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Indigenous participation in monitoring megafauna within the Reef 2050 Integrated Monitoring and Reporting Program:

Final report of the Indigenous Participation Team in the Megafauna Expert Group

Peter Bayliss and Mibu Fischer

CSIRO Oceans and Atmosphere, Queensland Bioscience Precinct (QBP), The University of Queensland, St Lucia, Brisbane, Australia 4072.

The Great Barrier Reef Marine Park Authority acknowledges the continuing sea country management and custodianship of the Great Barrier Reef by Aboriginal and Torres Strait Islander Traditional Owners whose rich cultures, heritage values, enduring connections and shared efforts protect the Reef for future generations.

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Great Barrier Reef Marine Park Authority
280 Flinders Street Townsville | PO Box 1379 Townsville QLD 4810
Phone: (07) 4750 0700
Fax: 07 4772 6093
Email: info@gbrmpa.gov.au
www.gbrmpa.gov.au

Shortened Forms

CSIRO	Commonwealth Scientific and Industrial Research Organisation
DPSIR	Drivers, Pressures, States, Impacts, Responses framework
GAC	Girringun Aboriginal Corporation
GDC	Gidarjil Development Corporation
The Authority	The Great Barrier Reef Marine Park Authority
JCU	James Cook University
Megafauna	Large animal species (generally >45 kg body weight)
NAILSMA	North Australia Indigenous Land and Sea Management Alliance Pty Ltd
NESP	National Environmental Science Program
QPWS	Queensland National Parks and Wildlife Service
Reef 2050 Plan	Reef 2050 Long-Term Sustainability Plan
RIMReP	Reef 2050 Integrated Monitoring and Reporting Program

Acknowledgments

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Executive Summary

This report summarises a desktop review and analysis of Indigenous participation in monitoring megafauna in the coastal waters of the Great Barrier Reef (the Reef), and contributes to the development of design recommendations that satisfy the objectives of the Reef 2050 Integrated Monitoring and Reporting Program (RIMReP). The review commences with an overview of Traditional Owner groups in the Reef that have strong cultural connections to megafauna, particularly sea turtles and dugongs, and highlights their aspiration to participate in RIMReP comprising an inseparable component of the *Reef 2050 Long-Term Sustainability Plan* (Reef 2050 Plan). About 20 per cent (9/44) of Traditional Owner groups in the Reef were identified as participating in megafauna monitoring activities, mostly through ranger programs. However, apart from detailed reports of dolphin and dugong boat surveys undertaken by James Cook University (JCU) in partnership with five north Queensland Traditional Owner groups, representing 11 per cent of Traditional Owner groups in the Reef, we found no other documentation. Hence, our assessment should be treated with caution given the limitations of using information collated only from a desktop review. Nevertheless, the apparent absence of broad participation in megafauna monitoring activities provides an opportunity to implement a coordinated and standardised approach throughout the Reef from the outset as reflected in our recommendations.

In general we recommend that the objectives and design of the participatory monitoring component of the RIMReP megafauna theme undertaken by Indigenous ranger groups address capacity building and training needs in the first instance for the following four interdependent activities identified in our desktop assessment as being critical: (i) undertaking systematic and standardised population-level surveys underpinned by a robust spatial and temporal sampling design; (ii) adopting standard protocols for data management and storage; (iii) accessing scientific expertise through research partnerships to analyse and evaluate monitoring data; and (iv) effective reporting and communication of results at local, regional and national levels.

Specifically we recommend the following: (i) extend the current desktop evaluation to the next level and undertake a comprehensive assessment involving direct engagement and consultations with Indigenous communities in the Reef; (ii) concomitantly undertake a comprehensive audit of the capacity of Indigenous ranger groups to undertake participatory monitoring programs, and assess training needs; (iii) initiate cross-cultural research to develop methods to integrate Traditional Ecological Knowledge of marine megafauna species with scientific survey data to incorporate into monitoring and evaluation frameworks such as Driver-Pressure-State-Impact-Response; (iv) design and implement a coordinated, systematic and cost-effective in-water monitoring program in partnership with Indigenous ranger groups at local and regional scales; (v) develop and implement monitoring programs to assess the condition of seagrass and other benthic habitats at megafauna monitoring sites, and indicators of pressures/threats to these habitats; (vi) facilitate partnerships between Indigenous ranger groups and research organisations to ensure that the best available scientific advice is

obtained; and (vii) derive comprehensive and realistic cost estimates to implement and sustain the participatory monitoring component of the RIMReP megafauna theme.

Contents

Table of Figures

Table of Tables

1.0 Introduction

The Reef Long-Term Sustainability 2050 Plan (Reef 2050 Plan) is a joint initiative between the Australian and Queensland governments to provide strategic and adaptive management for the Great Barrier Reef (the Reef). The plan identifies a set of actions, targets, objectives and outcomes to protect the Reef's values, health and resilience, while allowing ecologically sustainable development and use, and protecting the Reef's outstanding universal value.

One of the actions identified in the Reef 2050 Plan is to develop a Reef 2050 Integrated Monitoring and Reporting Program (RIMReP) to continuously assess whether or not the Reef 2050 Plan is on track to meet its targets and objectives, and to serve as a knowledge system that drives adaptive management of the Reef and its adjacent catchments. RIMReP includes a program design phase whereby a series of expert theme groups develop recommendations for monitoring and/or modelling of key values and components of the Reef system, including consideration of associated drivers, pressures, states, impacts and management responses. "*Megafauna*" (other than Great Whales) is one expert theme group and includes dugongs (*Dugong dugon*), sea turtles, coastal dolphins and seabirds/shorebirds encompassing well recognised iconic conservation wildlife species that occur throughout the Reef. Relevant outcomes, objectives and targets from the Reef 2050 Plan for monitoring megafauna include:

Biodiversity 2050 Outcome:

The Reef maintains its diversity of species and ecological habitats in at least a good condition with a stable to improving trend.

Biodiversity 2035 Objectives (BO):

BO2: The survival and conservation status of listed species within the World Heritage Area is promoted and enhanced.

BO3: Trends in populations of indicator species across their natural range are stable or increasing.

Biodiversity 2020 Target (BT):

BT5: "Trends in populations of key indicator species and habitat condition are stable or improving at Reef-wide and regionally relevant scales."

Whilst megafauna have intrinsic biodiversity value *per se*, they have also recognised cultural heritage values to Indigenous coastal communities as recognised in the Reef 2050 Plan. Hence, relevant outcomes, objectives and targets from the Reef 2050 Plan specific to monitoring culturally important megafauna species in the Reef should be both consistent with the RIMReP (2018) Cultural Heritage values and aspirations reported by Jarvis *et al.* (2018 draft), in addition to the following two RIMReP megafauna components: Indigenous

participation in megafauna monitoring (Indigenous in-water monitoring, this report); and Indigenous catch monitoring (via Kewagama Research).

A high level conceptual model of the "*Strong Peoples – Strong Country framework*" for Traditional Owner contributions to RIMReP developed by the Indigenous Heritage Expert Group is illustrated in Figure 1 (from Jarvis *et al.* 2018 draft), and demonstrates the strong connectivity between customary values (for example, culture and knowledge, community health and empowerment), socio-cultural aspirations of well-being (for example, economic, human health and education) and the "health" of sea country (for example, abundance and trend of culturally important megafauna species and their habitats). The Indigenous Heritage Expert Group was created to provide advice on the design of RIMReP in a context where it has been recognised that the most striking gap in "socio-economic monitoring" is the absence of monitoring pertaining to Traditional Owner use, dependency and well-being (Jarvis *et al.,* 2018 draft).

Figure 1. The Strong Peoples – Strong Country framework Traditional Owner wellbeing through connections to Country developed from Traditional Owner concepts within the Great Barrier Reef land and sea country. Copyright Mallie Designs.

2.0 Traditional Owners in the Great Barrier Reef

The Reef is home to over 40 identified Traditional Owner groups with varying levels of authority, management and monitoring capacity. Some groups have well developed ranger programs with collaborators from universities and State and Federal government agencies, whilst other groups have no known capacity. As The Reef 2050 Plan acknowledges that participation by Traditional Owners is crucial, it is important to understand the current status of their participation in the monitoring of megafauna species and their future aspirations.

Before the current status of participatory monitoring by Traditional Owners is understood we first need to have a clear picture of who they are, what current organisational arrangements

are in place and what their capacity is for training and undertaking participatory monitoring activities. Figure 2 shows the varying range of Indigenous Areas that have a stake in the Reef. It should be noted, however, that although there are some gaps in the map reflecting no 'formal' arrangement for the custodians of the land and sea in those areas, it does not signify that Aboriginal cultural heritage does not exist.

In addition to the legally recognised areas, Aboriginal groups have formed corporations, land trusts and bodies to represent collectives of clans. Many of these groups have developed Sea Country Plans, which outline the aspirations and objectives of the Traditional Owners in their sea country.

Although limited Indigenous ranger groups are established along the Reef, government workshops and training programs have been undertaken with a total of 33 rangers trained in turtle monitoring techniques (Cape York Natural Resource Management 2013). The Queensland Government (2018) reported that they funded 22 new ranger positions across a number of Indigenous ranger groups in Queensland in 2017. The Federal Minister for Indigenous Affairs, the Hon. Nigel Scullion (2018), announced in a press release that 17 new Indigenous ranger positions have been authorised for Marine Inspector duties by the Great Barrier Reef Marine Park Authority (the Authority) in 2017. In the same announcement it was pledged that the Authority will receive $2.55 million over three years to train 40 additional rangers. The Traditional Owner groups that identified for the additional funding were: Apudthama Land and Sea Rangers, Hope Vale Congress Rangers, Yuku-Baja Muliku Rangers, Jabalbina Rangers, Yirrganydji Land and Sea Rangers, Djunbunji Land and Sea Program, Gunggandji Land and Sea Rangers (Gunggandji PBC Aboriginal Corporation, 2013) and Girringun Aboriginal Corporation Rangers.

