to provide a structure for the selection, measurement and combinations of indicators. The key recommendations from this study are presented below:

- Provide a clear hierarchical structure in the report card.
- The report card be based on a balanced reporting of the environmental, social, cultural and economic components of the health of Gladstone Harbour.
- The selection of social, cultural and economic indicators should be subject to a pilot process.
- Selection of the final indicators be chosen following consultation with the Gladstone community.
- The inclusion of both objective and subjective measures is considered to broaden the opportunity for those affected by harbour health (positive or negative) to be included in the overall grade.
- Present environmental health separately to social, cultural and economic components.

- Report on the performance of the report card and the direct outcomes of its application to the Gladstone community.

Reports and Publications

Greer, L., & Kabir, Z. (2013) Guidance for the selection of social, cultural and economic indicators for the development of the GHHP Report Card, Report to the Gladstone Healthy Harbour Partnership, School of Human Health and Social Science, CQ University Australia, Rockhampton.

ISP 005 Piloting of social, cultural and economic data for the Gladstone Healthy Harbour Partnership Report Card (Completed)

CSIRO Marine and Atmospheric Research

Report cards have become an increasingly popular method to document progress towards environmental goals. In general these report cards focus on the biophysical components of the system such as water quality and the condition of key ecosystems such as seagrass meadows and coral reefs. The Gladstone Harbour report card is unique in that in addition to reporting on progress towards environmental goals it will report on progress towards, social, cultural and economic goals for the Gladstone Harbour region. These goals developed by the GHHP in conjunction with stakeholders have been outlined in the vision statement for Gladstone Harbour. The specific objectives for cultural, social and economic indicators are listed below:

Cultural objectives

- Registered cultural heritage sites associated with the harbour and waterways are protected.
- The Gladstone community's sense of identity and satisfaction with the condition of the harbour is increased.

Social objectives

- Maintain / improve easy access to the harbour waters and foreshore for recreation and community users.
- Maintain / improve a safe harbour for all users (e.g. swimming, boating and foreshore activities.
- Enhance liveability and wellbeing in the region.

Economic objectives

- The Gladstone Harbour is managed to support shipping, transport and a diversity of industries.
- Economic activity in the Gladstone Harbour continues to generate social and economic benefits to the regional community.

The key aim of this project was to develop and pilot a system for the collection and analysis of data relating to appropriate cultural, social and economic indicators guided by the these objectives and to report on

these for the 2014 pilot report card. A summary of the findings of this study is presented in the body of this document and the full report will be uploaded to the GHHP website when finalised.

Reports and Publications

Pascoe, S., Cannard, T., Marshall, N., Windle, J., Flint, N., Kabir, Z. & Tobin, R. (2014) Piloting of social, cultural and economic indicators for the Gladstone Healthy Harbour Partnership Report Card. Draft Report prepared for the GHHP by CSIRO, Oceans and Atmosphere Flagship.

ISP 006 Development of a Gladstone Harbour Model to support the Gladstone Healthy Harbour Report Card (To be completed June 2016)

CSIRO Wealth from Oceans Flagship, Hobart

When completed this full system model will comprise a suite of models which will be collectively referred to as the Gladstone Harbour Model. The primary purpose of the model is to enable the GHHP Management Committee to undertake annual scenario analysis. Effectively road testing management strategies before implementing them in reality. These analyses will assist the management committee to provide advice on how the Gladstone Healthy Harbour Partnership should respond to annual report card results while providing stakeholders with a tool to explore various future management options.

As outlined below the Gladstone Harbour Model will include existing models and new models currently being developed by CSIRO and it will be delivered in three stages:

1) **Receiving Water Quality Model to be completed by June 2015.**

In addition to providing direct inputs into the report card the receiving water quality model will provide a direct link between the hydrodynamic models and system models. This component of the model will enable the development and running of management scenarios that involve water-column processes. This component of the project will use the CSIRO's Environmental Modelling Suite which integrates hydrodynamic, sediment transport and biogeochemical modules. These will effectively capture the water quality dynamics of Gladstone Harbour and allow realistic distributional modelling of the key habitats within the harbour.

