Workshop on Mud Crabs in Gladstone Harbour

8th of March 2021

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Conduct

The virtual workshop was held over one and a half hours and was chaired by Professor John Rolfe from the Independent Science Panel (ISP).

Attendees included members of the GHHP Independent Science Panel, the GHHP Management Committee, the Port Curtis Integrated Monitoring Program, and mud crab researchers from CQUniversity, Fisheries Queensland, NSW DPI and NT Fisheries.

Purpose of the workshop

The workshop was the second annual workshop organised by the Independent Science Panel on a focus issue, with the previous one held in February 2020 on nutrient levels in the Gladstone Harbour.

The purpose of the workshop was to discuss the indicators for mud crabs in Gladstone Harbour and to reference that with other mud crab research occurring in Australia.

Presentations

- **ISP report card & GHHP mud crab indicator (Mac Hansler)**
  - Mac Hansler provided a brief overview of the Gladstone Harbour Report Card, Environmental Component, geographic scope of the mud crab monitoring program, how the mud crab indicator is scored for the report card, general trends in mud crab scores and referred to QFish commercial mud crab data in the Gladstone region.
- **Mud crabs in Gladstone: research issues and trends (Nicole Flint)**
  - Nicole Flint provided a succinct overview of the GHHP mud crab monitoring program. This covered indicator measure selection, monitoring data, indicator refinement since 2017, trends in results, and research to inform the mud crab indicator. She also briefly discussed current mud crab research in Gladstone and continuing research needs to help better understand mud crab biology and ecology.
- **Research and policy updates for mud crabs in Qld (Julie Robins)**
  - Julie Robins gave an overview of the Qld mud crab fishery, which included comparisons of the east coast and the Gulf of Carpentaria. She also covered the harvest strategy for the Qld mud crab fishery (i.e., upcoming changes in legislation) and current mud crab research and monitoring in Queensland.

- **Research and policy updates for mud crabs in NT (Thor Saunders)**
  - Thor Saunders gave an overview of catch data in the NT, which is broken into the Gulf of Carpentaria and west of the Gulf of Carpentaria. Catch and climate data suggest recovery in mud crab populations following a rain event, such as in 2017. Makes management of mud crabs difficult. NT also has a closure-based fishery, as opposed to the sex-based fishery employed in Qld.
- **Strategic research on mud crabs in NSW (Daniel Hewitt)**
  - Matt Taylor gave a brief update on 'Informing adaptive management of portunid fisheries in NSW'. This covered an overview of the portunid crab project (mostly blue swimmer crab some giant mud crab) and progress/outcomes
  - Daniel Hewitt provided an update his PhD research project: 'Spawning, dispersal and movement of Giant Mud Crab (*Scylla serrata*) in NSW'. The project aimed to answer three questions: (1) 'What are environmental cues for female spawning migration?' using acoustic tagging (2) 'How does oceanographic variability impact larval dispersal?' using oceanographic modelling (3) 'How does environmental variability alter adult movement?' using acoustic tags and habitat mapping.

Background

GHHP selected mud crabs as an important indicator species when assessing the health of Gladstone Harbour. This followed community consultation and the development of a conceptual model for Gladstone Harbour (Dambacher et al. 2013). Three sub-indicators were identified as indicative of mud crab health: abundance, sex ratio and a visual health assessment.

Mud crabs in the Gladstone Harbour have been monitored twice-yearly by Central Queensland University since 2017. There are currently four years of data in and a fifth year of sampling has been contracted for 2021. The 2020 Technical Report (pages 90–99, GHHP 2020) and the 2017 project report (Flint et al. 2017) provides information on the development of the mud crab indicator.

Scores for the mud crab indicator are derived by comparing each index value against a pilot benchmark and a worst case scenario (WCS). Using this method, index values worse than the WCS score a 0, while index values better than the benchmark score a 1 and all other index values range between these bounds. Scores are then assigned into one of five grades, ranging from Very Poor (E) to Very Good (A).