3.0 Indigenous Heritage and marine megafauna in the Great Barrier Reef

The Reef 2050 Plan was developed alongside Traditional Owners (Commonwealth of Australia, 2015). To reach the objectives of the plan, collaboration with the Traditional Owners of the Reef is crucial (Commonwealth of Australia, 2015; Gidarjil Development Corporation, 2016). Aboriginal and Torres Strait Islander people have been managing and utilising the resources of the Reef for thousands of years. With their deep connection to both land and sea Country, they also developed cultural connections and traditions with marine fauna (Great Barrier Reef Marine Park Authority, 2018). For example, in Torres Strait, the dugong is of great cultural importance because it is a food source that is linked with celebratory events such as weddings and funerals (Johannes and MacFarlane, 1991; NAILSMA, 2006). The dugong also has significant social and cultural value amongst Aboriginal communities of the Reef, with dugong featuring in creation stories, rituals and totemic sites (Leong, 1998). The dugong is not the only megafauna that is of cultural significance to groups along the Reef. Turtles are considered an important food source for both Torres Strait and Aboriginal communities

(Johannes and MacFarlane, 1991; NAILSMA, 2006). Some traditional owners along the east coast of Queensland continue to hunt for dugongs and green turtles, which is seen as an expression of their identity and keeping with custom. Two other marine megafauna groups that have cultural significance to certain communities are estuarine or saltwater crocodiles (*Crocodylus porosus*) and coastal dolphins. Whilst some communities have dreamtime stories, spiritual connections and totemic links to saltwater crocodiles, there is scant documentation of the cultural importance of coastal dolphins (Great Barrier Reef Marine Park Authority, 2018). However, we assume that saltwater crocodiles will be reported elsewhere in the RIMReP theme reports.

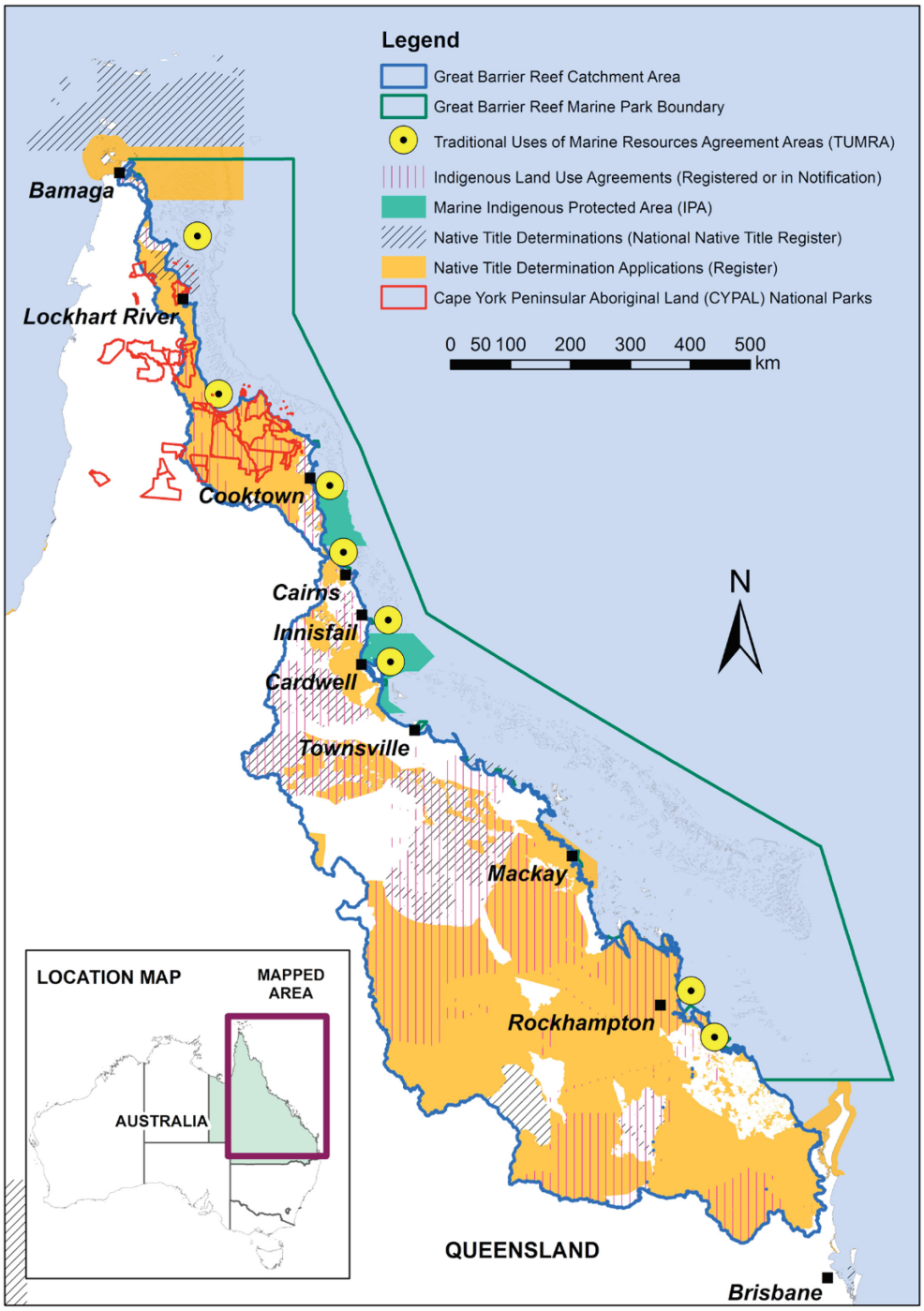


Figure 2. Map of Indigenous areas within Great Barrier Reef (from Dale et al. 2016, NESP factsheet, page 4)

To summarise, Traditional Owners have great interest in the management of the Reef because of their obligation as custodians of the land and sea (see NESP, 2016). Furthermore, due to significant and deep cultural values that marine megafauna hold for communities, the management and monitoring of these species in partnership with Traditional Owners is of particular interest.

3.1 Traditional Owners aspirations for monitoring megafauna

Dale *et al.* (2016) identified 44 Traditional Owner groups with an expressed stake in the Reef south of Torres Strait. Whilst about 40 per cent (19/44) of these groups were identified through a desk top review as participating (or having participated) in megafauna monitoring activities, only about 20 per cent (9/44) detailed these activities (see Current status of Indigenous participation in monitoring, Table 2). Nevertheless, it cannot be assumed that the other groups do not want to participate in monitoring and management activities within the Reef, nor that the discovered information used in this report is entirely accurate (i.e. requires a more thorough assessment and face-to-face interviews).

Perret *et al.* (2010), Ross *et al.* (2004) and Gidarjil Development Corporation (2016) found in their consultations that all Traditional Owners want more involvement in monitoring and management of what is happening in their sea country. In the Sea Country Plans of some of these communities, recurring themes about increasing knowledge on conservation issues, research and monitoring, and species of cultural significance are prominent (Dawul Wuru Aboriginal Corporation, 2014, 2018; Girringun Aboriginal Corporation, 2013; Gungandji PBC Aboriginal Corporation, 2014).

Needless to say, the ability for Aboriginal communities to conduct monitoring surveys has been, and will be, very much dependent on funding opportunities. The few Indigenous ranger groups who operate within the Reef vary from extremely active to limited activities. Groups like Yuku Baja Muliku at Archer Point are extremely active in conservation and management efforts on their country. This group has 14 rangers, with a range of training from I-tracker (CyberTracker™) to Certificates 3 and 4 in Conservation and Land Management, and they collaborate with experts in turtle rehabilitation. Like many ranger groups the Yuku Baja Muliku rangers received funding from the Land and Sea Management Fund (Yuku Baja Muliku Land Trust, 2018).

3.2 Traditional Owner objectives in the Reef 2050 Long-Term Sustainability Plan

The Reef 2050 Plan outlines the importance of Traditional Owner involvement in implementing the actions of the plan. This can be seen in six of the seven themes through objectives that directly and indirectly link to Traditional Owner groups in relation to marine megafauna monitoring (Table 1).

4.0 Scope

Reef megafauna includes dugongs, marine turtles, cetaceans, crocodiles and seabirds/shorebirds, but only dugongs, marine turtles and coastal dolphins are included in this sub-Theme report. There is also a critical need to monitor some sawfish species and these will be included under the Fisheries Theme.

The general requirements of this report are to contribute to the development of detailed design recommendations for monitoring megafauna in the Reef within RIMReP. The detailed requirements are to undertake a desktop review and analysis of Indigenous participation in monitoring megafauna in the Reef, and to contribute to the development of recommendations for an effective integrated monitoring and reporting framework that satisfies the objectives of RIMReP.

The main deliverable is a report that:

Reviews the current status of in-water monitoring of marine megafauna by Indigenous rangers in the Reef, including an evaluation of primary drivers, pressures and responses to megafauna cultural values using the Drivers, Pressures, States , Impacts, Responses (DPSIR) framework where appropriate;

Identifies potential priority indicators for participatory monitoring of the key values associated with these elements of the DPSIR framework, and potential sources of data;

Assesses the adequacy of existing participatory monitoring activities to achieve the objectives and requirements of RIMReP; and

Provide recommendations for the effective participation by Indigenous ranger groups in the in-water monitoring of marine megafauna in the Reef.

Ecosystem Health

- EHO1 – The knowledge innovations and practices of Traditional Owners relevant for conservation and cultural use of biocultural diversity are persevered and maintained.
- EHO3 – Trends in the condition of key ecosystems including coral reefs, seagrass meadows, estuaries, islands, shoals and inter-reefal areas are improved over each successive decade.

Biodiversity

- BO1 – Traditional Owners are engaged and participate in and manage the conservation and ecologically sustainable use of cultural keystone species and biocultural resources.
- BO2 – The survival and conservation status of listed species within the World Heritage Area is promoted and enhanced.
- BO3 – Trends in populations of indicator species across their natural range are stable or increasing.
- BO5 – Reef habitats and ecosystems are managed to sustain healthy and diverse populations of indicator species across their natural range.

Heritage

- HO1 – Traditional Owners cultural heritage rights and responsibilities are incorporated in all facets of management.
- HO2 – Indigenous and non-indigenous heritage including natural, aesthetic, historic, scientific and social values are identified, conserved and managed in partnership with the community.

Community Benefits

- CBO1 – The rights of Traditional Owners to derive benefits from the conservation and cultural use of biological resources are recognised.
- CBO4 – Local, regional and Reef-wide community benefits are understood and the community is actively engaged in managing Reef activities.

Economic Benefits

- EBO1 – Traditional Owners derive economic benefits from conservation and sustainable use of biological resources.
- EBO2 – Protecting the Reef's Outstanding Universal Value is embedded within decision making with impacts first avoided, then mitigated and then, as a final consideration, any residual impacts are offset to achieve a net environmental benefit.

Governance

- GO2 – This Plan guides decisions about the Reef made by governments, industry and the community.
- GO3 – Strong partnerships with Traditional Owners, industry, researchers and the community support protection and management of the Reef.

Table 1. Summary of the key objectives under six themes (of 7) of the Reef 2050 Long-Term Sustainability Plan (Australian Government, 2015) that highlight the importance of Traditional Owner participation in implementing actions of the plan.

Relevant outcomes, objectives and targets from the Reef 2050 Plan specific to monitoring culturally important megafauna species in the Reef should be both consistent with the RIMReP report on *Cultural Heritage Values and Aspirations* by Jarvis *et al.* (2018 draft), in addition to the following two RIMReP megafauna components: Indigenous participation in megafauna monitoring (Indigenous in-water monitoring, this report); and Indigenous catch monitoring (via Kewagama Research). The RIMReP reporting requirements for the Megafauna Theme are primarily focused on population-level monitoring.