2) **Qualitative (conceptual) model of the social and economic components of Gladstone Harbour a report on the findings of this component of the model will be delivered in late 2014.**

This component of the project will develop qualitative models that synthesise a conceptual understanding of the cause and effect relationships between human pressures and the environmental and ecological components of the Gladstone Harbour region. These models will be based on workshops with key social, economic and cultural experts and consultation with the Gladstone community including people with expertise/interest in areas such as; agriculture, commercial fishing, recreational fishing, retail, real estate, tourism, media and communications, shipping and ports, mining, heavy industry, the environment and education.

The aim of the workshop and subsequent consultation will be to identify:

- The human behavioral drivers that explain the occurrence of anthropogenic pressures on the harbour.

- How these pressures may increase or reduce other pressures on the harbour.
- The key connections within the social and economic aspects of the Gladstone Harbour region that defines its overall behavior.
- Where the social, economic and stewardship indicators sit in the broader social and economic system context of Gladstone Harbour.

The models developed from this process will be used as a basis for defining the human components and interactions modelled within the Gladstone Harbour Model. A report on this project will be delivered in late December 2014.

3) Full systems model (using the Atlantis framework) for the Gladstone Harbour and immediate surrounds. The full systems model will be fully operational by December 2015.

The final stage of this project is the development of the Gladstone Harbour Model. This model will be used to improve our understanding of the potential outcomes of an increasingly expanding list of possible interactions between factors that may directly or indirectly effect the health of Gladstone Harbour.

The first step in conceptualising a system-wide understanding of the interacting components and developing a structural basis for quantitative modelling will be linking the qualitative modelling work already completed (ISP 003) with the conceptual models developed during Stage 2 of this project. Building on this, the construction of the full system model will also involve collating and adding large volumes of data on all aspects of the system including biological, physical, social, cultural and economic data. This information will come from a range of sources including environmental and ecological research and monitoring, economic input and output statistics for all major industries in the area and Australian Census data for the region. A review of system relevant information will also be conducted in order to compile an inventory of the key drivers of change in and around Gladstone Harbour. Close collaboration with stakeholders throughout the model development process will ensure that the Gladstone Harbour Model is fit-for-purpose and that it is flexible enough for any future modifications that will be required as new information becomes available.

A workshop will be conducted with the GHHP Management Committee in early 2016 to formulate scenarios to be run on the full system model. These scenarios will be developed in conjunction with the Management Committee in response to the first full report card delivered in 2015. The final technical reports for this project will be delivered by June 2016.

ISP 007 Development of Connectivity Indicators for the Gladstone Healthy Harbour Report Card

CSIRO Wealth from Oceans Flagship, Hobart, University of Queensland

Connectivity of water bodies is an important driver of productivity in marine ecosystems helping to maintain ecosystem function. It contributes to the health of habitats found within Gladstone Harbour such as seagrass beds, mangroves and coral reefs by cycling nutrients, facilitating biological and genetic connectivity and in the dilution and flushing of contaminants. However connectivity between contaminant inputs and vulnerable habitats such as between dredging activities and seagrass beds can also have negative effects on harbour health. The development of shipping channels, land reclamation and coastline

armouring has the potential to alter connectivity within the harbour owing to altered bathymetry and is also being assessed as a component of this project.

To address the Gladstone Harbour report card objective for connectivity "maintain / improve connectivity of water within and between Gladstone Harbour, related rivers, estuaries and adjacent waters" CSIRO is developing a state-of-the art-hydrodynamic model to calculate connectivity indices for the Gladstone Harbour report card and to provide sufficient information for the calculation of scores for the report card. This model will also constitute a key component of the Gladstone Harbour Model.

Three classes of indicator have been developed to inform the connectivity score for the Gladstone Harbour Report Card:

1) Flushing time. This indicator will provide a measure of water exchange through the system. This indicator is commonly used as an indirect indicator of water quality.
2) Ecological connectivity. This indicator will provide a measure of water exchange between spawning grounds and nursery areas for iconic species such as barramundi.
3) Contaminant connectivity. This indicator will provide a measure of the potential of contaminants to move other parts of the system from the input source.

