Workshop on Nutrient Loads in Gladstone Harbour

Hosts:	Gladstone Healthy Harbour Partnership (GHHP) Independent Science Panel Port Curtis Integrated Monitoring Program (PCIMP)
Date:	Monday the 24th of February, 2020
Time:	9am to 1pm (lunch will be provided)
Location:	Room 7, Floor 8, CQUniversity, 160 Ann St, Brisbane
ZOOM:	https://cqu.zoom.us/j/981290810
Chair:	John Rolfe (ISP Chair)

Overview

The purpose of this workshop is to explore whether nutrient levels in Gladstone Harbour are excessively high, whether there may be links to habitat condition, and what are priorities for monitoring, research and management.

Key questions to be addressed would include:

1. What is currently known about nutrients in the Harbour?
2. Are nutrient levels in the Gladstone Harbour excessively high?
3. Are the current parameters used to assess nutrients appropriate?
4. What data and modelling are available to understand nutrients in the Harbour?
5. Is there a potential relationship between high levels of nutrients in the Gladstone Harbour and adverse impacts on habitats such as corals?
6. What lines of evidence are needed to draw linkages between nutrients and habitat condition?
7. What are priority areas for data collection and research?

The workshop invitees include members of the GHHP ISP and science team, PCIMP, GHHP Management committee, outside experts, and other key stakeholders.

The workshop will run from 9am to 1pm, and participants are welcome to attend in person or join by Zoom.

Background

Water quality in the Gladstone Harbour is monitored quarterly by PCIMP, and a subset of the parameters that are measured is made available to GHHP for the purposes of creating the annual report card.

Currently the focus of GHHP and the ISP has been on monitoring and annual reporting stages, with limited attention paid to identifying actions that would lead to improvements in the health of Gladstone Harbour.

Nutrient levels have been at elevated levels in the Gladstone Harbour for the past five years. At the same time corals have been in poor health, and there is increasing evidence that high levels of macroalgae cover may be part of the cause. There may be links between elevated levels of nutrients and increased macroalgae.

Issue

Since the first report card in 2015, nutrients have consistently scored satisfactory to poor at the whole harbour level. Similarly, the four years of poor to very poor coral scores are largely attributed to low coral cover and high macroalgae cover. Macroalgal cover may be hindering coral recovery processes such as juvenile settlement, juvenile growth and adult fecundity (Tanner, 1995; Foster et al., 2008; Costello et al., 2018; Thompson et al., 2018). There may be a potential link between the elevated nutrient concentrations and high macroalgal cover within the harbour, as higher nutrient loads tend to favour macroalgal-dominated communities.

De'ath and Fabricius (2010) indicate a turning point for higher macroalgal cover at 0.45 µg/L of chlorophyll. Chlorophyll was chosen as a proxy for nutrient availability as it can be estimated from satellite imagery. This threshold is supported within the Marine Monitoring Program in that higher levels of macroalgae tend to occur with a higher chlorophyll concentration (pers. comm. Angus Thompson). Although chlorophyll levels in Gladstone Harbour often fell within Queensland water quality guidelines, the 0.45 µg/L chlorophyll threshold was often exceeded by chlorophyll-*a* concentrations in the Mid Harbour and the Outer Harbour where the GHHP-monitored coral reefs are located.

Gladstone Harbour experiences a higher nutrient load from the Boyne and Calliope catchments compared to the pre-development load – approximately 2 to 3 times higher (Table 1). The majority of land within both the Calliope and Boyne catchments is used for grazing (~76%/~72%) and conservation and natural environments (Table 2). The remaining land use within the basins includes intensive use (i.e. residential, industry, transport and utilities), forestry, water (marsh/wetland, river and reservoir/dam) and cropping (~1%). The most current modelling estimates indicate 64% of total suspended solids with the catchments (approximately 44 kilotonnes each year) is derived from grazing land use (Table 3). Potential sources for total suspended solids are likely conservative as streambank erosion is considered its own land use type, however, may be located on grazing lands – which accounts for over 70% of land use in both catchments.

The Gladstone receiving water model indicated the greatest potential to decrease chlorophyll concentrations occurred with a reduction in nutrient loading in the agricultural runoff management scenario (Baird & Margvelashvili, 2015). The Atlantis model also indicated Gladstone Harbour is an externally driven system, with the largest effects from floods, climate, catchment loads and level of economic growth (Fulton et al., 2017). The largest potential improvement to water quality scores occurred with a reduction in nutrient loads scenario. However, the model demonstrates that ecosystem outcomes are complex due to indirect effects. A greater understanding of how nutrients and habitation (such as coral, macroalgae or seagrass communities) are related is essential to bridge the gap in knowledge with regard to the cascading effects of a reduced nutrient load.

In addition to catchment-related loads, nutrient loads in Gladstone Harbour are influenced by discharge from portside industries. Based on the National Pollutant Inventory (NPI) of Gladstone Harbour in 2017-18, fluoride compounds represented the greatest volume of discharge (~200 t) followed by the nutrients – total nitrogen (~130 t), total phosphorus (~14 t) and ammonia (~4 t). This represents an additional total nitrogen and total phosphorous load of 13% and 3% respectively when compared to the modelled baseline catchment loads in 2012/13 (see Table 1), as NPI data is not included in the modelled estimates. Compared to the modelled anthropogenic load, portside discharge in Gladstone Harbour accounts for an additional total nitrogen and total phosphorous load of 20% and 4% respectively.

The Reef Water Quality Report Card 2017-2018 highlights that nutrients are a problem along the majority of Queensland's coast. Both Calliope and Boyne catchments were graded as "E" for water quality targets of sediment, particulate nitrogen and particulate phosphorous (URL links in references). For both catchments it was noted that "this region has minimal anthropogenic dissolved inorganic nitrogen loads."