The information underpinning the assessment and recommendations in this report is inherently limited by the fact that the scope only allows a “first pass” desktop review and analysis to be undertaken in a short period of time and therefore without direct engagement and consultation with Indigenous coastal communities and their associated ranger groups throughout the Marine Park. Hence, the major constraint, or caveat, is that our assessment is necessarily limited to what information is “discoverable” through published and unpublished reports that are mostly housed on the internet. Nevertheless, an enormous amount of good work directly relevant to this report has already been undertaken over the decades and previously reported by a multitude of researchers from universities, government agencies and Indigenous communities. We collated and drew from this invaluable resource that encompasses not only Indigenous engagement in monitoring and management activities in the Reef (for example, Turning the Tide, 1993; Petersen and Rigbsy, 1998; Sea Forum, 1999; Savage, 2003; George *et al.,* 2004; Ross *et al*., 2004; Crase, 2008; Barnett and Cecarelli, 2007; Crase, 2008; Kennett *et al.,* 2010; Nursey-Bray, 2009a,b; Nursey-Bray, *et al*. 2010; Smyth, 2001, 2009; Perett, 2010; Maxwell Consulting, 2011; Shortland, 2011; Kingsley *et al.,* 2013; Cape York Turtle and Dugong Taskforce, 2013; National Sea Change task Force, 2014; McKenzie *et al.,* 2014; Marshall *et al.,* 2016; Dale *et al.,* 2016; Jarvis *et al.,* 2018 draft; Cleguer *et al.,* 2016; Gooch *et al.,* 2017), but megafauna population ecology such as dugongs and sea turtles (for example, Marsh *et al.,* 1996, 1997, 2015; Environment Australia, 2003; Limpus, 1993, 1995; NAILSMA, 2006, 2012; QPWS, 2014; Fitzsimmons and Limpus, 2016), and integrated assessment and monitoring frameworks (for example, Great Barrier Reef Marine Park Authority and QG, 2014; Great Barrier Reef Marine Park Authority, 2014, 2017; Commonwealth of Australia, 2015, 2016; Walshe *et al.,* 2014; Udy *et al.,* 2018).

5.0 Megafauna Theme Objectives

The overarching megafauna RIMReP Theme objectives are summarised below to provide context to the specific objectives for assessment of Indigenous participation in megafauna monitoring.

Evaluate the adequacy of existing monitoring activities for potential indicators of marine megafauna to achieve the objectives and requirements of RIMReP.

Compare

list of potential indicators needed with the indicators that are currently being monitored;

levels of accuracy and detectability (confidence) of existing monitoring programs with those expected by managers and stakeholders

Consider

adequacy of the sampling methods, spatial and temporal resolution, and statistical power of existing monitoring programs to achieve the objectives and requirements of RIMReP

Identify

gaps where existing monitoring fails to collect data

links and interdependencies between themes

Develop strategies to ensure continuity and comparability with long-term data sets and a smooth transition in cases when changes to existing monitoring are recommended;

Define the desired environmental or social state, and develop potential thresholds for critical elements of the Reef (for example, what is considered a “healthy” population of dugongs?).

6.0 Objectives for Indigenous participation in megafauna monitoring

The specific objectives and deliverables of this draft desktop report are:

An assessment of the current status of Indigenous cultural values of megafauna relevant to the Reef, including an evaluation of primary drivers, pressures and responses using the Drivers, Pressures, State, Impacts, Responses (DPSIR) framework;

An assessment of the current status of Indigenous community participation in the monitoring of megafauna population condition with reference to the DPSIR framework;

Identification of potential priority indicators that may be relevant to monitoring components of the DPSIR framework in relation to key Indigenous cultural values associated with megafauna;

Identification and assessment of current and potential sources of monitoring data to address identified priority indicators;

An appraisal of the adequacy of existing monitoring activities to achieve the objectives and requirements of RIMReP; and

Recommendations for the design of an integrated monitoring program as a component of RIMReP, specifically considering:

The management information requirements for culturally relevant megafauna species in the Reef to ensure that appropriate data and information are being collected to meet the fundamental objectives of RIMReP;

The spatial and temporal sampling design (including logistics) to ensure effectiveness and efficiency of participatory data collection; and

Resources and effort required to implement the recommended monitoring design (for example, likely funding sources).

7.0 The DPSIR Framework

The Driver, Pressure, State, Impact, Response (DPSIR) framework illustrated in Figure 3 provides a multidisciplinary and integrative conceptual model for analysis to inform single assessments or multiple assessments of cumulative effects (Hedge *et al.,* 2013; Walshe *et al.,* 2014).

7.1 Cultural values of megafauna and hunting pressure

Dugongs and sea turtles are important species in marine ecosystems and, concomitantly, both have high biodiversity conservation value and Indigenous cultural value as a hunting resource. Their conservation status across much of north and northeast Australia is, however, variable depending on pressures and, for migratory sea turtles, will depend on species and whether or not they seasonally nest or forage where and when they occur (Dethmers *et al.,* 2010).

The Torres Strait, parts of the Reef and the coastal waters of north-west Western Australia encompass some of the largest remaining dugong populations in the world. Cultural harvests of dugongs over millennia in north-west Western Australia are likely the only known pressure, however this could change with increasing development pressures in combination with potential climate change impacts. In contrast, dugong populations along the east coast of Australia encompassing the Reef are subjected to many more multiple pressures, particularly from development and associated degradation of seagrass habitats. Current and future risks to marine megafauna, therefore, need to be continuously monitored and evaluated using integrative assessment frameworks that support adaptive management.

One such generic framework is the DPSIR framework that is currently adopted by RIMReP. Figure 4 is a schematic diagram of the relations among drivers, pressures and the state of dugong and sea turtle population abundance in the Reef developed at the Marine Megafauna workshop in Townsville in February 2017. In this conceptual model the population abundance (and subsequent trend) of dugong and sea turtles are assumed to capture the “state” or “condition” of their biodiversity conservation value and, similarly, of their Indigenous cultural values. That is, they are basically assumed to be equivalent indicators although their assessment endpoints with respect to values are very different. Given that “societal attitudes” is identified as a key driver in Figure 4, and for the purposes of this report, a cultural harvest (i.e. an offtake or extraction) is considered an acceptable societal “trade-off” in abundance, albeit under the following conditions: that the density of a harvested population is acceptable with respect to other values (i.e. within a multiple use context); and that harvests are sustainable in the long-term and account for both innate environmental variability (for example, decadal trends in extensive flooding in coastal catchments and associated seagrass dieback) and the cumulative negative effects of multiple anthropogenic pressures (see Figure 4 – for example, habitat loss, incidental mortality from fishing), in particular the negative effects of

climate change identified as another major driver (for example, seagrass loss due to marine heat waves, see Thomson *et al.,* 2014 for WA).

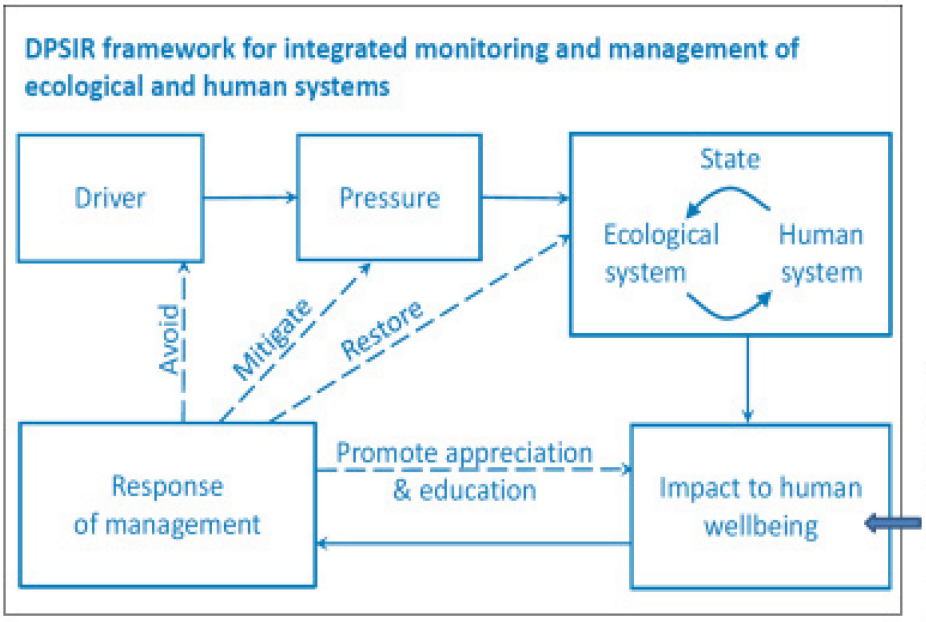


Figure 3. Modified DPSIR framework showing pathways of management intervention and identifying Traditional Owner concepts of well-being that need to be included with other recognised values (from Jarvis *et al.,* 2018 draft as modified from Hedge *et al.*, 2013: 72).

Regardless of the above simplifying assumption that equates cultural and biodiversity values through an index of abundance, cultural value with respect to megafauna is likely to be much richer and more complex than simply consuming bush tucker, involving ritual, ancestral story lines and strong social connections (see Bradley 2010 for dugong; Bayliss and Ligtermoet, 2017 for magpie geese A*nseranus semipalmata* on World Heritage Kakadu National Park).

