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Incorporating dugong habitats into the marine protected area design for the Great Barrier Reef Marine Park, Queensland, Australia

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Abstract

Dugong habitats were considered in the design for the new zoning network for the Great Barrier Reef Marine Park as part of the Representative Areas Program. One of the specific design guidelines developed as part of the biophysical operational principles recommended that 50% of all high priority dugong habitats should be incorporated in the network of no-take areas. The high priority dugong habitat incorporated in no-take protection increased from 1396 to 3476 km^2 (or 16.9–42.0% of all identified sites). Although this increase in protection fell short of the recommended 50%, overall the level of protection afforded by the *Great Barrier Reef Marine Park Zoning Plan 2003* increased for all the locations identified.

1. Introduction

Dugongs (*Dugong dugon* or sea cows) were highlighted in the World Heritage nomination for the Great Barrier Reef [1]. The Great Barrier Reef Marine Park (Marine Park) is one of the world's largest marine protected areas (344,400 km^2) and contains globally important populations of dugongs [2] with an estimated population size of about 14,000 dugongs [3,4]. Despite this population size, there is a need to continue to address impacts [2] on dugongs for a number of reasons, particularly as there is good evidence that dugong numbers are now substantially less than in the 1960s along the urban coast of Queensland, south of Cooktown [5,6].

Although there is considerable controversy about the effectiveness of using high profile species as a basis for designing protected areas (e.g. see Refs. [7–10]), marine megafauna are being used increasingly in the justification for

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and design of marine protected areas around the world [11–13]. In accordance with the accepted best practice, the Australian Federal Government's Representative Areas Program, developed and implemented by the Great Barrier Reef Marine Park Authority (GBRMPA), aimed to protect the Great Barrier Reef's biodiversity through protecting 'representative' examples of all the different habitats and communities in the Marine Park [14]. Nonetheless, because of the importance of the dugong to the region's World Heritage values [1], dugong habitats (e.g. seagrass habitats, locations where past research has indicated significant numbers of dugongs on a regular basis) were specifically included in the identification process for a new network of no-take areas (see Ref. [15] for a description of this process). The Representative Areas Program involved zoning the entire Marine Park and provided an opportunity to develop a consistent reef-wide framework for managing human use of the area. The aim of this paper is to describe how incorporating dugong habitat into the network of no-take areas helped achieve the aims of the Representative Areas Program as explained by Day et al. [16] and Fernandes et al. [14].

The *Great Barrier Reef Marine Park Zoning Plan 2003* is the overarching management tool used to manage human use and conserve areas of the Marine Park. The Zoning Plan divides the Marine Park into eight zones, providing for increasing levels of protection and various types of human use. Specific activities that may be undertaken in a zone with or without a permit are specified in the 'use and entry' provisions for each zone in the Zoning Plan. All other activities are prohibited. Listed below are examples of the types of use and entry provisions relevant to dugongs in relation to the eight zones:

- General Use – trawling and large mesh gill netting allowed.
- Habitat Protection – trawling prohibited, large mesh gill netting allowed.
- Conservation Park – large mesh gill netting prohibited; limited fishing and collecting allowed.
- Buffer – fishing limited to trolling for pelagics only.
- Scientific Research – all extractive use prohibited without the GBRMPA's permission except some types of Scientific Research.
- Marine National Park – all extractive use prohibited without the GBRMPA's permission.
- Preservation – most access prohibited without the GBRMPA's permission.
- Commonwealth Islands – in the waters surrounding the islands, all extractive use prohibited without the GBRMPA's permission.

For the purposes of the Marine Park, no-take areas are those areas zoned as Marine National Park or Preservation. For more detailed information about the Zoning Plan, zone objectives and types of activities, refer to GBRMPA [17,18].

In general terms, the Marine Park extends seaward from mean low water along the mainland coast of Queensland from the tip of Cape York Peninsula south to Baffle Creek, just north of Bundaberg (Fig. 1); but excludes all Queensland owned islands in this region. Another Marine Park under Queensland (state) jurisdiction complements the Federal Marine Park through complementary zone objectives, use and entry provisions, and extends these arrangements from mean low water to high water.