In 2019, the Gladstone Harbour Report Card was in its fifth year of reporting. Corals within the harbour have consistently been in poor to very poor condition while nutrients have been in satisfactory to poor condition for the four preceding years. These issues may continue in future years if the underlying negative pressures are not reduced. Understanding linkages between the various indicators is a critical first step in identifying actions that would lead to improvements in the health of Gladstone Harbour.

Additional data

A key gap in knowledge is where the major sources of nutrients and sediments are in the upstream catchments. This information would be important if actions to improve water quality, coral and seagrasses are undertaken.

In June 2019, the Department of Environment and Science provided GHHP with a long-term dataset from the Boyne and Calliope catchments. The dataset is extensive and spans multiple locations within each catchment and includes data from 1976 to 2013, however, some of the datasets are not complete (e.g. by site and/or by parameter over time). Most of the 2013 to present day data is available online. This data can be used in addition to modelled data to provide a better understanding of nutrients in the harbour. The Gladstone Harbour Model and other eReefs models may also provide insight into the water quality and habitation condition of Gladstone Harbour.

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Table 1. Modelled export loads for nutrients from Calliope and Boyne catchments (Source: McCloskey et al., 2019)

Basin Name	Pre-Development	Baseline 2012/2013	Anthropogenic Baseline	Increase factor from pre-development load to anthropogenic baseline load
Total suspended solids load (kt.y^{-1})				
Calliope	6	52	46	7.7
Boyne	2	17	15	7.5
Total	**8**	**69**	**61**	**7.6**
Total nitrogen load (t.y^{-1})				
Calliope	230	740	509	2.2
Boyne	127	278	151	1.2
Total	**357**	**1,018**	**660**	**1.8**
Total phosphorous load (t.y^{-1})				
Calliope	87	336	250	2.9
Boyne	40	113	74	1.9
Total	**127**	**449**	**324**	**2.4**

The *pre-development* model is representative of a pre-agricultural development scenario; the *baseline* model is reflective of the baseline management practice for 2012/13; *anthropogenic baseline* is the difference between the pre-development model and the baseline model.

Table 2. Proportion (%) of land under various land uses for the Boyne and Calliope catchments. Source: Derived from Queensland Land Use Mapping Program 2017 dataset. Land use areas calculated in ArcGIS® Pro 2.2.0 via the clip function.

Land Use	Calliope	Boyne
Grazing	75.5%	71.8%
Conservation / Natural Environments	8.0%	16.2%
Forestry	5.2%	5.2%
Intensive Use	5.5%	2.1%
Water Bodies	4.6%	4.1%
Cropping / Farming	1.3%	0.6%

Table 3: Land use contribution to total suspended solids loads (kilotonnes per year) for the Calliope and Boyne basins (Source: McCloskey et al., 2019).

Basin	Grazing	Forestry	Conservation	Stream	Cropping	Urban	Other	Total
Calliope	34	3	5	9	0.1	0.9	0.7	**52**
Boyne	10	0.3	1	5	0.0	0.3	0.7	**17**
Total	**44**	**3**	**6**	**14**	**0**	**1**	**1**	**69**

Note: Stream bank erosion is not segregated into a land use but is considered its own land use. As such, a significant proportion of streambank erosion will be occurring on grazing lands since they make up approximately 76 and 72 percent of the Calliope and Boyne catchments respectively.

References

Baird M, Margvelashvili N (2015) Receiving Water Quality & Sediment Scenarios: Technical Report. CSIRO, Australia. 48 p.

Costello P, Thompson A, Davidson J (2018) Coral Indicators for the 2018 Gladstone Harbour Report Card 2018: ISP014. Report prepared for Gladstone Healthy Harbour Partnership. Australian Institute of Marine Science, Townsville. (43 pp)

De'ath and Fabricius, 2010. Water quality as a regional driver of coral biodiversity and macroalgae on the Great Barrier Reef. Ecological Applications 20(3): 840-850.

Foster NL, Box SJ, Mumby PJ (2008) Competitive effects of macroalgae on the fecundity of the reef-building coral *Montastrea annularis*. *Marine Ecology Progress Series* 367: 143-152.

Fulton EA, Hutton T, van Putten IE, Lozano-Montes H and Gorton R (2017) Gladstone Atlantis Model – Implementation and Initial Results. Report to the Gladstone Healthy Harbour Partnership. CSIRO, Australia.

McCloskey, G.L., Waters, D., Baheerathan, R., Hateley, L., Fentie, B., Darr, S., Dougall, C., Ellis, R., Askildsen, M., 2019. Modelling pollutant load changes due to improved management practices in the Great Barrier Reef catchments: updated methodology and results – Technical Report for Reef Report Card 2016, Queensland Department of Natural Resources, Mines and Energy, Brisbane, Queensland.

Tanner JE (1995) Competition between hard corals and macroalgae: an experimental analysis of growth, survival and reproduction. *J Exp Mar Biol Ecol* 190:151-168

Thompson A, Costello P, Davidson J, Logan M, Greg Coleman, Gunn K (2018) Marine Monitoring Program. Annual Report for coral reef monitoring: 2016 to 2017. Australian Institute of Marine Science, Townsville. 146 pp.

URL links to Reef Water Quality Report Card 2017 and 2018

Calliope: https://reportcard.reefplan.qld.gov.au/home?report=target&measure=ALL&area=FZ-Call

Boyne: https://reportcard.reefplan.qld.gov.au/home?report=target&measure=ALL&area=FZ-Boyn