7.2 Drivers

Drivers are the overarching causes/trends that influence a range of pressures and drive changes in the environment of the system of interest (Commonwealth of Australia, 2016; Great Barrier Reef Marine Park Authority, 2014; Great Barrier Reef Marine Park Authority, 2017). The following six drivers of change have been identified for the Reef system, all of which operate across a range of spatial and temporal scales and which are interlinked (Great Barrier Reef Marine Park Authority, 2017):

1. Climate change
2. Population growth
3. Economic growth

4. Technological development
5. Societal attitudes
6. Governance systems

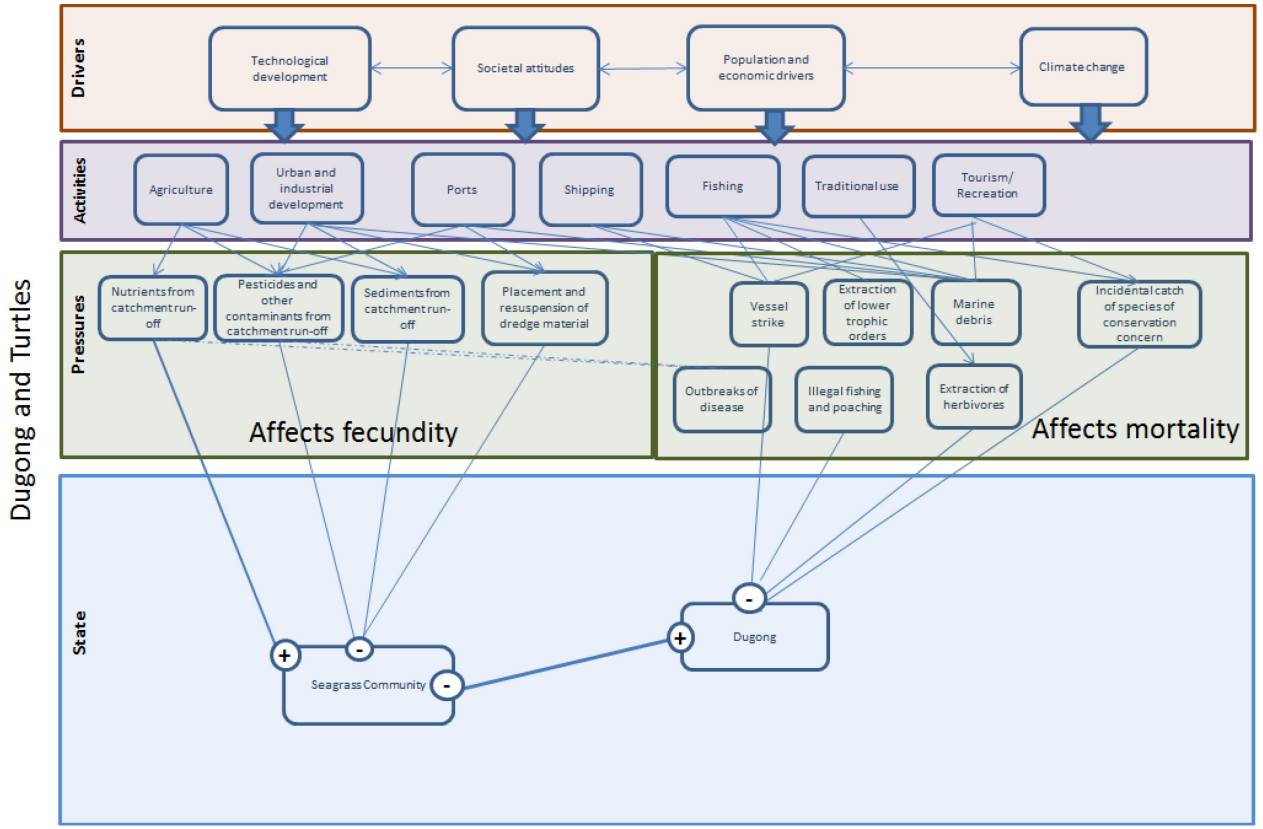


Figure 4. Schematic diagram of the relations among drivers, pressures and the state of dugongs and sea turtles in the Great Barrier Reef using the DPSIR framework. The thickness of the lines and the size of +/- circle are indicative of relative influence. Dashed lines indicate linkages that are uncertain or contentious. February 2017 Megafauna Workshop, Townsville.

The drivers illustrated in Figure 4 for the dugong and turtle DPSIR conceptual model have been re-arranged to the following four: Technological development; Social attitudes; Population and economic factors; and Climate change.

7.3 Activities

There are seven main human activity areas, or multiple-use classes, influenced by high order overarching drivers, and activities which in turn creates a range of pressures on values. Here this refers to the abundance of dugongs or turtles as a primary indicator of the health of their biodiversity and cultural values.

7.4 Pressures and Impacts

Pressures (often referred to as threats) derive from the human activities caused by drivers that will affect changes to values (Great Barrier Reef Marine Park Authority, 2017). Pressures, including customary hunting harvest, are organised into the following two classes of impacts: (a) those that affect fecundity; and (2) those that affect mortality. Pressures that affect fecundity include: nutrients from catchment runoff; pesticides and other contaminants from catchment runoff; sediments from catchment runoff; and placement and resuspension of dredge material. Pressures that affect mortality include: vessel strike; extraction of lower trophic orders; marine debris; incidental catch of species of conservation concern; outbreaks of disease; illegal fishing and poaching; extraction of herbivores (for example, customary harvests of dugong and sea turtles).

Impact is the resultant effect to human well-being, including Traditional Owner concepts of human-well-being (for example, reduced hunting resources) that flows from a change in the state of a value or combination of interconnected values (regardless of whether or not that value is biophysical, socioeconomic or cultural heritage; Great Barrier Reef Marine Park Authority, 2017). Values are those aspects or attributes of an environmental and/or human system that are of significance (Great Barrier Reef Marine Park Authority, 2014). For culturally important species of marine megafauna, impacts can be arranged according to:

1. Environmental impacts (for example, due to pollution pressures on seagrass habitat)
2. Socio-economic impacts (for example, reduced use of bush protein)
3. Cultural impacts (for example, reduced hunting and associated ceremonies)

7.5 States and Responses

In the DPSIR framework ‘state’ represents the condition of a value. For example, the abundance of dugong or sea turtle populations indexing biodiversity and/or cultural health; the extent and condition of their dependent seagrass habitat. This can change qualitatively or quantitatively over time (Great Barrier Reef Marine Park Authority, 2017).

Responses are actions taken by resource managers and/or communities to influence drivers (for example, societal attitudes) in order to mitigate pressures and restore the desired state of values within the socio-ecological system.

7.6 Cumulative effects

In the dugong and turtle DPSIR model for the Reef (Figure 4) 'impacts' and 'responses' are illustrated by the links between pressures and states and the sign (+ or -) of the state connection. The thickness of the connection lines indicate their relative influence in the impact and response. Whilst not included conceptually in Figure 4 it is possible, and likely desirable at some stage, to include a third class of pressure that deals with cumulative effects and the potential for complex system interactions, and therefore predictions, between high order drivers, activities, pressures and endpoint states (see Bayliss *et al.,* 2018 for an example of an Integrated Risk Assessment framework for the management of key threats to aquatic coastal ecosystems on World Heritage Kakadu National Park).

The DPSIR conceptual model focuses on pressures, states, impacts and responses primarily within the Reef region, and we note that parts of the critical life history of migratory species such as sea turtles can occur outside this region or Australian waters.

7.7 Management Context

The RIMReP management information needs of the Megafauna Theme are outlined below to provide context to this report.

1. Population abundance and distribution for Outlook (Reef 2050 Plan) reporting and the effects of permitted activities on population levels.

2. Effectiveness of management initiatives including dugong protection areas, turtle excluder devices and fox baiting.

3. Substantiating hunting levels for green turtles and dugongs.

It has been noted that it would be difficult, if not impossible, to assess 1 and 2 above via a monitoring program, whilst for 3 above it may be possible for some Indigenous communities.

The specific management requirements of the RIMReP megafauna report are outlined below with priority species indicated, with the focus in this report on point 1.

1. Distribution, abundance and trends at management and unit/stock/ecological scales appropriate for megafauna species (dugongs; snubfin and humpback dolphins; loggerhead, flatback and green turtles).

2. Monitoring nesting and foraging populations of marine turtles: loggerheads (particularly to understand the proportion of new recruits entering the Reef's foraging grounds at Capricorn Bunkers and Swains; hawksbills at index sites; northern Reef greens at Raine/Moulter, Millman and index beaches in the Torres Strait.

3. Updating the southern Reef green turtle population model every five years and the completion of the northern Reef model.

4. Trends in, and causes of, megafauna strandings – continuation and strengthening of StrandNet (all species). Better necropsy monitoring of disease and anthropogenic impacts of animals that do strand.

5. Incidental catch of megafauna by fisheries and shark control measures (all species). Some of this information will come from StrandNet but in addition, a fisheries observing program needs to be re-established.

7.8 Monitoring Methods (case studies from Queensland, Northern Territory and Western Australia)

7.8.1 AERIAL SURVEY — LOCAL VERSUS REGIONAL-SCALES

Monitoring trends in the distribution and abundance of diverse megafauna groups such as dugongs, sea turtles and coastal dolphins over extensive and remote regions of Australia such as the Reef with sufficient precision to detect significant change is both challenging and expensive. The conventional method is by standardised fixed-wing aerial survey because it is cost-effective over continental and regional scales (see Marsh *et al.,* 2020 for dugongs, RIMReP Megafauna Theme report). However, aerial survey methodology is largely unsuitable for local-scale surveys that require more detailed population-level information (for example, reproductive status, age/size), or fine-scale seasonal distribution and abundance patterns for habitat management purposes.

Additionally, broad-scale aerial surveys that aim to collect baseline data on distribution and abundance over large areas may exclude effective participation by Indigenous rangers and use of their customary and local knowledge. Nevertheless, a baseline aerial survey of dugongs was successfully undertaken for the North Kimberley in 2015 with the participation of Indigenous ranger groups after a five-day intensive training course (Bayliss *et al.,* 2016), which aimed to increase the level of engagement in dugong management in sea country and co-managed marine parks. However, it was recognised during a project feedback session in 2017 that whilst fixed-wing aerial survey provides necessary regional and national contexts of a species distribution and abundance, they were generally unsuitable for monitoring local populations more frequently in smaller high priority management areas.

One aerial survey platform that has received less attention in the past is the helicopter. They can fly lower and slower that fixed-wing aircraft, two survey variables that significantly reduce observer counts making them superior inshore survey platforms. Additionally, the lower aircraft speed and survey height will considerably reduce potential miss-identification rates of co-occurring species where their sighting images are similar, such as for dugongs and snubfin

dolphins (Bayliss *et al*., 2016). However, use of helicopters in regional-scale surveys of megafauna IS generally constrained by significantly higher operating costs and smaller flight durations compared to fixed-wing aircraft. Hence, there are few published examples of use of helicopters as observation platforms for broad-scale surveys of marine megafauna. Palmer (2015) and Palmer *et al.* (2017) undertook extensive inshore dolphin surveys from helicopters and found that they are more widespread in the coastal waters of the Northern Territory than previously thought, particularly the Australian snubfin dolphin, and that there may be abundance “hotspot” areas for different species. Their results for inshore dolphins in the Northern Territory demonstrate that marine megafauna surveys using helicopters as observation platforms may have significant cost advantages for monitoring small areas in the Reef by Indigenous ranger groups, and should be assessed.

7.8.2 BOAT SURVEYS — IN-WATER MONITORING

Many previous studies have developed boat-based survey methods for in-water monitoring of marine megafauna that were highly suitable for local-scale needs and conditions (for example, Dawson *et al.,* 2004 for coastal dolphins; Jackson *et al.,* 2016 for sea turtles in the Kimberley; Brown *et al.* 2016 for Australian snubfin and humpback dolphins in the Kimberley; Beasley *et al.,* 2014a-c, 2016a-c, 2017a and b for inshore dolphins in northeast Queensland/Reef). There are three good case studies relevant to the Reef of Indigenous participation in monitoring marine megafauna using small boats as counting platforms, two from the North Kimberley (marine turtles and dolphins) and one from the Reef/north Queensland (dolphins and occasional dugong).