2. Methods

The application of biophysical data in the 'Identification Phase' of the Representative Areas Program [15] was assisted by advice from an independent Scientific Steering Committee and other reef and non-reef experts [14]. The Scientific Steering Committee recommended 11 biophysical operational principles (see Ref. [14] for a description of these principles) to guide the establishment of a new network of no-take areas that would achieve the objectives of the Representative Areas Program.

One of the biophysical operational principles was '*to represent a minimum amount of each community type and physical environment type in the overall network*'. This principle was developed to ensure that all known communities and habitats that exist within bioregions are included in the network of no-take areas. Specific communities and habitats were identified under this principle for protection in the no-take areas based upon the reliability and comprehensiveness of available data. For dugong habitats, the Scientific Steering Committee recommended to the GBRMPA that as a minimum, no-take areas should represent identified dugong habitat summing to about 50% of all high priority dugong habitats.

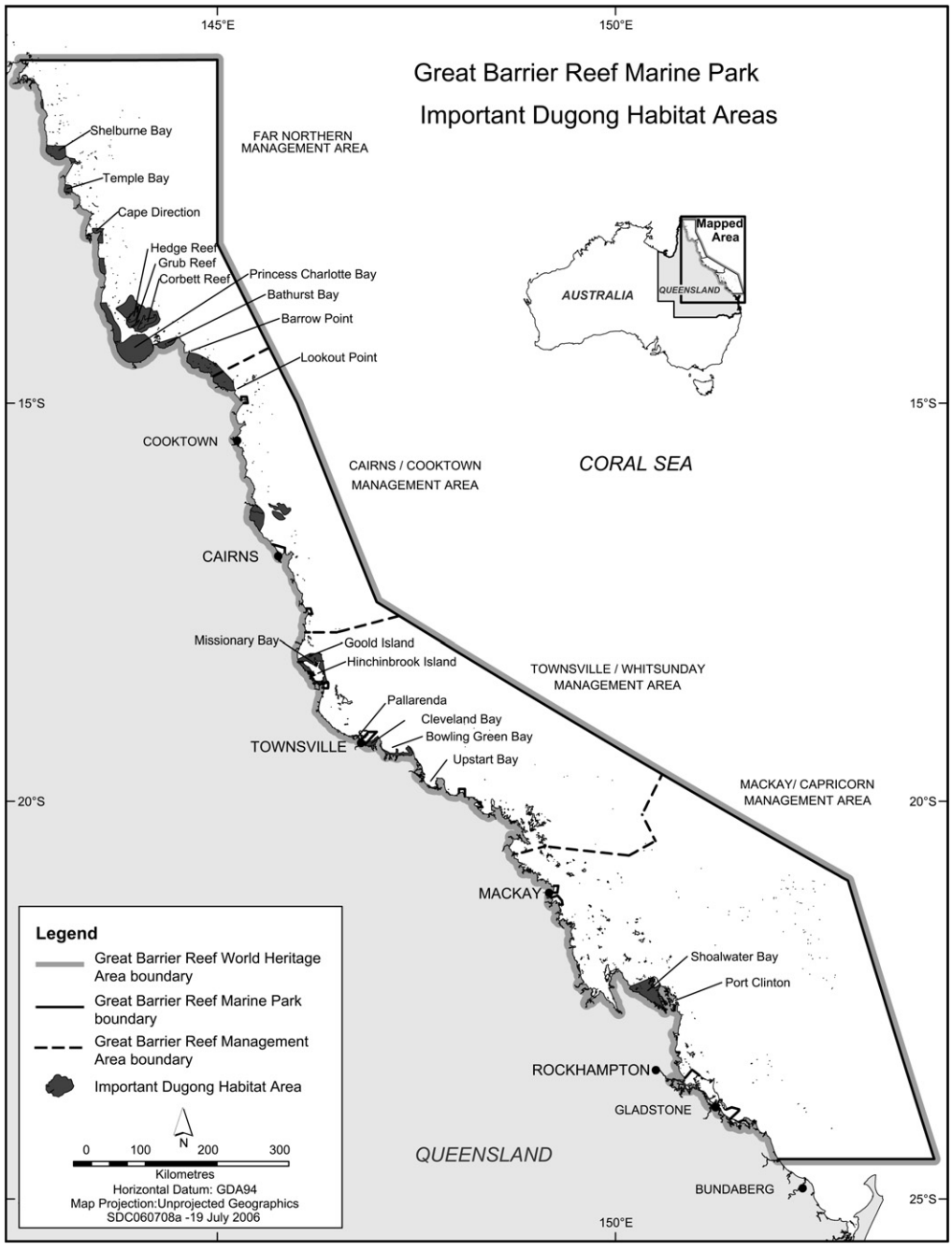

Fig. 1. Important dugong habitats in the Great Barrier Reef World Heritage identified for the Representative Areas Program.

Scientific experts on dugongs and dugong habitats identified 31 sites that are important for dugongs (Fig. 1). In addition, they made specific recommendations with respect to 6 of the 31 locations (Table 1) to further guide implementation of the principle. Important dugong habitat was identified based on information from aerial surveys [3,4] and seagrass surveys [19–22]. These studies indicated parts of the Marine Park where dugongs could be regularly found or identified habitats where dugongs could be expected to be found. For example, results of four aerial surveys (1985, 1990, 1995, 2000) conducted north of Cooktown highlighted that between 25% and 56% of the dugongs in the region were recorded regularly in Princess Charlotte Bay and Bathurst Bay [4,23–25]. Thus, these bays were 2 of the 31 locations identified as important for dugongs in the Marine Park.

Table 1
Site-specific recommendations for six dugong habitats in the Great Barrier Reef

Dugong site	Pre-Representative Areas Program	Post-Representative Areas Program