From 2017 to 2020, several general trends have emerged from the study:

- An overall very poor score for sex ratio (i.e., female dominated catch) from 2018–2020
- An overall poor abundance score from 2018–2020
- A decreasing abundance benchmark (75th percentile of scores for current and previous years, up to 10 years) from 2017–2020 (Table 2 in Flint et al. 2020)
- An insufficient catch (>5 crabs from 40 pots) was recorded in Auckland Creek from 2018–2020
- In 2019, very good scores were received for all three sub-indicators from an unfished crab population at Eurimbula Creek (Table 5 in Flint et al. 2019)

Figure 1. Trends in Mud Crab measures scores from 2017 to 2020. Please note confidence intervals displayed on the trend plots are 95% bootstrap confidence intervals. They are calculated as the upper and lower 95 percentile of values estimated from bootstrapping the scores 1000 times
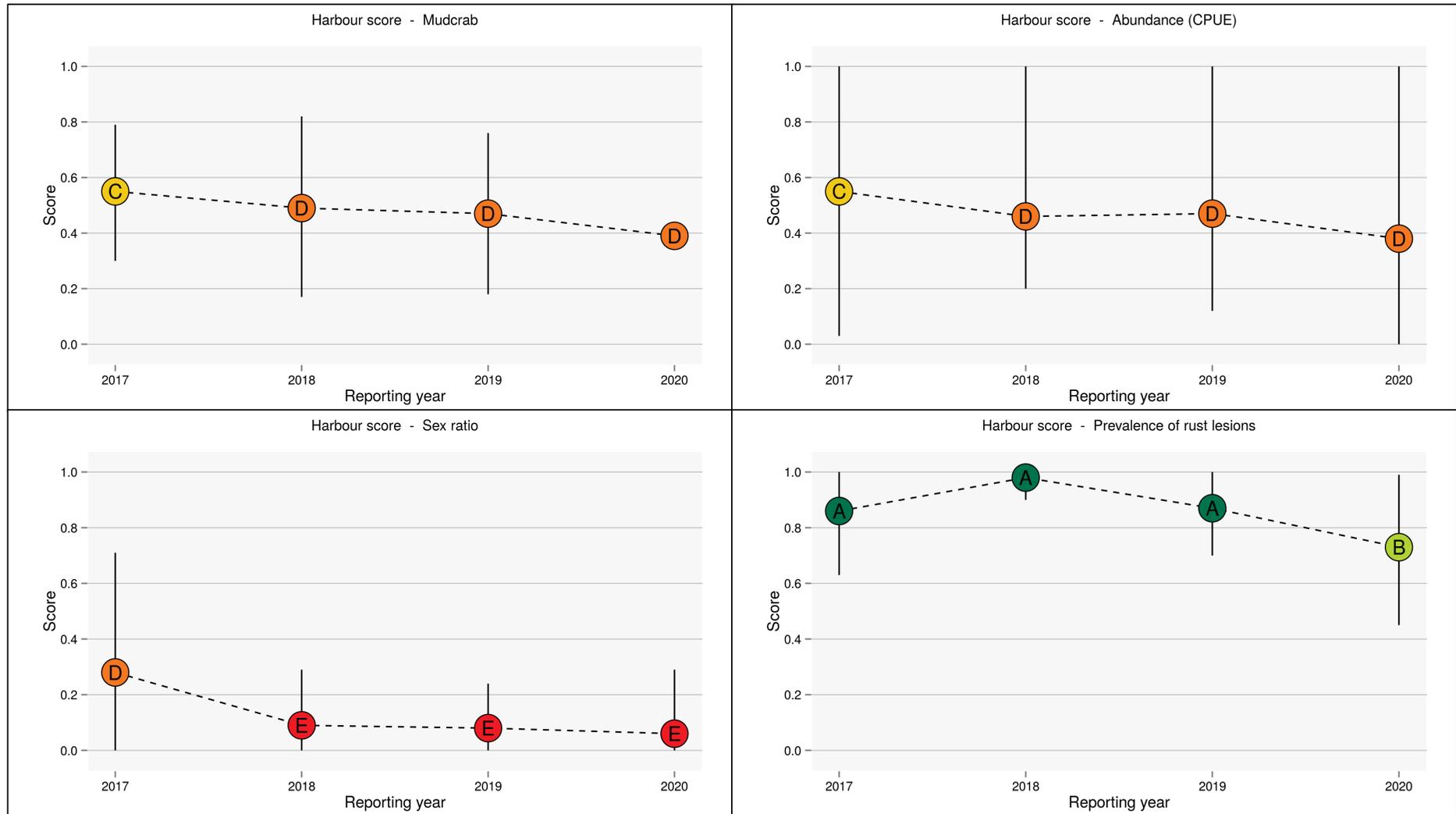
The mud crab indicator in the GHHP report card