7.8.3 INSHORE DOLPHINS — NORTH QUEENSLAND, NORTHERN TERRITORY AND NORTH KIMBERLEY WA

The overall population size and trends of three dolphin species that occur in coastal waters of northern Australia - the Australian snubfin, humpback and bottlenose dolphins - are poorly known and their conservation status has been difficult to resolve (Palmer *et al.,* 2014a). Whilst estimating the abundance of inshore dolphins using line transect methodology applied to small boat surveys has been extensively used around the world, it has recently gained traction in Australia.

Perhaps the most extensive use of small-boat surveys and line transect methods to estimate trends in the distribution and abundance of inshore dolphins in successful partnership with Indigenous ranger groups are those undertaken by JCU in the northern Reef (Beasley *et al.,* 2014a-c, 2016a-c, 2017a and b). These are highly relevant to this review and the overall aims of RIMReP. The surveys establish a high standard model to apply to other areas in the Reef when designing future in-water megafauna monitoring programs that need to address the following RIMReP objectives: use of consistent and standardised survey methods with respect to survey effort and species identification; a survey design that reflects effective spatial

coverage; effective participation by Indigenous ranger groups; and highly effective reporting and communication. The Indigenous organisations and associated ranger groups that participated in these dolphin/dugong boat surveys are: Lama Lama (Beasley *et al.,* 2014aandb); Mandubarra (Beasley *et al.,* 2014a, 2017a); Girringun (Beasley *et al.,* 2016c); and Jabalbina-Yalanji (Beasley *et al.,* 2017b). Additionally, the status of inshore dolphin abundance was also evaluated along the north Queensland Coast (Beasley, 2016a) and in Halifax and Cleveland Bays (Beasley, 2016b) using the same boat-based survey methodology.

Training in field survey methods, including species identification, was undertaken with Indigenous ranger groups prior to surveys, and all reports indicate a high standard of consistent data collection with respect to transect location, survey speed and effort, observers and associated environmental survey conditions. Additional water quality variables were collected also on some surveys (for example, pH, salinity, turbidity, temperature). No detailed analysis of abundance data are presented in reports, and the methodology does not indicate whether or not conventional Distance-based line transect models (i.e., detection probabilities vs. perpendicular distance from the boat) were used or will be used. Nevertheless, data can be standardised for variable survey effort and, potentially, variable environmental conditions encountered in different months (i.e. seasonal effects), to derive a consistent and stable index of abundance. Hence, if the data collection methods have been ascertained correctly from the reports, then the resultant standardised indices of abundance should be sufficient for tracking relative changes in abundance and distribution over time depending on management and survey objectives. With respect to characterising patterns of distribution and abundance, the systematic transect-based survey design facilitates mapping of groups sizes of observations on a species or megafauna group basis. All “first-time” surveys would comprise baseline surveys from which to monitor future changes in relative abundance with repeat surveys. For example, sea country areas that were re-surveyed once, such as Lama Lama and Mandubarra, provides data for comparison between a one and three year interval, respectively. However, any interpretation of change would need to account for potential seasonal effects given the different month of surveys. Preliminary reports demonstrate that, depending on re-survey intervals and the length of the time series, in several years’ time it should be possible to undertake a robust change analysis for future megafauna RIMReP reports with respect to both the condition or trend in abundance of dolphin species and the level of participation by Indigenous ranger groups.

Palmer *et al.* (2014b) used photo-identification data collected during systematic boat-based transect surveys and Pollock’s robust capture–recapture design model over a three-year sampling period to estimate the abundance (and apparent survival) of the above three dolphin species in Port Essington, providing the first baseline for the Northern Territory. Their methodology appears sufficiently robust and repeatable to apply to other areas.

Brown *et al.* (2017) investigated the population genetic structure and relative abundance of the Australian snubfin dolphin and Australian humpback dolphin at selected study sites in the Kimberley. Boat-based visual surveys and photo-identification revealed the presence of

snubfin and humpback dolphins at all survey sites, although in variable numbers and degrees of approachability by boat. Although they used standardised boat-based survey methods, they found that difficulties in approaching dolphins by boat limited the effectiveness of photo-identification techniques at some sites. Whilst Brown *et al.* (2017) did not evaluate or report on the effectiveness of boat-based abundance estimates for long-term monitoring purposes of two inshore dolphin species, they presented maps of their relative distribution and abundances at selected survey sites using group sizes of observations. They investigated also the application of passive acoustic monitoring as a technique to monitor the occurrence and activity of both species, with an eye on future application. However, the application of passive acoustic monitoring was limited to monitoring occurrence only.

A similar “boat-shy” response was found for dugongs in Wunambal Gaambera sea country in 2012 (Jackson *et al.,* 2012) and, this in combination with low numbers, led to an assessment that it was an unsuitable survey method for regular monitoring purposes in this particular location. Hence, the focus shifted instead to regular monitoring of the condition of their seagrass habitat (Howley *et al.,* 2015).

7.8.4 SEA TURTLES IN THE KIMBERLEY — FORAGING SITE SURVEYS TO COMPLEMENT BEACH NESTING SURVEYS

In 2012, Uunguu and Dambimangari rangers in the North Kimberley, North Australia Indigenous Land and Sea Management Alliance and CSIRO formed a partnership to develop and implement a monitoring program for marine turtles (Mangguru), dugongs (Balguja) and their habitats that was suitable to community-driven local-scale management needs (Jackson *et al.* 2015; Austin *et al.* 2017). The project specifically supported Target 10 of the Wunumbal Gaambera Healthy Country Plan (WGAC 2010, 2016) that relates to managing marine turtles and dugongs based on a sound knowledge of their distribution and abundance, and also supported management goals of the Balanggarra (BAC, 2011), Dambimangari (DAC, 2012) and Bardi Jawi Niimidiman (BJ 2013, 2017) Healthy Country Plans. The survey method entails small (~6m) boat-based surveys at known foraging sites, a systematic transect design and is supported by a hand-held iTracker (CyberTracker) application to log data (Kennett *et al*. 2010). Turtles were identified to species when possible, allocated a size and activity class, and their perpendicular distance (via 3 50m bands) from transects estimated and recorded in order to use Distance (see Thomas *et al.* 2009, v6.0) or Line Transect models (Burnham *et al.,* 1978); Buckland *et al*., 2001, 2004) to estimate total numbers and density in the survey area. Turtles (mostly green turtles) were allocated into three size classes: juveniles, sub-adults and adults (see Supplementary Material to Jackson *et al.,* 2015) Additionally, a standardised set of environmental survey variables likely to affect visibility conditions, animal behavior and, hence, detection probability were also recorded (for example, tide, sea state, water depth and clarity, turbidity, glare, wind and cloud cover).

Jackson *et al.* (2015) describes the context and process of developing a boat-based survey approach to marine turtle monitoring by Indigenous rangers in the Kimberley using a

collaborative partnership model that supports Traditional Owner aspirations and their management objectives. The monitoring methods were specifically tailored to suit the needs and resources of Indigenous rangers programs in the Kimberley, and is considered a successful approach given that two ranger groups have been able to independently sustain systematic annual monitoring of turtles at important foraging sites since commencement (Uunguu rangers: seven annual turtle surveys, six annual seagrass surveys, 11 surveys in total; Dambimangari rangers: six annual turtle surveys and similarly for inshore dolphins, benthic habitat surveys have commenced).

7.9 Data Management

One of the goals of the Reef 2050 Plan is to enhance the level of participation by Indigenous communities, particularly through ranger programs, in monitoring and reporting of the condition of natural and cultural heritage assets, and this particularly applies to marine megafauna. For a number of reasons monitoring activities by Indigenous communities may not be adequately incorporated into national planning frameworks. Communities with extensive traditional and local knowledge of culturally important species of megafauna have the capacity to contribute to new research and monitoring initiatives, but there appears to be no easy mechanism, pathway or framework for this to occur. A necessary pre-requisite for such a framework, therefore, is the development of a data repository and associated protocols that can house data collected by Indigenous communities. The framework could develop pathways also for data within the repository to contribute effectively to existing national planning frameworks and processes of priority to government, in addition to regional-scale Reef management needs and Indigenous Protected Area Management and Healthy Country Planning needs at more local scales. Such a data storage facility or infrastructure should lead to increased communication and coordination of in-water monitoring activities (among others) in the Reef undertaken by a diversity of Indigenous ranger groups spread across large geographic domains. Such a ‘network’ should lead to greater update and impact of data collected by Indigenous ranger groups in, for example: the State of the Environment Reporting; the National Recovery Plan for Marine Turtles; and the Threatened Species Scientific Committee (threatened species listing). The major outcomes of such an initiative could be greater participation by Indigenous people in environmental management, and improve understanding of trends in marine megafauna populations including potential links between these trends and trends in the condition of their habitats (for example, dugongs, turtles and seagrass). This “data management” activity should be “joined at the hip” with any monitoring activity undertaken by ranger groups in the field as the two cannot be separated and, therefore, each demands equivalent resourcing.

Some additional discussion points related to the key roles of data storage and management that need to underpin monitoring programs are now presented. Brammer *et al.* (2016) and others highlighted that, based on currently available resources, monitoring undertaken exclusively by professional scientists is insufficient to address ongoing environmental challenges and that the role of digital data entry in participatory environmental monitoring will only increase. They argued that, whilst there exists various forms of participatory monitoring

being used to increase the extent and resolution of monitoring data, the degree to which participants such as stakeholders, resource users, local residents, Indigenous people and interested citizens become engaged will vary between those that solely collect data to those that lead monitoring design, implementation and subsequent management responses. Participation by Indigenous ranger groups in RIMReP for marine megafauna will likely encompass the full spectrum at some stage, highlighting the need for capability training in digital data management, storage, retrieval and analysis at various levels.

Additionally, Dwyer *et al.* (2015) highlighted that whilst recent improvements in telemetry technology are allowing scientists to monitor animal movements with increasing accuracy, precision and frequency, the downside is that the increased complexity of such data collections demands additional software and programming skills to process, store and disseminate the datasets. The same principles apply to survey count data. They highlighted also that the recent focus on data availability has increased the need for sustainable data management solutions to ensure data integrity and to provide longer term access. They point out that a number of online facilities have been developed for the archiving, processing and sharing of telemetry data, and that these facilities offer secure storage, multi-user support and analysis tools that improve data access, long-term data preservation and science communication. They developed and promote a comprehensive, highly accessible and fully transparent software facility for animal movement data called OzTrack, which is an open Web-based system for the analysis and sharing of animal tracking data. Bayliss and Hutton (2017) used this facility for dugong satellite tracking data in the Kimberley. OzTrack uses exclusively free and open-source software and, because the source code is available online, the system promotes open access not only to data but also to the tools and software underpinning the system. It may be desirable, if not necessary, if a similar open access Web-based software facility was developed for Indigenous ranger groups to safely store, process and continuously analyse monitoring survey data so that they are not entirely dependent on external research collaborators to perform these tasks and that often result in inevitable assessment and reporting bottlenecks.

