Pilot survey of deep-water seagrasses using the Great Reef Census framework

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Chartrand KM and Scott A

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Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER)

James Cook University

Email : Katie.Chartrand@jcu.edu.au

Phone : (07) 4232 2027

Web : www.jcu.edu.au/tropwater/

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EXECUTIVE SUMMARY

A pilot study was established in 2021 to test the effectiveness of using the Great Reef Census (GRC) to collect broadscale survey data on deep-water marine macrophytes (seagrass and algae) and associated inter-reef habitats of the Great Barrier Reef World Heritage Area (GBRWHA).

This report presents survey results from the 2021 field campaign and includes a review of how this approach can be used in future to effectively update 20-30 year old datasets and validate predictive models on seagrass distribution in the inter-reef lagoon.

Overall, results provide a snapshot of deep-water seagrass and *Halimeda* algal bed distribution where GRC expeditions targeted more remote and logistically challenging regions of the GBR: Far North, Ribbon Reefs and Swain Reefs.

We were able to deploy and record footage with the necessary camera equipment and methodology using three different vessel types and the personnel/participants on board: 1) the game fishing vessel *MV Allure* (Ribbon Reefs), 2) the superyacht *MV Aroona* (Far North), and 3) the long-range multi-purpose charter vessel *MV Eastern Voyager* (Swains). The opportunity provided the opportunity to educate participants in the importance of seagrasses and inter-reef habitat communities and was met with strong enthusiasm and desire to continue these efforts into the future.

Inter-reef habitats >20m were surveyed using live and recorded CCTV camera systems to verify benthic macrophyte presence. Survey results are compared against probability models of seagrass presence.

Geographic Information System(GIS) layers and associated metadata on seagrass and algae site information are available to inform research analysis and management advice. This resource will be incorporated into future iterations of the e-Atlas seagrass synthesis layers and available on request from TropWATER.

Trial seagrass survey technique across at least 3 geographic areas along the length of the Great Barrier Reef with three different types of operations and participants (e.g. tourism operator, commercial operator, Traditional Owner ranger vessel) to allow for understanding of logistical operations

In addition to deepwater survey trials, this project enabled the additional survey of greater than 315 reefs during GRC in 2021; far in excess of goals to add an additional 15 reefs as part of this pilot study's objectives.

1. INTRODUCTION

Seagrasses are one of the most productive marine habitats on earth and provide a variety of important ecosystem services with substantial economic value (Costanza et al. 2014; Barbier et al. 2011). These services include the provision of nursery habitat for economically important fish and crustaceans (Heck et al. 2003; Coles et al. 1993), and food for grazing marine megaherbivores like dugongs and sea turtles (Scott et al. 2018; Heck et al. 2008). Seagrasses also play a major role in the cycling of nutrients (McMahon and Walker 1998), sequestration of carbon (York et al. 2018; Lavery et al. 2013; Fourqurean et al. 2012), stabilisation of sediments (James et al. 2019), and the improvement of water quality (McGlathery et al. 2007).

Globally, seagrasses have been declining due to natural and anthropogenic causes (Dunic et al. 2021; Waycott et al. 2009). Explanations for seagrass decline include natural disturbances such as storms, disease and overgrazing by herbivores, as well as anthropogenic stresses including direct disturbance from coastal development, dredging and trawling, coupled with indirect effects through changes in water quality due to sedimentation, pollution and eutrophication (Short and Wyllie-Echeverria 1996). In the Great Barrier Reef (GBR) coastal region, multiple threats accumulate including urban, port, industrial and agricultural runoff (Grech et al. 2011). In Queensland this has been recognised and a strategic monitoring program of these high risk areas has been established to aid in their management (Coles et al. 2015).

The vast majority of seagrass species are located in relatively shallow water habitats with favourable hydrodynamics and sediment chemistry and where light is adequate to meet gross energy requirements (Koch 2001; Hemminga and Duarte 2000). In the Great Barrier Reef World Heritage Area (GBRWHA), research and monitoring programs have detailed the distribution, seasonality, drivers, risks and threats to these specialised plant communities (Chartrand et al. 2016; McKenna et al. 2015; Collier et al. 2012; Grech et al. 2011). However, information on deep-water tropical seagrass communities — generally classified as growing at depths >10-15 m — is limited (Chartrand 2021; York et al. 2015). These deeper meadows are primarily composed of species from the genus *Halophila* (Hydrocharitaceae) and within the GBRWHA have been mapped down to 60 m and modelled to cover over 40,000 km^2 of the seafloor (Coles et al. 2009).