Hinchinbrook area	Conservation Park Zone with speed restrictions would be a good outcome for this area. A Marine National Park Zone from headlands of Missionary Bay extending northerly to encapsulate Gould Island may reduce traffic	Conservation Park Zoning achieved with no speed restrictions
Cleveland Bay	Conservation Park Zone with speed restrictions. Priority is the area around Cape Pallarenda. Reduction of traffic and protection of seagrasses are important but the local banana prawn industry should be considered. Shallow areas < 3 m with seagrass are the priority	Zoning achieved with no speed restrictions
Bowling Green Bay	Conservation Park Zone with speed restrictions. The southeastern portion of Bowling Green Bay was the priority	Zoning achieved with no speed restrictions
Upstart Bay	Conservation Park Zone with speed restrictions	Zoning partially achieved
Shoalwater Bay	Marine National Park Zone	Achieved
Port Clinton	Marine National Park Zone	Outside the Marine Park

3. Results

The total area of dugong habitat identified for the Representative Areas Program was 8278 km^2. Greater than 40% of this habitat was incorporated into no-take areas under the new network, which represents more than double the original amount in no-take areas (Table 2).

Overall there was a general reduction in the amount of dugong habitat contained in less protected zones (e.g. General Use) and more in protective zoning (e.g. Habitat Protection or Conservation Park) which prohibits trawling and/or large mesh gill netting. Although these zones allowed limited fishing or collecting, it is important to remember that these zones still offer a level of protection against activities considered harmful to dugongs and/or their habitats.

Four important dugong habitats (Cape Direction; Lookout Point to Barrow Point; Shelburne Bay; Temple Bay) had 50% or more of their areas in no-take zones under the previous zoning arrangements. Under the *Great Barrier Reef Marine Park Zoning Plan 2003*, two additional sites had 50% or more in no-take zones (Hedge, Grubb and Corbett reefs; Shoalwater Bay).

The specific zoning recommendations made about the six key habitats were achieved ($n = 4$) or partially achieved ($n = 1$) for five of the six sites (Table 1). The sixth site, Port Clinton, is located outside the Marine Park; however, the GBRMPA did achieve the recommended Marine National Park zoning on the headlands surrounding the entrance to Port Clinton.