The GHHP mud crab indicator is an example of a biological indicator where the condition of the resource reflects exposure to the cumulative effects of a range of pressures and conditions in their environment, which can result in a range of biological responses. Local pressures on mud crabs in Gladstone Harbour potentially include recreational and commercial fishing, coastal development affecting mangrove and estuary habitat quality, water quality, climate and local weather changes associated with global climate change. Community concern about the prevalence of fish and mud crab diseases in Gladstone Harbour following a flood event that occurred in 2012 (Wesche et al., 2013, Dennis et al., 2016), mean the prevalence of locally relevant disease is also an important consideration.

The GHHP mud crab indicator is composed of three measures, which were selected in 2017 through a rigorous scoring process against predefined selection criteria (Flint et al. 2017a). A literature review was first undertaken to assemble a list of potential measures suitable for a mud crab monitoring program. These included biomarkers of contamination, bioaccumulation of toxicants, sex ratio of adult crabs, abundance (catch per unit effort of adult and sub-adult crabs), nursery value (catch per unit effort of juvenile crabs in nursery habitats), prevalence of rust lesions, prevalence of other diseases and parasites, the relationship between carapace width and body weight of adult crabs, and morphometrics (such as claw size ratio). These potential measures were reviewed, compared and scored against a set of ten predefined selection criteria that were modified from criteria used in other relevant studies (Rainbow, 1995; Cooper et al., 2009; Flint et al., 2017b). The three selected measures include: abundance (CPUE), prevalence of rust lesions, and sex ratio.

An important criterion for the GHHP mud crab indicator was monitoring cost and complexity – this has been a consideration throughout the development and ongoing monitoring of the mud crab indicator. As such, technically-complex indicators, indicators that are very costly to monitor, or those requiring substantial additional research to allow them to be incorporated into the report card, were not considered practical. The GHHP mud crab indicator developed in 2017 is relatively simple to monitor in comparison to some other potential biological indicators that require laboratory analysis, and importantly it also has minimal impacts on the target species, local ecosystem or stakeholders, as sampling is non-lethal and uses a low-impact fishing method. As described in the CQUniversity reports to GHHP since 2017 (Flint et al., 2017a, 2018, 2019, 2020), there are some ongoing considerations relating to the continuous improvement of the GHHP mud crab indicator as new information becomes available. The overall grade results for each of the monitoring sites, sampled twice annually since 2017, are likely reflect a variety of pressures on mud crabs in Gladstone Harbour, including commercial fishing, recreational fishing and environmental/habitat condition. However natural biological variability also plays a role in catches of mud crabs, which is why a long-term view of the trends and patterns in scores and grades is warranted.

New research discussed at the workshop:

- Since the development of the indicator in 2017, new research has become available from Queensland's Gulf of Carpentaria (by Dr Julie Robins) and NSW (by Dr Matt Taylor). Both projects were supported by the Fisheries Research and Development Corporation. The NSW project is nearing the completion, and represents a 4-year, $700,000 research program (https://frdc.com.au/project/2017-006). Data gathered through these research projects, and

by NT Fisheries in their jurisdiction, can provide valuable insights relevant to the GHHP indicator.

- Fisheries Queensland (Dr Julie Robins) has been awarded a new, 4-year, $689,000 research program, also funded by FRDC, which is being conducted in collaboration with CQUni (Dr Nicole Flint) and NSW DPI (Dr Matt Taylor). This research program aims to provide knowledge to inform the assessment and management of Queensland's mud crabs. Gladstone Harbour is one of several key Queensland regions highlighted in the project, given the large proportion of catch coming from the region. Information on the research project is available here, including a link to a fact sheet: https://frdc.com.au/project/2019-062

- The new FRDC project will support new management arrangements coming in to place for the Queensland Mud Crab Fishery, including allocation of Individual Transferable Quota, a Total Allowable Catch, and some additional tagging and reporting requirements for commercial fishers (a fact sheet on the management changes is available here: https://www.daf.qld.gov.au/__data/assets/pdf_file/0008/1512296/factsheet-reg-changes-sep-2020.pdf)

Mud crab abundance:

- It was noted that measured abundance of mud crabs (as measured by catch-per-unit-effort) was generally low but variable in the harbour.
  It was noted that both recreational and commercial fisheries are continuing in the harbour although commercial catch has been lower in recent years.