Reports and Publications

Condie, S., Herzfeld, M., Andrewartha, J., Gorton, B. & Hock, K. (2014) Project ISP007: Development of Connectivity Indicators for the Gladstone Harbour Report Card. Draft Report. CSIRO Wealth from Oceans Flagship, Hobart, University of Queensland.

ISP 008 Provision of statistical support during the development of the Gladstone Harbour Report Card (To be completed March 2015)

Queensland University of Technology

The provision of statistical support covers two critical elements for developing the pilot report card, these are trialing the indicators and reference conditions and developing the report card scoring methodologies. This will include assisting with the determination of reference conditions for each report card indicator, statistical support required to develop new monitoring programs and to validate existing ones, development of methods to calculate indicator scores, development of methods to aggregate overall report card scores and to assist with trialing report card indicators. In the pilot report card year particular attention was paid to the development of indicators for water and sediment quality.

Specific objectives for this project include working with project teams developing indicators and scores for the pilot report card and full report card to:

- Assist with refining report card indicators and indices.
- Provide advice on the aggregation of indices and report card scoring methodology
- Perform investigative and validation studies required to inform the monitoring program design.
- Develop methods to address statistical QA/QC issues.

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ISP 009 Development of a data and information management system for the GHHP report card monitoring data (To be completed December 2015)

Australian Institute of Marine Science

To facilitate knowledge transfer across the monitoring and project areas and to the broader community a Digital Information Management System (DIMS) is being developed in parallel with the pilot report card. When completed this system will:

- Allow report card data providers, GHHP Partners, and modelers to upload data sets and other information to an online repository.
- Contain an automated report card system which collates analyses data to generate a report card score including graphs and figures.
- Allow the public through the report card website and metadata system to view the current and past report cards and to search and view DIMS for reports and other information related to the health of Gladstone Harbour.

The Digital Information System will be linked to the Gladstone Harbour Report Card Website and consist of three major components; the report card system, the repository and the metadata system. These system and the linkages between system administrators data providers and user groups are illustrated in Figure 5.1 in the main body of this report.

A limited but operational version of DIMS was delivered in October 2014 and was used in the generation of the pilot report card. The complete system including full automation of quality assurance and quality control, remote data entry and translation of data to visual products for the report card and GHHP website will go online in September 2015.

Reports and Publications

AIMS (2014) Design and Architecture of the Data and Information Management System (DIMS) for the GHHP Report Card Monitoring Data. Project ISP009. Australian Institute of Marine Science, Townsville.

ISP 010 Statistical Assessment of the Fish Indicators and Score for the Pilot Report Card (To be completed in 2015)

Dr Bill Venables CSIRO Research Fellow

The GHHP vision statement "Supports a sustainable population of marine species (including megafauna—dolphins, dugongs and turtles)" will be addressed by the measurement of indicator species, such as barramundi *Lates calcarifer*, yellow fin bream *Acanthropagus australis* and pikey bream *Acanthopagrus berda* and mud crabs *Scylla serrate.* These species have been chosen as indicators as they will respond rapidly to environmental change and provide information about the overall environmental and ecological health of the harbour. Megafauna were not selected as indictors as there can be a long lag-time between an environmental impact and a change in their condition. And, as their range will usually extend beyond the limits of Gladstone Harbour it may be difficult to associate changes in condition to impacts within the

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harbour. This project deals exclusively with the suitability of existing data sets and monitoring programs to derive report card scores.

Infofish Australia undertakes an annual barramundi recruitment assessment for Gladstone Harbour and the Fitzroy River that could inform the barramundi indicator for the report card. They have also collected data for the two bream species of interest. The historical data sets, including recruitment data, provide details of surveys conducted in the estuarine regions from 1999 to present. Data collection on individual tagged fish which contributes to the recruitment index began in 1990.