In summary, robust and sustainable data management activities will increase the capacity of local communities to better manage and use their monitoring data not only for Indigenous Protected Area and Healthy Country planning, but for government to better use data collected by Indigenous communities to inform regional and national level management (for example, RIMReP), which in the long-term will have significant environmental and social benefits. The number of communities in the network that use more enhanced data management systems and trained operators would be good performance indicators, along with the number that make contributions to State of the Environment reporting or Species Recovery Plans.

8.0 Integrating Indigenous Ecological Knowledge and Scientific Surveys

Aboriginal and Torres Strait Islanders are major stakeholders in the management and protection of Australia's natural and cultural marine-coastal resources. Traditional Owners

have cultural and legal rights, and responsibilities, to sustainably use and manage their extensive land and sea country. They have deep ongoing connections to both land and sea, and recognise them as inseparable. This world view is embedded in the Reef 2050 Plan and requires research approaches and policy and management solutions that encompass Indigenous perspectives, values, knowledge and aspirations from the outset. The demand for regional assessments and multiple use management planning tools that are underpinned by both scientific and cultural knowledge will therefore only increase given national agendas for sustainable development and economic wellbeing, particularly given that research priorities will largely be determined by the need to facilitate complex trade-offs between different values and uses (Bayliss *et al.,* 2014) as exemplified in the Reef.

As highlighted in the Scope relevant outcomes, objectives and targets from the Reef 2050 Plan specific to monitoring culturally important megafauna species in the Reef should be both consistent with the RIMReP (2018) Cultural Heritage values and aspirations reported by Jarvis *et al.* (2018 draft), in addition to the following two RIMReP megafauna components: Indigenous participation in megafauna monitoring (Indigenous in-water monitoring, this report); and Indigenous catch monitoring (via Kewagama Research). Whilst there are many excellent studies that document the importance of Indigenous knowledge of marine megafauna in the Reef and its potential role in undertaking integrated assessments, we found no studies that attempted to combine both knowledge systems. This indicates a key knowledge gap given the increasing interest and need. The use of Bayesian probability methods that recognise both the intrinsic value of expert knowledge and quantitative data has been used extensively to integrate knowledge from a variety of sources in many studies, and is one approach that may be useful. For example, Bayliss *et al.* (2016) attempted to integrate Indigenous and scientific knowledge of dugongs in the north Kimberley using a Bayesian probability approach to map important dugong areas (see Appendix 3).

9.0 Current Status of Indigenous Participation in Monitoring

Dale *et al.* (2017) identified 44 Traditional Owner groups with an expressed stake in the Reef south of Torres Strait and, of these groups, about 20 per cent (9/44) have been identified as actively participating in marine megafauna activities mostly through existing ranger programs in collaboration with government agencies or other organisations such as universities (JCU in particular) with respect to their dolphin and dugong boat surveys in north Queensland (Table 2). Nevertheless, as highlighted in the introduction of this report, it cannot be assumed that the other groups do not want to participate in monitoring and management activities within the Reef, nor that the discovered information through the desktop assessment used in this report is entirely accurate. We recommend, therefore, that for planning and design purposes the current desktop evaluation process progress to the next level to undertake a more comprehensive assessment involving direct engagement. In informal telephone interviews by one of us (Mibu Fischer), some groups expressed a desire to become involved in the desktop assessment and share knowledge of their megafauna monitoring activities, however were hesitant to share unpublished and unavailable reports and data without direct interaction.

Apart from the comprehensive monitoring reports primarily for inshore dolphins and dugongs by JCU (Beasley *et al.,* 2013, 2014a and b, 2016a-c, 2017a and b) in partnership with five north Queensland Traditional Owner groups (Girringun Aboriginal Corporation, Mandubarra Aboriginal land and Sea Inc., Dawul Wuru Aboriginal Corporation, Jabalbina Yalanji Aboriginal Corporation and the Yintjingga Aboriginal Corporation/Lama Lama rangers), we found no other documentation detailing the nature of any collaborative partnerships, funding sources, monitoring methods, selected species, spatial locations of survey sites, data availability and custodianship, nor any analysis reporting abundance or trends (see Table 2).

About 20 per cent (9/44) of Traditional Owner groups in the Reef were identified in the desktop review as being involved in marine megafauna monitoring activities through existing ranger programs. However, apart from the comprehensive monitoring reports of inshore dolphins and dugongs undertaken by JCU in partnership with five north Queensland Traditional Owner groups, representing 11 per cent (5/44) of all groups, we found no documentation for the other four Traditional Owner groups that detail the nature of any collaborative partnerships, funding sources, monitoring methods and species surveyed, spatial locations survey sites and activities, and data availability and custodianship. Taken at face value the boat surveys for dolphins in north Queensland, however, represent about 56 per cent of the Indigenous organisations that reported some form of megafauna monitoring activity in the Reef (assuming that these figures are correct) and may reflect a combination of factors such as a lack of opportunity for the other four ranger groups, or lack of current organisational capacity to develop and implement monitoring programs at a level that will satisfy RIMReP requirements in terms of a robust design and consistent methods. Another interpretation may be that all or some unreported monitoring activities are reported elsewhere, either in inaccessible parts of the grey literature zone or through collaborative partnership arrangements with government agencies, non-government organisations or university researchers, and this needs to be ascertained in follow-up assessments.

We reiterate that of the 80 per cent (35/44) of Traditional Owner groups that apparently did not undertake any monitoring activities of marine megafauna, it cannot be assumed that they do not want to participate in future megafauna monitoring, nor that information discovered (or not discovered) in our desktop review is accurate. Hence, in summary, more information is required to correctly interpret results of our desktop review and assessment. One result is without doubt, however, and that is all Traditional Owner groups in the Reef have expressed a strong aspiration to become involved at some level in RIMReP (see Jarvis *et al.,* 2018 draft).

10.0 Priority Indicators for Participatory Monitoring

The success or failure of any monitoring and reporting program will ultimately depend on the choice of indicators used to assess the health or condition of the value(s) being protected. The underlying assumption in this review is that the level of participation by Indigenous communities in megafauna monitoring programs is a likely indicator of cultural health given the strong connections to sea country and aspirations to look after associated cultural values,

particularly with respect to maintaining sustainable customary harvests of dugongs and sea turtles. However, there are few studies that can claim success in developing appropriate and effective indicators of cultural health, in large part likely due to the challenging complexities and diversity of cross-cultural world views. A notable exception may be the Cultural Health Index developed to manage water quality of streams and waterways by Māori people in New Zealand (Tipa and Teirney, 2006). Nevertheless, despite the challenge, the scope of the megafauna and Cultural Heritage Themes within RIMReP, and our component within megafauna focussed on participation by Indigenous rangers in monitoring, may simplify the task although this optimism will obviously depend on feedback from Traditional Owners in the Reef.

Table 2. List of Aboriginal Groups in the Great Barrier Reef identified as conducting marine megafauna monitoring

Groups	Dugong	Turtles	Dolphins	Crocodiles	Resources/Capability
Yuku Baja Muliku	Voluntary moratorium on hunting	Monitoring (seagrass monitoring)		Assist Wildlife Officers in management	14 Rangers, Turtle Rescue Centre, trained in number of areas[1]
Yintjingga Aboriginal Corporation and Lama rangers	Monitoring2		Monitoring[2]		4 Rangers Certificate II in Maritime Operations[3]
Jabalbina Yalanji Aboriginal Corporation	Monitoring[15]		Monitoring[4,6] [15]		11 Rangers[5]
Dawal Wuru Aboriginal Corporation			Surveys[6]	Crocodile management[7]	
Gudjuda Reference Group Aboriginal Corporation	Monitoring	Monitoring, tagging, tracking and protection. (Seagrass monitoring)[8]	Monitoring		
Gidarjil Development Corporation		Monitoring (Seagrass monitoring)[9]			3 Rangers
Girringun Aboriginal Corporation	Monitoring – especially in Dugong Protected Area[10]	Tagging and Stranding. Training and Monitoring10	Monitoring[11,6]		10 Rangers
Manduburra Aboriginal Land and Sea Inc.	Monitoring[12] [14]		Monitoring12[,11]		
Djunbunji Land and Sea Program		Strandings, training and participation at Mon Repos[13]			

[1] Yuku Baja Muliku Land Trust (2018)
[2] Beasley *et al.* (2013; 2014a)
[3] Taking Care of Country (no date)
[4] Beasley *et al.* (2016a)
[5] Jabalbina Aboriginal Corporation (2018)
[6] Beasley *et al.* (2016b)
[7] Dawul Wuru Aboriginal Corporation (2018)
[8] WWF (2018); Gudjuda Reference Group Aboriginal Corporation (2013)
[9] Gidarjil Development Corporation (2018)
[10] Girringun Aboriginal Corporation (2016)
[11] Beasley *et al*. (2014b)
[12] Beasley *et al.* (2016c)
[13] Djunbunji Ltd. (2018)

[14] Beasley *et al.* (2017a)

Whilst the components or species groups of the megafauna theme will develop their own performance indicators, they will all essentially be underpinned by estimates of population abundance and trends in abundance as defined in the initial RIMReP scope (i.e. The RIMReP megafauna reporting requirements will be primarily focused on population level monitoring). The use of population abundance, and in some examples the condition of their dependent habitats, as appropriate indicators of the health of culturally important megafauna species is reflected in existing reported monitoring activities undertaken by Indigenous ranger groups in the Reef (Table 2). Hence, all components of the megafauna theme that encompass culturally relevant species, particularly Indigenous-catch monitoring, appear to be consistent with respect to a range of potential population-level indicators. Additionally, the relevant outcomes, objectives and targets of the Reef 2050 Plan specific to participatory monitoring of culturally important megafauna species also appear consistent with RIMReP Cultural Heritage values and aspirations reported by Jarvis *et al.* (2018 draft). Appendix 1 summarises discussion notes on potential megafauna indicators in relation to managing sea country by Indigenous ranger groups in the Reef that was compiled from published and unpublished sources of information by Jarvis *et al.* (2018 draft; distilled from their Appendix 4). Only two of 11 examples in Appendix 1 relate to development and implementation-specific population-level abundance indicators of megafauna and cultural health (Bayliss *et al.* 2015 for dugongs and Jackson *et al.* 2015 for sea turtles, both case studies in the Kimberley WA). One of the authors of this report (Bayliss) was involved in both Kimberley projects and the consultation and engagement process initiated by Indigenous rangers was designed to specifically target development of robust local population-level indicators. The other examples in Appendix 1 are more aspirational and indicate that further consultation and engagement are required to develop indicators acceptable to the community and reporting agencies.