Deep-water seagrasses (>10m) within the Great Barrier Reef World Heritage Area were first surveyed and mapped at broad spatial scales by James Cook University's Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER) Seagrass Group (formerly part of Queensland Department of Agriculture and Fisheries) from 1994-1999 (Coles et al. 2009). Further opportunistic, broadscale survey data on seagrass presence/absence was collected during CSIRO Seabed biodiversity surveys from 2003-2006 and collated with all existing data available within the GBRWHA by Carter et al. (2016) as part of a synthesis effort under the National Environmental Science Programme's Tropical Water Quality Hub.

The first detailed studies by TropWATER (previously as Fisheries Qld) from 2011 – 2016 aimed to contribute critical information on the growth strategies that drive spatial and seasonal dynamics of tropical deepwater *Halophila* spp. communities in the Great Barrier

Reef lagoon (Chartrand 2021). This includes determining the relationships between environmental conditions (namely light and temperature), and seagrass abundance, productivity and reproductive effort in a range of deep-water seagrass community types to address critical information gaps and to provide management advice to protect these populations at risk from anthropogenic activities.

The growing recognition of the value and importance of deepwater seagrasses has also led to the acknowledgement that deepwater seagrasses have been underrepresented as part of existing monitoring programs despite their value as an important ecological resource that contributes to sustaining the processes and values of the Reef (Udy et al. 2019). The Seagrass Expert Working Group for the Reef 2050 Integrated Monitoring and Reporting Program made clear recommendations for offshore deepwater seagrass meadows to be included in a future program sampling design. This inclusion is essential to report appropriately on progress towards Reef 2050 Plan targets, objectives or outcomes that aim to report "at the Reef-wide and regional scales".

The expert group recommended three key areas of seagrass monitoring needed to deliver on the Reef 2050 Plan objectives for the 12 identified types of seagrass communities within the GBRWHA: process monitoring, health assessment and habitat assessment. Reef-wide habitat assessment of seagrass presence is on-going for many parts of the estuarine and intertidal habitats through existing programs such as the Marine Monitoring Program and port-related monitoring within the GBRWHA. The most noticeable gap continues to be in subtidal and deep-water reef-wide habitat assessment for seagrasses since concerted efforts made in the 1990s (Coles et al. 2009). With over 25 years of additional coastal inputs from catchments and impacts of shifting ocean currents and temperature regimes linked to climate change there is a recognised need to re-visit these deeper seagrass communities.

The wide and sparse distribution of this deeper community type creates logistical and budgetary challenges that may be best overcome using a citizen science based program to infill clear data gaps. The Great Reef Census is a successfully trialled 21st century approach to collect valuable gaps in knowledge that complements existing monitoring efforts. It utilises a mass mobilisation of vessels and people to deliver large-scale data capabilities.

This report describes a pilot study designed to survey offshore inter-reef habitats using the Great Reef Census as a model to collect updated information on the spatial footprint of subtidal and deepwater seagrasses as well as other important inter-reef communities currently under-represented in existing monitoring programs. The NESP-funded project to collate existing data on seagrass communities and predict their broader spatial footprint provides the foundation from which survey trials were based. This work also aligns with RTP-funded and GRC partner organisation Science Under Sail looking at comparable shallow seagrass extent mapping to address this identified gap in seagrass systems.

2. METHODS

Three Great Reef Census expedition trips were selected to participate in trialling deep-water habitat surveys during from October to December 2021. Surveys during this period help to capture seagrasses at their likely seasonal peak in distribution and abundance, and to facilitate comparisons with the previous surveys conducted in the area. Expeditions were selected to cover three distinct survey regions of the GBRMP that are also areas logistically challenging to reach by most vessels and monitoring programs; Far North, Ribbon Reefs and Swain Reefs (Figure 1).