To assess the suitability of the infofish data to develop report card scores and to provide recommendations for ongoing monitoring suitable for report card use this project aims to:

- In collaboration with Infofish review the utility of Infofish's barramundi data including
    - documenting the data collection and analysis methods,
    - reviewing the statistical methods used to produce the recruitment indices,
    - and providing recommendations to Infofish on improved sampling and statistical methods used to calculate the barramundi recruitment index.
- Provide advice on the statistical methods to develop the GHHP report card barramundi indicator from the Infofish recruitment index and the methods used to combine the three indicators (barramundi and two bream species) into a report card fish score.
- Provide advice on the potential application of the barramundi statistical methods to the bream species data.

It was concluded from initial assessments of the data sets that there was no reason why that a robust and effective annual monitoring survey could not be planned and conducted that would inform the barramundi indicator for the Gladstone Harbour report card.

ISP 011 Gladstone Healthy Harbour Partnership Seagrass Pilot Report Card

Centre for Tropical Water & Aquatic Ecosystem Research, Cairns

Seagrass meadows are one of the most important habitat types within Gladstone Harbour. While the area and distribution of the seagrass meadows can vary on an annual basis, at peak distribution seagrass meadows can cover an area of approximately 12,000ha. This area can include intertidal, shallow, sub-tidal and deep-water habitats. In addition to providing a range of important ecosystem functions such as sediment stabilisation, nutrient cycling and carbon sequestration. The seagrass meadows can also provide nursery areas for juvenile fish including barramundi and food for dugongs and turtles.

The GHHP report card objective for key ecosystems is to "maintain/improve habitat function and structure of key ecosystems". In order to measure progress against this objective for seagrass in the Gladstone Harbour report card. The Gladstone Healthy Harbour Partnership required quality assured seagrass data and ongoing annual monitoring of seagrass beds within the harbour to identify baseline conditions to measure change against and to develop seagrass indicators and scores.

The Seagrass Ecology group within TropWATER at James Cook University has been monitoring seagrass at least annually in Port Curtiss and Rodds Bay since 2002 and has consequently been engaged by GHHP to:

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- Develop a set of thresholds and five condition categories (grades) for the assessment of each of the seagrass indicators (area, biomass and species composition). This is based on the existing data sets.
- Identify baseline conditions for which yearly assessments will be benchmarked against to determine their status.

Reports and Publications

Bryant CV, Jarvis JC, York PH & Rasheed MA (2014) Gladstone Healthy Harbour Partnership Pilot Report Card: ISP011 Seagrass Draft Report – October 2014, Centre for Tropical Water & Aquatic Ecosystem. Research Publication 14/53 James Cook University.

GHHP Gladstone Fish Health Research Program

GHHP, Fisheries Research and Development, Canberra.

The Gladstone Healthy Harbour Partnership Management Committee has asked the Independent Science Panel to develop priority research areas for identifying the causality of recent fish health issues observed within Gladstone Harbour and to develop approaches to enhance early detection of fish health issues in the future.

The broad goals of the Gladstone Harbour fish health research program are to:

- Better understand outstanding questions around causal links of fish ill health and other environmental or anthropogenic impacts.
- Develop approaches to enhance early detection of fish health issues in the Harbour in the future.

In order to identify priority research projects an invitation only Fish Health workshop will be conducted in Gladstone in 2015. The workshop involving a small panel of experts will be coordinated by The Fisheries Research and Development Corporation in conjunction with the Independent Science Panel. The results of this workshop are expected to include research project proposals including proposals that could lead to the development of a tool for early detection of fish health issues. It is hoped that this research would be completed within a five year time frame and that the early detection tool would also be available at this point. Initially projects will have a research focus however it is expected that research outcomes will contribute, in the future, to the annual Gladstone Harbour report card.

It is expected that the results from this workshop will be made available in late 2015 and that the ongoing research program will commence in 2015 and conclude in 2020.