4. Discussion

The ability to set specific guidelines for dugong habitats was the result of the significant amount of research and monitoring of this species and its habitats that had occurred in the Great Barrier Reef World Heritage Area over the

Table 2
Comparison of zoning for important dugong habitats within the Great Barrier Reef Marine Park before and after the Representative Areas Program

Zoning	Pre-Representative Areas Program		Post-Representative Areas Program	
	Percentage	Area (km^2)	Percentage	Area (km^2)
Unzoned	6.2	512.9	0	0
General Use	40.2	3329.5	23.9	1975.7
Habitat Protection	23.9	1979.5	20.3	1679.7
Conservation Park	11.5	954.8	13.8	1145
Buffer	1.3	104.3	0	0
Scientific Research	0.011	0.9	0.013	1.1
Marine National Park	15	1241.8	40.2	3326.3
Preservation	1.9	154	1.8	150.1

past 25 years (summarised in Refs. [2,5,6,26]). This information allowed the most important dugong habitats to be specifically identified and incorporated into the new network of no-take areas. Similar research and monitoring information has been used as the basis for recommendations for dugong conservation in eastern Indonesia [27].

The Representative Areas Program achieved many of the recommended biophysical operational principles [14]. For example, all 70 bioregions (biophysically distinct habitats) achieved a minimum of 20% in the no-take zones. Overall, no-take protection across the Marine Park was increased from 4.5% to almost 33.5%. The Representative Areas Program also minimised impacts on other users where possible, which meant that the recommended protection of significant dugong habitats to a minimum of 50% in no-take areas was achieved in some areas but not in others.

Some of the dugong habitats identified for the Representative Areas Program were also identified as no-take areas for other reasons. For example, the important dugong habitat of Hedge, Grub and Corbett reefs in the northern Marine Park was also partially identified as important for foraging hawksbill and northern Great Barrier Reef green turtles [28]. Corbett Reef and Hedge Reef were identified as areas that were special or unique because of physical or biological natural attributes (Dobbs, unpublished data). The zoning of the dugong habitat in the Hedge, Grub and Corbett reefs further implemented the principle developed for the Representative Areas Program, specifically that no-take areas should represent 20% of the identified priority marine turtle foraging sites [28].

There were no specific recommendations made as part of the Representative Areas Program to account for the movement corridors that may be used by dugongs in the Marine Park because there are no known specific migratory pathways. Aerial surveys and satellite tracking of dugongs have shown that their movements occur at both local and large spatial scales [6,26]. The drivers of such movements are not fully understood but are believed to result from changes in seagrass habitats and forage quality from events such as cyclones, floods and outbreaks of toxic algae such as *Lyngbya* species [6,29–31]. There is also considerable individual variation in dugong movement patterns, with the home ranges of tracked individuals varying from 1.6 to 127.9 km^2 [26,32–34] while the movements of at least one dugong spanned some 800 km of the Queensland coast [35].

The declaration of no-take areas is not the only management tool that will contribute to the conservation of dugongs or that is required for population recovery, especially along the urban coast adjacent to the Marine Park. Dugong conservation in the Marine Park is achieved through managing a range of human activities that impact on dugongs, including both current activities and predicted future activities. Other protection measures that came into effect through the *Great Barrier Reef Marine Park Zoning Plan 2003* and which should benefit dugongs and their habitats include the following.

- Incorporating a Remote Natural Area as part of the Far Northern Management area of the Marine Park. This means that works involving dumping spoil, reclamation, beach protection works, harbour works, and constructing or operating a structure other than a vessel, mooring or a navigational aid are prohibited in this part of the Marine Park.
- Categorising dugongs as 'Protected Species', which means that the written permission of the GBRMPA is required to take an animal of this species from the Marine Park. This has led to the development of a reef-wide *Policy on managing the direct take of Protected Species from the Marine Park*.
- Controlling or preventing activities through zoning such as dredging, aquaculture, and other activities that may affect benthic seagrass communities.
- Establishing additional large mesh netting restrictions in Princess Charlotte Bay by the declaration of a Special Management Area.
- Reinforcing management arrangements under the Queensland *Fisheries Regulations 1995* for Dugong Protection Areas.