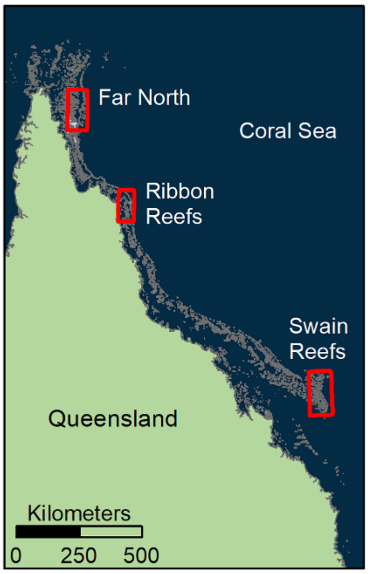

Figure 1. Deep-water habitat survey areas during Great Reef Census 2021 within the Great Barrier Reef Marine Park.

Deep-water sites were surveyed using a boat-based sled system with an underwater camera attached. At each site, the sled and camera are towed for approximately 100 m while footage is observed through a live feed on a monitor. The technique ensures that a large area of seafloor is surveyed and integrated at each site so that patchily distributed macrophytes and benthic life typically found in deep-water habitats is detected. The intent of this pilot study was to simplify the methodology from one where a towed net is typically attached to the sled to capture surface benthos to verify footage. The goal of these deep-water surveys was to create a practical and simple means to validate areas never surveyed or those not re-visited in a substantial length of time (>15 years).

Sites were randomly visited at depths >20m while traversing between reefs.

Habitat mapping and Geographic Information System

All survey data were entered into the Geographic Information System (GIS) using ArcGIS 10.8®. A GIS site layer was created to describe the spatial features of each site.

Site Layer: The site (point) layer contains data collected at each site, including:

- Site number
- Temporal details – survey date and time.
- Spatial details – latitude and longitude, depth below mean sea level (datum LAT; metres).
- Habitat information – sediment type; seagrass information including presence/absence, species observed; algae presence/absence and growth form.
- Fish and invertebrates observed during video surveys.
- Sampling vessel and any relevant comments.

SUMMARY AND DATA USAGE

A total of 47 habitat characterisation sites were surveyed from October to December 2021 across three vessel expeditions during the annual Great Reef Census (Figure 2). Seagrass was present at 49% of sites which were randomly distributed based on planned expedition itineraries rather than on a strategic sampling design or historic presence of seagrass presence.

Four species were observed on video footage (Figure 3), albeit not confirmed by sampling as is typically done using a sled net to confirm taxonomy to the species level. All seagrasses were from the genus *Halophila* with the majority of sitings being the most dominant species from deep-water habitats, *Halophila decipiens*. The deepest sites with recorded seagrass were found in the Swains sector at 53m and on the Ribbon reef east of Ribbon No. 8 at 52m.

Historically, Coles et al. (2009) found seagrass at 31.4% of the 1404 sites surveyed from 1994-1999. During GRC, seagrass was found on all three expeditions with the majority found during the Ribbon Reefs expedition (Figure 4). Seagrass presence alignment with probability models varied by region. In the Far North section, seagrass probability was very low and yet over 50% of surveyed sites had seagrass with one or two species co-occurring (Figure 4a). In the Ribbon Reefs, seagrass probability was high and widespread, which aligned with most of the observations except for three sites in which seagrass was not recorded where a high probability was predicted (Figure 4b). Seagrass was only found at one site and in a very small patch in the Swains which was supported by the probability distribution model in this region (Figure 4c). The Swains is known for incredibly high currents and tidal movement amongst the dense patch reef system which would lead to regular high shear stress on bottom sediments. Surveys were also carried out in December which is towards the end of the expected growing season for the most dominant deep-water seagrass *Halophila decipiens*. The timing of the surveys could therefore have under-estimated seagrass occurrence.

Significant stands of *Halimeda* beds known as ‘bioherms’ were also noted on video footage, particularly in the Ribbon Reef region and to a somewhat lesser extent at Far North survey sites (Figure 4). *Halimeda* algal bioherms occupy >6,000 km^2 of the inter-reef seabed predominantly in the Northern region of the GBR as estimated from the CSIRO biodiversity surveys in the early 2000s and recent analysis by McNeil et al. (2016). This estimated area is more than twice that of adjacent shallow coral reefs and with rich biodiversity of plant, vertebrate and invertebrate communities inhabiting these *Halimeda* bioherms (McNeil et al. 2021).