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Appendix 2: The role of the Independent Science Panel

The role of the ISP is to ensure environmental, social and economic challenges of policy, planning and actions to achieve the vision of GHHP are supported by credible science through the provision of independent scientific advice, review and direction. This is a review and oversight role, and ISP project work will be carried out by collaborators or consultants with the ISP providing advice, as reflected by the time commitment agreed upon for ISP members. In undertaking its role the panel will engage with stakeholders such as the Gladstone community and industry to ensure their participation in the process.

Chair of the Independent Science Panel

The Chair of the Independent Science Panel is responsible for championing the integrated and collaborative approach to research and monitoring. The Chair will be an ex-offico member of the GHHP MC and will work with the GHHP to convene the ISP. The Chair is also responsible for managing conflict of interest issues that may arise among the ISP members. The Chair is the spokesperson for the ISP.

The Independent Science Panel will be supported by the Secretariat and a Science Convenor. The role of the Science Convenor is to support the ISP including supporting the ISP by coordinating the operations, recommendations and outputs from the panel (including preparation, synthesis and collation of information). With the ISP Chair, the Science Convenor is also responsible for progressing the ISP deliverables by overseeing and managing ISP projects, keeping projects on task and reporting any delays or changes in project scope to the Chair.

Composition of the Independent Science Panel

The Independent Science Panel will comprise of up to 11 members (including the Chair and the Convenor) with expertise on one or more of the following:

- Water quality
- Ecosystem health
- Marine biogeochemistry
- Marine toxicology
- Decision support tools/modelling
- Social science
- Resource economics
- Computational informatics, statistics, decision support and modelling
- Dredging (technical) and engineering
- Marine biodiversity (including fish and seagrass)

Roles and Responsibilities

The role of the ISP is to provide independent scientific advice on the piloting and system testing of the GHHP endorsed GHRC. This includes:

- the monitoring program to support the report card;

- over sighting the synthesis work required to ascertain report card grades to ensure the independence of the grades;
- over sighting the continued development of the Gladstone Harbour Model that will be used by the GHHP to underpin advice to policy, management and regulatory agencies, industry and other stakeholder;
- research projects (if required) to improve the GHRC; and,
- monitoring improvement plans that may be needed to improve the efficiency and/or effectiveness of the Gladstone Harbour report card, its monitoring program and/or the Gladstone Harbour Model.

The ISP will also provide independent scientific advice when requested by the GHHP. The key output from the ISP for 2014 would be an updated report card framework recommendation for implementation in 2015.

Other roles of ISP

Enhancement of Research Partnerships

The ISP will ensure that partnerships and collaboration are enhanced in the generation of science advice to GHHP. The ISP will facilitate the links with research partnerships and initiatives (e.g. research alliances, centers of excellence) and other researchers and academics (e.g. in-house industry scientists) to address scientific and technical key issues identified by the ISP and the GHHP. Leveraging of resources to address research questions will also be facilitated.

Scientific Quality Assurance

The ISP will ensure that the recommendations are based on science activities that are designed, conducted, coordinated, integrated and peer-reviewed in accordance with best practice in scientific community.

Effective Scientific Communication

The ISP will support stakeholder decision making through the provision and access to synthesised knowledge and, information and robust decision support tools. The ISP will ensure, to the best of its capability that a common science consensus/recommendation on any particular issue in relation to Harbour will be presented to the GHHP and the community, as required. The ISP will work with GHHP to facilitate the provision of effective communication of results and recommendations to the wider community as required.

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Appendix 3: Data sources for water quality, social and economic indicators

Water quality indicators

- Water quality data used to determine water quality scores and grades for the 2014 pilot report card were obtained from the Port Curtis Integrated Monitoring Program (PCIMP). This was collected from 53 sites across thirteen harbour zones in the December 2013, March 2014 & June 2014 sampling periods.

Social indicators

- Primary data to assess the social measures were collected using a Computer Assisted Telephone Interview survey (CATI) of 400 local residents undertaken in August 2014.
- Oil spills and marine pollution data: Marine Safety Queensland (2013) Summary of oil spills and other marine pollution events reported to Marine Safety Queensland. Queensland Government, Brisbane.
- Marine safety incidents: Department of Transport and Main Roads (2014) Marine incidents in Queensland, 2013. Queensland Government, Brisbane.
- 2011 Australian Census: Australian Bureau of Statistics.