- The catch of mud crabs in baited pots can vary in response to a range of natural and anthropogenic factors. Some of these, which have now been investigated more closely in Queenland's Gulf of Carpentaria (by Dr Julie Robins' recently complete FRDC project), include weather variations such as rainfall and temperature.

- Factors particularly relevant to Gladstone may include sequential years of drought and higher temperatures, variations in commercial fishing pressure as fisheries effort was transferred to and from other areas, and changes in recreational fishing activity.

- While catch rates in baited pots are limited by crab abundance, they can also at times reflect a change in 'catchability' of either all crabs, or certain sized crabs. It is recognised that catch in some areas is more variable than others – for instance catch in the NT and the Gulf of Carpentaria is much more variable than in Hinchinbrook Channel on the Queensland east coast. With the five years of data now available from Gladstone Harbour, local variability could be more closely considered and compared to a range of factors, including rainfall patterns.

- Measures of abundance has some limitations in short-term datasets, as a wide range of natural and anthropogenic factors can potentially influence both the local abundance of mud crabs (the carrying capacity) and the catchability of crabs. Discrepancies in abundance can be caused by capture technique, sampling areas and sampling times, or by differences in crab distribution, growth or survival induced by habitat and environmental conditions (see also Alberts-Hubatsch et al., 2016).

- In the GHHP mud crab monitoring program, possible variations due to seasonality, tidal cycle, catch and sampling techniques are controlled to the greatest possible extent by accounting for these factors when scheduling field work. When these factors are controlled, abundance can be better related to pressures such as extraction (fishing) and recruitment limitation.

- To account for the natural variability in mud crab populations for the GHHP assessment, a ten-year moving average benchmark was applied for this measure, beginning in 2018.
- As recruitment of juvenile mud crabs in Gladstone Harbour is not monitored, the relationship between recruitment and adult abundance is not well understood. The NSW DPI project attempted to monitor juvenile mud crabs but encountered difficulties. NSW DPI have developed a larval recruitment model working forwards from larval catches and backwards from known female spawning locations.
- Another thought to consider, is whether 'abundance' is the best name for the standardised, independent monitoring of mud crab CPUE, or whether a name change would avoid confusion.

Sex ratios in fished mud crab populations:

- Queensland has a different management system to NSW and NT; whereas Qld does not allow females to be harvested, NSW and NT use season closures to maintain the fisheries.
- The sex ratio measure, based on crabs over the legal size limit of 150mm carapace width, reflects a high participation sex-biased fishery in Gladstone Harbour (the fewer that legal-sized males are caught relative to females, the greater the fishing pressure). The indicator thus provides information on fishing pressure.
- There were questions raised about the potential biological or ecological effects of a female-biased population, in a species which is male-biased in unfished populations. It is unknown whether changes in sex ratios may affect how mud crab population dynamics function, including in terms of key life-history stages such as reproduction and recruitment.
- Male and female mud crabs have different behaviours – only male mud crabs dig long burrows; and only female mud crabs migrate offshore to spawn (although not all female mud crabs do this). Both behaviours serve ecological functions in coastal environments, the implications of which are not yet well understood. It is unclear whether these different behaviours impact on the sampling results.
- The unfished sex ratio of 2 males per female from other unpublished studies in south-east Queensland/northern New South Wales was confirmed by CQUni team in sampling an unfished site in central Queensland (Eurimbula Creek) (with additional funding from GHHP) in 2018-19 (Flint et al. 2019). The results from Eurimbula correspond with those from marine reserves in south east Queensland and northern NSW.
- During the workshop, the sex ratio of mud crabs below the legal size limit of 150mm was discussed as a possible area for future investigation. This was first investigated by the CQUni team during the development of the indicator in 2017, and fewer females were caught under that size, possibly reflecting a larger catchable size for females than males. The catch of smaller females were so low that it posed difficulties for indicator scoring. This could now be re-analysed with the larger (five-year) dataset, to check for trends.