An indirect benefit of video footage capture has been the observational data of other macro-invertebrate and fish communities found in these inter-reef habitats. Sea cucumber monitoring was identified as one of 11 critical gaps prioritized for further investment under Reef Integrated Monitoring and Reporting Program (RIMReP). Our expedition trip to the Ribbon Reefs was able to support the first data collection trip for this parallel program. Footage of sea cucumbers was provided for machine learning and AI development to assess the population and demography of sea cucumbers on the GBR. Preliminary habitat maps from our pilot study were also requested by AIMS for the development of inter-reef fish monitoring programs prioritized as a critical gap through RIMReP.as they are the only up-to-date information available since the CSIRO surveys in the early 2000s.

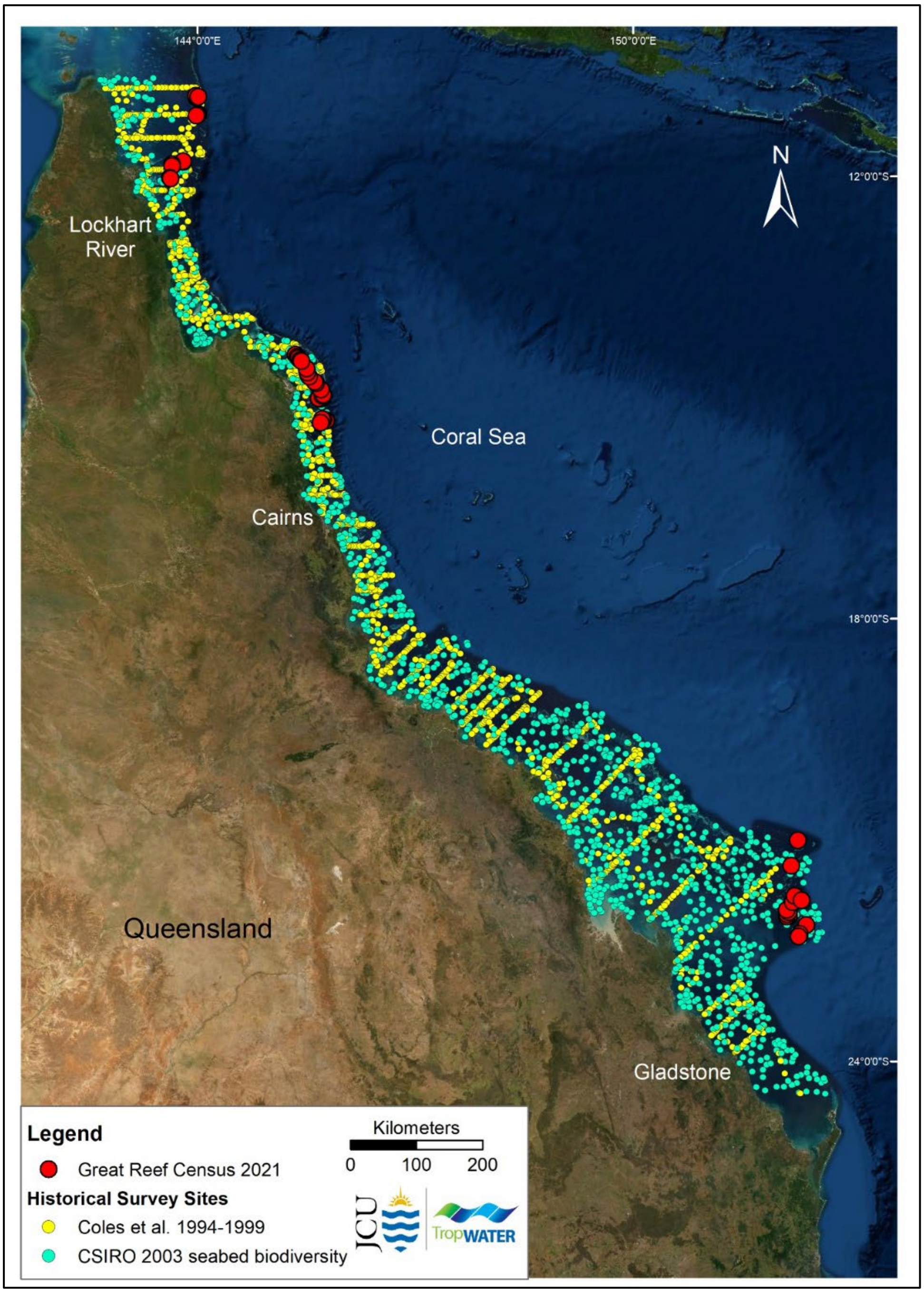

Figure 2. Seagrass presence/absence at inter-reef sites surveyed during the 2021 Great Reef Census pilot study.