Economic indicators

- Demographic and travel cost data were collected using a Computer Assisted Telephone Interview survey (CATI) of 400 local residents undertaken in August 2014.
- Commercial fishing: Based on catch by fishing method data from the Qfish data base (http://qfish.daff.qld.gov.au) in area S30. Average price derived from ABARES fisheries statistics. Skirtun, M., Sahlqvist, P. and Vieira, S. (2013). Australian fisheries statistics 2012, FRDC project 2010/208. ABARES, Canberra.
- Shipping activity, monthly shipping movements by cargo type and destination/origin: Gladstone Ports Corporation Limited.
- Employment and turnover of harbour based industries: Queensland Office of Economic and Statistical Research Data Base
- Tourism related data: economy.id.com.au http://economy.id.com.au/gladstone
- Recreational fishing reports from InfoFish Australia.
- Community participation (Harbour Festival and other events) figures from http://gladstonefestival.com/ and Gladstone Harbour and Festival office at Gladstone Regional Council
- 2011 Australian Census: Australian Bureau of Statistics.

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Appendix 4: Water quality guidelines used in the calculation of water quality scores.

The 90th Percentiles are estimated from Gaussian distributions based on the 50th and 80th percentile (Johnson et.al 2015). The 50th Percentiles shown in bold type are the relevant water quality guidelines for the Gladstone Harbour zones in the Capricorn Curtis Coast Water Quality Objectives (DEHP (2014).

Zone Number	Zone Name	Percentile	Physical Chemical			Nutrients		Metals	
			DO (% sat)	Turbidity Wet (May–Oct.)(NTU)	Turbidity Dry (Nov.–Apr.) (NTU)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Aluminium (µg/L)	Copper (µg/L)
1	The Narrows	20	87.00	8.00	4.00	15.00	140.00		
1	The Narrows	50	**92.00**	**15.00**	**7.00**	**20.00**	**170.00**	**24**	**1.3**
1	The Narrows	80	95.00	30.00	12.00	29.00	220.00		
1	The Narrows	90	97.86	44.32	16.77	36.00	280.00		
2	Graham Ck	20	83.00	10.00	3.00	15.00	140.00		
2	Graham Ck	50	**88.00**	**13.00**	**8.00**	**20.00**	**170.00**	**24**	**1.3**
2	Graham Ck	80	94.00	28.00	14.00	29.00	220.00		
2	Graham Ck	90	99.73	42.32	19.73	36.00	280.00		
3	Western Basin	20	91.00	7.00	4.00	14.00	145.00		
3	Western Basin	50	**96.00**	**13.00**	**8.00**	**18.00**	**170.00**	**24**	**1.3**
3	Western Basin	80	100.00	29.00	17.00	29.00	210.00		
3	Western Basin	90	103.82	44.27	25.59	43.00	250.00		
4	Boat Ck Estuary	20	85.00	13.00	9.00	15.00	160.00		
4	Boat Ck Estuary	50	**92.00**	**25.00**	**14.00**	**22.00**	**190.00**	**24**	**1.3**
4	Boat Ck Estuary	80	98.00	32.00	22.00	32.00	220.00		
4	Boat Ck Estuary	90	103.73	38.68	29.64	45.00	270.00		
5	Inner Harbour	20	93.00	7.00	4.00	15.00	130.00		
5	Inner Harbour	50	**96.00**	**13.00**	**8.00**	**21.00**	**160.00**	**24**	**1.3**
5	Inner Harbour	80	98.00	29.00	17.00	33.00	220.00		
5	Inner Harbour	90	99.91	44.27	25.59	42.00	260.00		
6	Calliope Estuary	20	91.00	6.00	5.00	17.00	140.00		
6	Calliope Estuary	50	**95.00**	**11.00**	**11.00**	**22.00**	**175.00**	**24**	**1.3**
6	Calliope Estuary	80	100.00	24.00	21.00	25.00	210.00		
6	Calliope Estuary	90	104.7	36.41	30.54	27.00	240.00		

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Appendix 4: Water quality guidelines used in the calculation of water quality scores

The 90th Percentiles are estimated from Gaussian distributions based on the 50th and 80th percentile (Johnson et.al 2015). The 50th Percentiles shown in bold type are the relevant water quality guidelines for the Gladstone Harbour zones in the Capricorn Curtis Coast Water Quality Objectives (DEHP (2014).