Appendix 2 summarises examples of selected indicators that may relate to Traditional Owner well-being in the Reef, and was distilled from information in Appendix 5 of Jarvis *et al.* (2018 draft) that was compiled from published and unpublished sources. The information in this table focuses on the following two facets of RIMReP megafauna performance indicators highly relevant to this review: (i) the focus on using abundance to monitor culturally important megafauna species (for example, numbers of crocodiles, dugongs, dolphins, sea turtles) and that for introduced species (for example, crown-of-thorns starfish), the use of concomitant indicators of the condition of important habitats (for example, seagrass, corals) including potential impacts from development pressures (for example, water quality, dredging, sedimentation, marine debris/ghost nets), and the impacts of other pressures on customary harvesting and harvesting *per se*; and (ii) indicators of cultural and socio-economic benefits derived from engagement and participation, such as participation by Elders and children to transfer cultural knowledge, and the creation of economic, employment, training and education opportunities. Appendix 2 captures specific management objectives, outcomes and potential performance indicators to monitor and assess participation by Indigenous communities in monitoring marine megafauna, and are in turn summarised in Table 3 as priority indicators.

As highlighted in the above section on "*Collection, management and safe storage of survey data*", monitoring the abundance of marine megafauna does not end with field survey activities as data needs to be compiled, quality controlled, analysed, interpreted and reported. Both activities are "two sides of the same coin" and, in reality, require equivalent resourcing and commitment to ensure that results are used to assess the success or otherwise of management responses. The number of communities that use more enhanced data management systems

and trained operators were flagged as potential performance indicators, along with the number of reports that contribute to national, regional, local and community-based planning processes. Critical questions would be, “what is the real impact of the monitoring program and do the benefits justify the costs?”

Table 3. Potential priority indicators for participatory monitoring of culturally important marine megafauna in the Great Barrier Reef. The Objective of this RIMReP component is to increase participation by Indigenous ranger groups in megafauna monitoring in the Reef.

Activities	Outcomes	Priority indicators
* Support development of Indigenous ranger programs for Aboriginal corporation * Provide training and skills * Employ Traditional Owners in ranger programs * Develop long-term partnerships with research agencies (for example, government, universities – see JCU dolphin case study, CSIRO) * Seek external funds for employment, training and infrastructure (for example, boats and survey equipment)	* Enhanced sea country management * Increased employment and economic opportunities * Enhanced conservation and management of megafauna species and their habitats *Enhanced management of cultural harvests	* Increase in number of ranger groups participating in monitoring; increase in numbers overall * Increase in number of rangers within each group and overall number that complete relevant training * Increase in number of Indigenous tertiary-trained scientists working on monitoring programs * Number of effective partnerships with research organisations * Number and level of successful funding applications * Number and type of land and sea management activity undertaken
* Transfer of Indigenous cultural knowledge of megafauna and their places from Elders to children	* Survival of stories, language and culture in relation to marine megafauna	* Number of Elders and children where appropriate participating in surveys in surveys *Number of public communications events associated with monitoring * Number of cultural knowledge transfer events
* Manage and monitor threats to natural and cultural values (for example, crown-of-thorns starfish, water quality, marine debris/ghost nets, strandings)	* Enhanced sea Country management * Increased employment and economic opportunities * Enhanced conservation and management of megafauna species and their habitats	* Amount of marine debris/ghost nets removed from seas * Number of stranding events assisted with * Reduced density of crown-of-thorns starfish in high value areas * Area of coral reef rehabilitated * Sustainable levels of cultural harvests maintained
* Undertake an infrastructure and capability audit and evaluation of organisations ability to safely store, manage, retrieve, analyse and report monitoring data * Provide capability training in data management, IP licencing, including GIS and use of data bases and appropriate software	* Direct pathway of monitoring data to management responses leading to more effective management outcomes	* Number of ranger groups/communities that use more effective data storage and management systems * Number of trained data management operators * Number of contributions by ranger groups to national, regional, local and community-based planning processes * Demonstrated impact of monitoring data in management outcomes

11.0 Resources Required for Participatory Monitoring

ABC News online (Rebgetz and Gartry 2018; http://www.abc.net.au/news/2018-04-29/great-barrier-reef-$500m-package-to-preserve-area/9708230) reported on 1 May 2018 that the Federal Minister for Environment and Energy, Josh Frydenberg, announced a $500 million funding package for Reef management including:

- $40 million for enhanced reef health monitoring and reporting (RIMReP); and
- $45 million for community engagement such as Indigenous traditional knowledge for sea country management.

Both allocations are highly relevant to this review, although a detailed breakdown of the total $85M package is currently unknown, nor is the duration of the investment. Further details are provided on *The Conversation* website (J. Brodie 3rd May 2018; https://theconversation.com/500-million-for-the-great-barrier-reef-is-welcome-but-we-need-a-sea-change-in-tactics-too-95875).

Estimates of costs for any monitoring and reporting program in high-value conservation estates such as the Reef are obviously critical, particularly in light of the recent funding initiative. At this stage, however, it would be premature to estimate appropriate resourcing levels required to implement participatory monitoring programs of culturally important species of megafauna in the Reef. Additional processes need to be undertaken to obtain further background information above what can be elicited from a rapid desktop audit. For example, a necessary first step would be direct consultation with Indigenous communities in the Reef to obtain agreement on priority indicators for participatory monitoring, concomitant with a comprehensive audit of the capacity of Indigenous ranger groups to undertake, or participate in, megafauna monitoring activities (for example, training and infrastructure, stage of Healthy Country or Indigenous Protected Area plans). More specific management and monitoring objectives than elicited to date are required and, following this, consensus on an appropriate program design at regional and local scales with respect to spatial and temporal sampling effort, consistency in methods and data, and the establishment of standards and protocols for data management and reporting. Institutional commitment to sustainable long-term resourcing levels is required to justify any initial level of investment. Furthermore, successful implementation and sustainability of participatory monitoring programs will critically depend also on effective partnerships between Indigenous groups and research organisations (for example, universities, government, CSIRO) in order to receive the best available strategic and tactical scientific advice on survey design and methods, statistical analysis of data, the integration of Indigenous cultural and local knowledge into assessment tools and, effective reporting and communication of results to national, regional and local stakeholders and planning frameworks. Therefore, realistic estimates of costs to develop and maintain effective research partnerships would need to be factored into overall estimates of resourcing levels at some stage, given that there are other and overlapping funding sources for scientific research. Research partnerships are also a critical component of continuous assessments of the effectiveness of monitoring information in influencing management decisions of marine megafauna and, needless to say, without this link monitoring activities become expensive activities without a clear purpose.

Nonetheless, very rough placeholder cost estimates are provided below for some community engagement and monitoring activities based on experience in the Kimberley and elsewhere, but should be treated with caution given that they are “back-of-the-envelope estimates” for field work undertaken in perhaps some of the most expensive and remote coastline in Australia. Operating costs in remote areas are assumed to be about 30 per cent of total costs that includes salary and overheads of all partnership organisations. A standardised format to derive cost estimates across different regions and organisations is required in order to provide accurate estimates of resourcing levels.

1. The National Environmental Research Program turtle and dugong boat-based monitoring project in the North Kimberley in partnership with 2 ranger groups (includes seagrass monitoring). $80,000 per year for two years, $40,000 per year or $20,000 per year, per ranger group (travel, boat hire, fuel). Total cost is approximately $67,000 per year, per ranger group/sea country monitoring site, including salary costs of ranger and technical research partners (x 10 people). Costs would be considerably less if boat hire was excluded (i.e. if rangers already had boats/operator training) and surveys were undertaken in less remote areas.

2. Western Australian Marine Science Institute dugong project, training and participation in the 2015 broad-scale North Kimberley aerial survey. The cost of a five-day training course on country is approximately $50,000 for 10 rangers participating in surveys, three scientific staff, four Ranger coordinators/Healthy Country managers, two training providers and one pilot and aircraft for practice surveys. Total training cost approximately $167,000.

3. Kimberley Land Council — CSIRO jointly facilitated Healthy Country Planning workshops to develop a regional assessment framework that incorporates saltwater and freshwater Healthy Country Planning targets. The aims of both workshops were to: assist all Kimberley ranger groups review Healthy Country Planning targets; help design future monitoring and evaluation programs and assess current programs; and to discuss methods to integrate Traditional Ecological Knowledge and scientific survey data for use in regional assessment frameworks (Kimberley Land Council - CSIRO 2015a,b). The Kimberley Land Council, CSIRO (Coastal program) and 14 Indigenous organisations and associated ranger groups in the Kimberley participated in both workshops. Operating costs including remote area travel (charter flights) were approximately $50,000, total cost of workshops $167,000 including salary of facilitators, preparation, travel and reporting. Costs would be greater if the salary cost of all Indigenous rangers were included (no available information).

More accurate costs estimates to undertake boat surveys including a training component for remote areas of the Reef are available from the JCU participatory monitoring project for inshore dolphins and other marine megafauna in north Queensland, but not reported here.

In summary, the general costs of developing, implementing and sustaining participatory in-water monitoring programs of marine megafauna based on small boat surveys throughout the Reef will realistically be high, particularly for remote areas. The costs of undertaking necessary community consultation and engagement processes focused on this component of RIMReP in the first instance, and the provision of infrastructure such as small boats, and comprehensive training packages for the life-times of these programs for all activities associated with monitoring. In particular, costs associated with data management, analysis and reporting must also be included in estimates of resourcing levels and cannot be

underestimated. An underlying assumption in the roll-out of any major megafauna monitoring program by Indigenous rangers groups is that there will be continued government funding to support existing ranger groups or to create new ones.

12.0 Recommendations

If our desktop assessment that there are few systematic in-water marine megafauna monitoring activities in the Reef outside of north Queensland is accurate, then this should be treated as an opportunity rather than a weakness given that it more than likely reflects past funding constraints rather than aspiration. There would basically exist a “clean slate” to develop and implement a well-coordinated and coherent strategic approach in partnership with Indigenous communities, using robust sample designs and consistent survey methods.

In general, we recommended that the objectives and design of the participatory megafauna monitoring component undertaken by Indigenous ranger groups address the following five critical and interdependent activities identified in our desktop assessment:

- Undertaking systematic standardised population-level surveys that are underpinned by a robust spatial and temporal sampling design;
- Adopting high standard protocols for data management and storage;
- Accessing scientific expertise to analyse and help evaluate monitoring data; and
- Reporting results at local, regional and national levels.
- Initiating training programs, or access to them, to support the above activities.