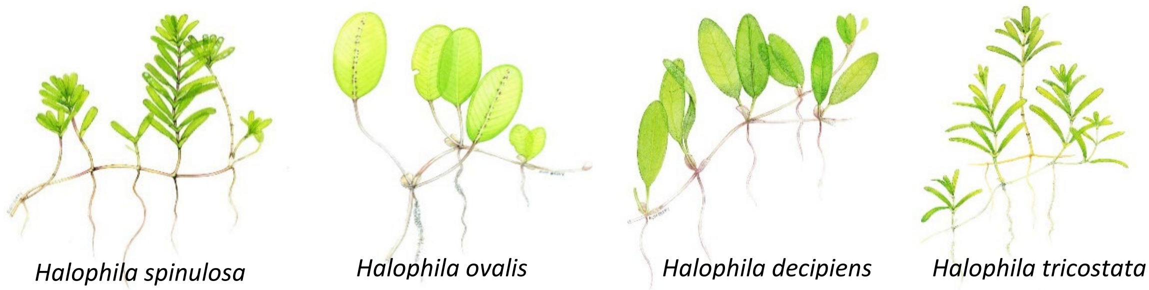

Figure 3. Seagrass species identified in video footage during the October – December 2021 surveys.

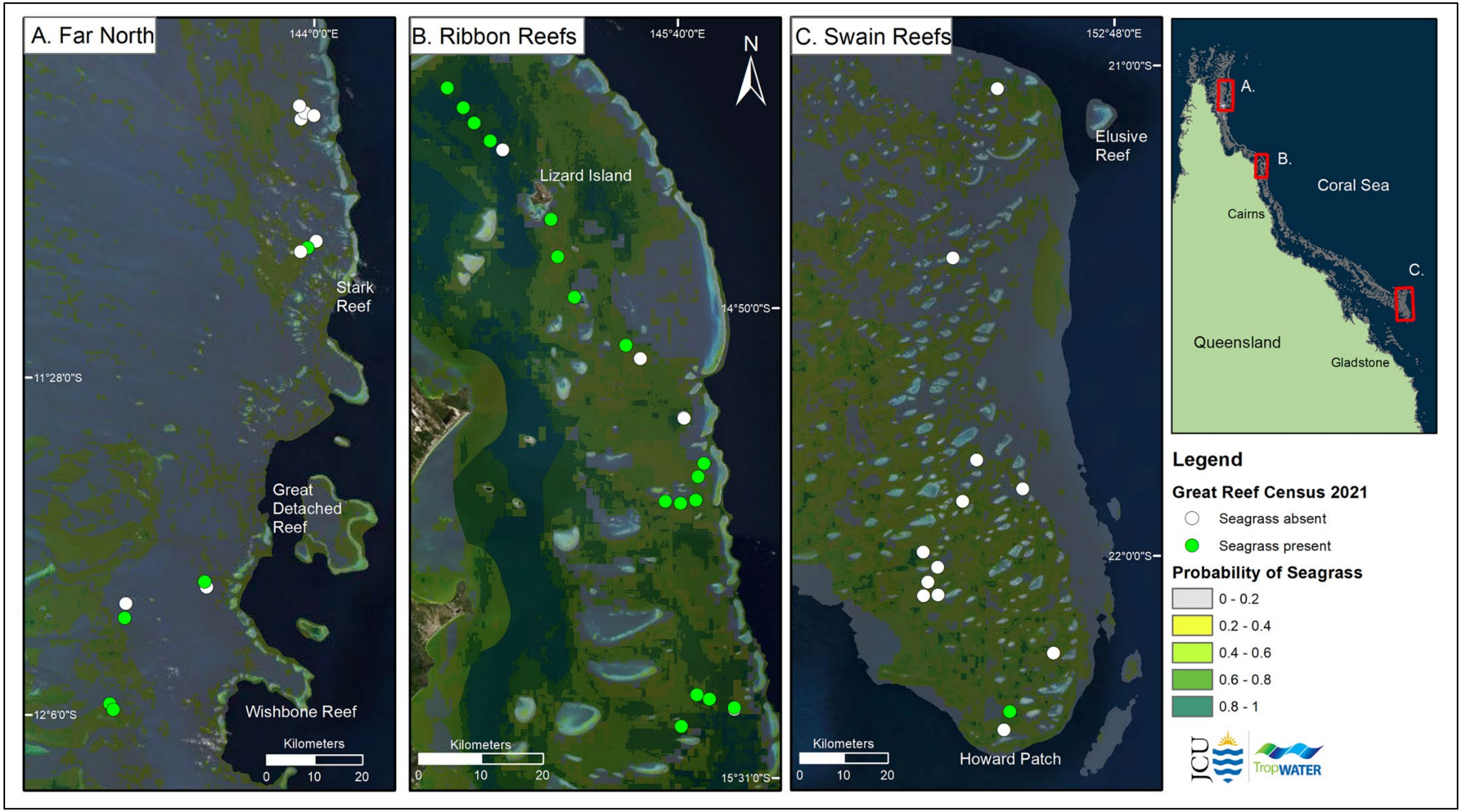

Figure 4. Seagrass presence/absence at sites surveyed in A. Far North, B. Ribbon Reefs and C. Swains Reefs

Figure 5. *Halimeda* presence/absence at sites surveyed in A. Far North, B. Ribbon Reefs and C. Swains Reefs

RECOMMENDATIONS AND CONCLUSION

The pilot study to survey inter-reef habitats using Great Reef Census vessel expeditions successfully generated a geo-referenced video library of inter-reef habitats and was used to generate pre-liminary seagrass and *Halimeda* maps as an example of the potential value future iterations of GRC. While we have excellent seagrass mapping and monitoring programs in the GBRWHA, subtidal and deepwater inter-reef habitats have been sorely underrepresented in existing monitoring programs. The demonstrated added value with extremely low budgetary impact using GRC highlights the value of citizen science more broadly in supplying the shortfalls and gaps needed to better manage at an ecosystem-wide scale whether for RIMReP or other Reef management needs. The scale at which footage is needed to ground-truth seagrass models is only possible by using the soft infrastructure operating system a program like GRC can provide.

This trial study also demonstrated the capacity for different vessel operators and participants to support inter-reef habitat surveys using this technique during GRC. The three different vessel types and the personnel/participants all found the experience rewarding and educational in expanding their knowledge on seagrasses and inter-reef habitat communities. All participants were amazed and enthusiastic about the findings and had a strong desire to expand our efforts beyond the sites we targeted and with further hope for opportunities to support this component of GRC in years to come.