Zone Number	Zone Name	Percentile	Physical Chemical			Nutrients		Metals	
			DO (% sat)	Turbidity Wet (NTU)	Turbidity Dry (NTU)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Aluminium (µg/L)	Copper (µg/L)
7	Auckland Inlet	20	93.00	5.00	3.00	12.00	140.00		
7	Auckland Inlet	50	**98.00**	**8.00**	**6.00**	**16.00**	**160.00**	**24**	**1.3**
7	Auckland Inlet	80	100.00	12.00	13.00	23.00	200.00		
7	Auckland Inlet	90	101.91	15.82	19.68	31.00	240.00		
8	Mid Harbour	20	94.00	4.00	2.00	9.00	110.00		
8	Mid Harbour	50	**97.00**	**9.00**	**4.00**	**14.00**	**135.00**	**24**	**1.3**
8	Mid Harbour	80	101.00	16.00	7.00	23.00	200.00		
8	Mid Harbour	90	104.82	22.68	9.86	35.00	225.00		
9	South Trees Inlet	20	86.00	7.00	4.00	15.00	140.00		
9	South Trees Inlet	50	**93.00**	**13.00**	**11.00**	**20.00**	**170.00**	**24**	**1.3**
9	South Trees Inlet	80	99.00	32.00	24.00	31.00	250.00		
9	South Trees Inlet	90	104.73	50.13	36.41	43.0	300.00		
10	Boyne Estuary	20	90.00	2.00	1.00	8.00	110.00		
10	Boyne Estuary	50	**97.00**	**5.00**	**3.00**	**11.00**	**120.00**	**24**	**1.3**
10	Boyne Estuary	80	102.00	10.00	6.00	17.00	180.00		
10	Boyne Estuary	90	106.77	14.77	8.86	33.00	240.00		
11	Outer Harbour	20	94.00	2.00	1.00	9.00	115.00		
11	Outer Harbour	50	**97.00**	**7.00**	**3.00**	**13.00**	**130.00**	**24**	**1.3**
11	Outer Harbour	80	100.00	13.00	6.00	21.00	170.00		
11	Outer Harbour	90	102.86	18.73	8.86	24.00	196.00		
12	Colosseum Inlet	20	86.00	3.00	1.00	8.00	105.00		
12	Colosseum Inlet	50	**91.00**	**7.00**	**3.00**	**10.00**	**130.00**	**24**	**1.3**
12	Colosseum Inlet	80	97.00	14.00	4.00	15.00	180.00		
12	Colosseum Inlet	90	102.73	20.68	4.95	18.00	200.00		

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Appendix 4: Water quality guidelines used in the calculation of water quality scores

The 90th Percentiles are estimated from Gaussian distributions based on the 50th and 80th percentile (Johnson et.al 2015). The 50th Percentiles shown in bold type are the relevant water quality guidelines for the Gladstone Harbour zones in the Capricorn Curtis Coast Water Quality Objectives (DEHP (2014).

Zone Number	Zone Name	Percentile	Physical Chemical			Nutrients		Metals	
			DO (% sat)	Turbidity Wet (NTU)	Turbidity Dry (NTU)	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Aluminium (µg/L)	Copper (µg/L)
13	Rodds Bay	20	93.00	2.00	3.00	11.00	140.00		
13	Rodds Bay	50	**96.00**	**5.00**	**4.00**	**13.00**	**160.00**	**24**	**1.3**
13	Rodds Bay	80	98.00	12.00	7.00	21.00	200.00		
13	Rodds Bay	90	99.91	18.68	9.86	23.00	230.00		

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