Rust lesions:

- Rust shell lesions are a periodically recurring issue in Gladstone Harbour (Andersen and Norton, 2001; Andersen, 2003; Wesche et al., 2013; Dennis et al., 2016). While lesions are not infectious and mud crabs with rust lesions are still suitable for human consumption, shell perforations and lesions can be unsightly, and generate concern amongst fishers and the community. Rust shell lesions do not only occur in Gladstone but have at times been reported at higher prevalence here than in other regions.

- After the 2011-12 flood event, prevalence of up to 37% was reported in the harbour (Dennis et al. 2016). Since GHHP monitoring has begun in 2017, much lower levels of incidence have been recorded.
- The cause is likely to be related to inhibition of calcium update following exposure to some metals, possibly copper and zinc, although this has not been experimentally confirmed (Andersen et al., 2000; Andersen and Norton, 2001). However, the exact reasons for changes in prevalence of rust shell lesions in Gladstone (and elsewhere) has never been definitively explained. This represents a knowledge gap that should ideally be addressed.
- As also noted by experts during the meeting, it is important to continue to monitor rust shell lesions in Gladstone, given the high prevalence that has been reported from the region at various times. Monitoring during non-event periods provides valuable baseline data and provides assurance to the report card's audience (managers and the community) that rust shell lesions are usually at low prevalence in the harbour.
- In future, as more data are collected, the measure could potentially be revised to incorporate lesion severity based on lesion size and whether the shell has been perforated (*sensu* Andersen, 2003).

General comments:

- It was noted that GHHP has a robust monitoring program. Previously, Qld Fisheries did sample annually but this was discontinued (likely because of funding constraints). Maintaining a monitoring program in Queensland is valuable to a number of stakeholders.
- The mud crab experts agreed that seasonal sampling (twice a year) should continue. They noted that ideally, sampling would occur more frequently (e.g., monthly as has occurred in NSW), however it is recognised this would add substantial cost to GHHP's program.
- With five years of data available from Gladstone Harbour by June 2021, additional statistical analyses could be undertaken, investigating not only patterns in the indicator measures as described above, but in other variables that are monitored (e.g., the sex ratio of smaller mud crabs and variability in abundance in relation to weather variables).
- When NSW DPI releases their final report to FRDC, the findings of these could be considered in relation to the GHHP mud crab indicator.
- Links to the new Queensland FRDC project should be maintained to maximise the benefits to Gladstone Harbour. This project is being run by Fisheries Queensland, CQUni and NSW DPI.
- There are a range of research gaps remaining about female mud crab biology and ecology. A CQUni PhD student has commenced research on this topic, and some information may be gathered through the FRDC project.
- After the new management changes come into place in the Queensland Mud Crab Fishery later in 2021, commercial fisheries data may be more detailed, providing a potential source of free data. The issue with this data source is that it is biased towards retained catch (i.e., large males) so doesn't provide information on the whole mud crab population. Nevertheless, commercial fishers set far more pots each year than is achievable for an independent monitoring program, and this data could provide a valuable addition or cross reference.
- It would be very helpful to have a better understanding of the movement of adult crabs and their habitat use, as has now occurred in NSW. Some preliminary data may be collected through the new FRDC project led by Fisheries Queensland, but additional funding could support the deployment of acoustic or satellite tags onto adult crabs.

Implications for the GHHP report card

The key outcomes of the workshop relevant to GHHP were as follows:

- The workshop provided a validation of the three indicators that GHHP has selected to monitor mudcrabs: Abundance, Sex ratio and Incidence of rust lesions.
- The workshop identified the long-term value of the monitoring done by GHHP, given that it is a systematic annual program whereas other research programs tend to shorter once-off programs.
- The workshop identified new research findings on mudcrabs relevant to GHHP, including information about the seasonal mobility of female crabs and the dispersal of juveniles.
- The workshop identified other research programs that may be relevant to the GHHP monitoring program.

Priority areas for future data collection and research

Potential areas of future research were noted, for the information of the various agencies and research institutions involved.

- Understanding the life history stages of mud crabs (spawning, larval dispersal, recruitment)
- Understanding the biology and ecology of adult mud crabs (e.g., does a female-dominated sex ratio impact mud crab population dynamics)
- Investigating how mud crabs respond to changed environmental conditions, both natural and anthropogenic
- How mud crabs will respond to a changing climate/environment

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