The capability to operate and record deepwater habitats using the towed camera system is important when considering whether such data can be collected through a citizen science based program like GRC. The minimum vessel requirements includes a capable deckhand to man the cable system and hauling as well as deck space and power supply necessary to capture video footage using the towed camera. There is still a need for a trained operator to run the required GIS and camera recording software. The skillset requires a basic level of training and achievable within the core Census team or other trainable Census trip leaders such as master reef guides or undergraduate level marine biologists. Cost per towed camera system, at approximately $8,000, is another limiting factor at this point in time with a single system including a 100m cable and laptop on board the vessel. Such costs limits the ability to upscale the number of systems in use at a given time. In the near future, equipment will likely become simplified and streamlined with lower costs to support multiple camera system units deployed on parallel Census expedition trips.

In addition to deepwater survey trials, this project enabled the additional survey of greater than 315 reefs during GRC in 2021; far in excess of goals to add an additional 15 reefs as part of this pilot study's objectives.

In summary, this pilot study demonstrated the low cost and high benefit with which GRC could continue to target inter-reef habitat surveys to update outdated maps and data that are key tools for researchers and managers as efforts grow to improve monitoring and resilience-based management at broad-scale. The results also supported parallel programs being developed to fill critical gaps in RIMReP for sea cucumber and fish monitoring demonstrating the value GRC delivers beyond its targeted scope.

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