In addition, after the *Great Barrier Reef Marine Park Zoning Plan 2003* [17] came into effect on 1 July 2004, the Queensland Government adopted complementary zoning arrangements for the Great Barrier Reef (Coast) Marine Park, effectively extending the Marine Park zoning to the high water mark along the Queensland coast and islands.

A more in-depth analysis of human-related mortality factors (e.g. large mesh gill netting and trawling, water quality, Indigenous harvest and boat strike) that impact dugong populations within the Great Barrier Reef World Heritage Area indicates that approximately 96% of the high conservation value dugong habitats are at low risk from key anthropogenic impacts as a combined result of the new network of no-take areas and other management arrangements that have been put in place [36]. Since the mid-1980s, aerial surveys of dugong distribution and abundance have monitored the species conservation outcomes of various dugong management initiatives. The surveys suggest that dugong

numbers are now stable at the scale of the entire urban coast of Queensland, although populations fluctuate at the level of individual bays, probably largely due to changes in seagrass habitats [6]. Nonetheless, population numbers are still far below those in the early 1960s, and Marsh et al. [5,6] caution that human-related mortality of dugongs along the urban coast of Queensland, south of Cooktown, should be managed to be as close as possible to zero.

Collectively, all these actions should make dugong conservation in the region more effective. However, there is a need to continue to address other activities that impact on dugongs and their habitats in the Marine Park. The GBRMPA is working with the Queensland Government to improve water quality to increase the protection of inshore habitats and to promote ecologically sustainable fisheries practices, including reducing the risk of entanglement and death of dugongs in large mesh gill nets. The GBRMPA is also working in partnership with the tourism industry to promote responsible practices for dugong tourism and with Aboriginal and Torres Strait Islander Traditional Owners to ensure sustainable hunting of dugongs in the Marine Park [37].

The Representative Areas Program provided an opportunity to increase the resilience of the Great Barrier Reef to current and future activities that may impact upon the reef ecosystem and its associated habitats. The biological characteristics of dugongs,

- vulnerable not only to short-term or acute impacts, but also to cumulative or chronic impacts;
- mobile, so management efforts must be mounted at local, state, national, and international levels to ensure that they are protected throughout their ranges;
- trends in numbers can take many decades to detect,

are a challenge for management because it is extremely difficult to assess whether populations are stable, increasing, or declining and to assess the effectiveness of management strategies. The effectiveness of the latest strategies, such as the Representative Areas Program, cannot be disaggregated from the other management initiatives to conserve dugongs and may not be measurable for another 20 years if indicators such as population estimates from dugong aerial surveys are used. This is due to the difficulty of detecting trends in marine mammal populations [38]. However, as Marsh et al. [5,6] have pointed out, other information, such as that collected about live or dead stranded dugongs, may provide earlier indications of the effectiveness of the upgraded management initiatives resulting from the Representative Areas Program.

5. Conclusion

The use of high priority dugong habitat as an explicit design factor in developing the network of no-take areas for the Marine Park represented the value of including a charismatic species as an important consideration within a marine protected area planning context. Dugongs are an important component of the overall biodiversity of the Great Barrier Reef and represent a valid factor to consider in the Representative Areas Program. The success of using dugong habitats was achievable because of the significant amount of research on dugongs and their habitats that had occurred within the region over the last 20 years. However, management actions should not rely solely upon highly protected areas for conserving such species. Although the *Great Barrier Reef Marine Park Zoning Plan 2003* prohibits trawling and large mesh gill netting within a large portion of important dugong habitats, there is still a need to have these and other fisheries managed in an ecologically sustainable manner (including the traditional harvest of dugongs) and to further reduce the risks of entanglement of dugongs in large mesh gill nets. The range of human-related mortality factors directly and indirectly affecting dugongs must be considered and specific actions undertaken to minimise these impacts upon depleted populations.

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