Although the scope and detail of this assessment is constrained by information collated from a desktop review, the following 10 specific recommendations are made:

1. As a follow-up of this desktop evaluation process, undertake a more comprehensive assessment involving direct engagement and consultations with Indigenous communities in the Reef with interest in participating in RIMReP. This is necessary to obtain confirmation and agreement on specific management and monitoring objectives, and priority indicators. Some communities may have already completed this step, whilst others may need to first identify specific management and survey objectives, and indicators.
2. Concomitantly undertake a comprehensive audit of the capacity of Indigenous ranger groups to participate in, or lead, megafauna monitoring programs in relation to the four critical activities outlined above (for example, training, infrastructure and stage of Healthy Country or Indigenous Protected Area plans).
3. Assess training needs to undertake RIMReP megafauna monitoring programs by Indigenous ranger groups following the capability audit, and develop and implement training courses to meet these needs, preferably certified training courses.
4. Initiate research to develop participatory methods to integrate Traditional Ecological Knowledge of species of marine megafauna with scientific survey data, for incorporation into monitoring and evaluation frameworks such as DPSIR.
5. Investigate the potential of other integrated monitoring and risk assessment frameworks available to help manage cumulative risks to populations of marine megafauna from multiple pressures including customary take.
6. Design and implement a coordinated, systematic and cost-effective participatory in-water megafauna monitoring program in partnership with Indigenous ranger groups. The design must satisfy RIMReP requirements with respect to spatial and temporal sampling effort at both local and regional scales, consistency in methods and quality of data collected. Additional design requirements should be the adoption of robust

standards and protocols for data management and sharing, storage, access and reporting, and all be subject to regular audits.

7. The design phase of in-water monitoring of dugong populations throughout the Reef should be guided by the results of long-term aerial survey data collected by JCU. Time series data on broad-scale distribution and abundance patterns may help identify high priority areas for more frequent local surveys in relation to existing pressure/threats to dugongs and seagrass, or highlight gaps in ecological knowledge such as seasonal habitat use or population structure. Additionally, with the view of combining all data and information, Traditional Owners could identify high priority areas for more intensive in-water monitoring of sea turtles and dugongs based on their knowledge of customary harvesting activities.
8. Develop and implement "seagrass watch" type monitor programs for ranger groups to help assess the condition of seagrass and other benthic habitats at local megafauna monitoring sites, and derive indicators of pressures/threats to these habitats. Such data may complement other existing or planned seagrass monitoring programs undertaken by various research providers with this expertise (for example, see Udy *et al.,* 2018).
9. Where required facilitate effective partnerships between Indigenous ranger groups and research organisations (for example, universities, government, CSIRO) in order to ensure that the best available scientific advice is obtained on survey design and methods, analysis of data, integration of cultural and local knowledge into assessments and decisions (see Recommendation 4), and effective reporting of results for national, regional and local planning frameworks.
10. Derive comprehensive and realistic cost estimates to implement and maintain the participatory monitoring program, including costs associated with: administration; infrastructure (for example, boats, data loggers, drones, cameras); operational (travel and fuel); salaries/overheads; training; forming and maintaining research partnerships (will entail benefits also); and essential research.

13.0 Summary and Assessment of Report Objectives

The specific objectives of the draft report for Indigenous participation in megafauna monitoring are self-assessed below, and are summarised from previous sections so repetitive.

An assessment of the current status of Indigenous cultural values of megafauna relevant to the Reef, including an evaluation of primary drivers, pressures and responses using the Drivers, Pressures, State, Impacts, Responses (DPSIR) framework.

Indigenous participation in RIMReP is an inseparable component of the Reef 2050 Plan. An overview of Traditional Owner groups in the Reef that have strong cultural connections to megafauna, particularly sea turtles and dugongs, is presented and highlights their aspiration to participate in RIMReP in order to effectively manage current and future pressures or threats to natural and cultural values. The generic DPSIR framework provided the context for the desktop review and assessment of both the condition of marine megafauna populations as indexed by abundance, and the level of Indigenous participation in the monitoring of culturally important species (details below).

An assessment of the current status of Indigenous community participation in the monitoring of megafauna population condition with reference to the DPSIR framework.

About 20 per cent (9/44) of Traditional Owner groups in the Reef were identified as participating in megafauna monitoring activities, mostly through ranger programs. However, apart from detailed reports of dolphin and dugong boat surveys undertaken by JCU in partnership with five north Queensland Traditional Owner groups representing 11 per cent of Traditional Owner groups, we found no other documentation for the other four Traditional Owner groups. For example, details on the nature of any collaborative partnerships, funding sources, monitoring methods and species surveyed, the spatial locations of survey sites and activities, and data availability and custodianship. The boat surveys for dolphins in north Queensland represent approximately 56 per cent (5/9) of the Indigenous organisations that report monitoring results and, assuming that these figures are accurate, may reflect a combination of factors such as a lack of opportunity for the other four ranger groups, or lack of current organisational capacity to develop and implement monitoring programs at a level that will satisfy RIMReP requirements in terms of a robust design and consistent methods. Another interpretation may be that these unreported monitoring activities are in fact reported elsewhere, either in inaccessible parts of the grey literature or through collaborative partnership arrangements with government agencies, non-government organisations or university researchers, and this needs to be ascertained in follow-up assessments. Needless to say, our assessment should be treated with caution given the inherent limitations of using information only collated from a desktop review. The apparent absence of widespread participation in megafauna monitoring activities, however, provides an opportunity to implement a coordinated and standardised approach across the Reef from the outset, and this is advocated in this review and reflected in our recommendations.

We note that of the 35 Traditional Owner groups that did not apparently undertake any monitoring activities, it cannot be assumed that they do not want to participate in megafauna monitoring in future, or that information discovered (or not discovered) in our desktop review is accurate. Hence, more information is required to correctly interpret the results of our desktop review and assessment. One thing is certain, however, and that is all Traditional Owner groups in the Reef have expressed clear aspiration to become involved at some level in RIMReP (see Jarvis *et al*. 2018 draft).

Identification of potential priority indicators that may be relevant to monitoring components of the DPSIR framework in relation to key Indigenous cultural values associated with megafauna.

Whilst the components or species groups of the megafauna theme will develop their own performance indicators for monitoring purposes, they will essentially all be underpinned by estimates of population abundance and trends in abundance as defined in the initial RIMReP scope (i.e. The RIMReP megafauna reporting requirements will be primarily focused on population level monitoring). The use of population abundance, and in some examples the condition of their habitat, as appropriate indicators of the health of culturally important megafauna species is reflected in existing monitoring activities undertaken by

Indigenous ranger groups in north Queensland. Hence, all components of the megafauna Theme that encompass culturally important species, particularly Indigenous-catch monitoring, will likely be consistent with the range of potential population-level indicators proposed for the megafauna Theme. Additionally, the relevant outcomes, objectives and targets of the Reef 2050 Plan specific to participatory monitoring of culturally important megafauna species will likely be consistent also with RIMReP Cultural Heritage values, aspirations for protection of these values and potential indicators as reported by Jarvis *et al.* (2018 draft).

General information on Traditional Owner aspirations in the Reef to develop potential indicators for monitoring and managing the health of sea Country was distilled from case studies reported in Jarvis *et al.* (2018 draft) compiled from published and unpublished sources (from the Reef and elsewhere). Only two of 11 examples related to development and application of specific population-level abundance indicators of marine megafauna in relation to cultural health, and both were for dugongs (Bayliss and Hutton *et al.,* 2017) and sea turtles (Jackson *et al.,* 2015) in the Kimberley, Western Australia. A characteristic of both these studies is that a comprehensive consultation and engagement process was undertaken with each Indigenous ranger group and was designed by research partners to specifically target development of robust population-level indicators. The other examples reported by Jarvis *et al.* (2018 draft) were more aspirational, indicating that further consultation and engagement are required to develop specific indicators of species and habitat health acceptable to the community and reporting agencies. In contrast, Jarvis *et al.* (2018 draft) also report examples of more specific potential indicators related to Traditional Owner well-being in the Reef in relation to marine megafauna and their habitats (Appendix 2), and was also compiled from published and unpublished sources. These more targeted examples focus on the following attributes that appear to satisfy requirements for RIMReP megafauna performance indicators and, additionally, they all fit comfortably within the DPSIR framework:

1. A focus on using species abundance to monitor culturally important megafauna species (for example, numbers of crocodiles, dugongs, dolphins, sea turtles), and that for introduced species (for example, crown-of-thorns starfish);
2. Use of concomitant indicators of the condition of megafauna habitat (for example, seagrass, corals), including monitoring potential impacts from development pressures (for example, water quality, dredging, sedimentation, marine debris/ghost nets), and the effects of these pressures on the sustainability of customary harvesting and harvesting *per se*;
3. Concomitant use of indicators of cultural and socio-economic benefits derived from engagement and participation in monitoring. For example, participation by Elders and children that facilitate transfer of cultural knowledge, and the creation of employment, training, education and economic opportunities.
4. Specific monitoring indicators that capture these attributes are summarised in Table 3 (for example, number of dolphins/effort of survey, reduction in number of crown-of-thorns starfish, number of training courses completed) and, while proposed as priority indicators they are only indicative but a good start.

Our review highlights also the critical role of consistent collection, management and safe storage of survey data. Field survey activities, and data management and reporting activities, are here considered "*two sides of the same coin*" with respect to RIMReP

objectives and, therefore, requires equivalent resourcing and commitment to ensure that results are actually used to assess the efficacy of management responses. The number of communities that use more enhanced data management systems and trained operators are flagged as critical performance indicators, along with the number of reports that contribute to national, regional, local and community-based planning processes. In summary, key questions would be - what is the real impact of the monitoring program for the conservation and management of the megafauna target species, do the benefits justify the costs, and what type of indicator can we use to undertake continuous evaluations of "*path to impact*"?

Identification and assessment of current and potential sources of monitoring data to address identified priority indicators.

Apart from the comprehensive monitoring reports primarily for inshore dolphins and dugongs by JCU (Beasley *et al.,* 2013, 2014a and b, 2016a-c, 2017a and b) undertaken in partnership with five north Queensland Traditional Owner groups (Girringun Aboriginal Corporation, Mandubarra Aboriginal land and Sea Inc., Dawul Wuru Aboriginal Corporation, Jabalbina Yalanji Aboriginal Corporation and the Yintjingga Aboriginal Corporation/Lama Lama rangers), no other sources of monitoring data were identified. However, this does not mean that other useful data sources are unavailable and, to be certain, a more comprehensive follow-up 'data discovery' process is required.

Training in field survey methods including species identification was undertaken with Indigenous ranger groups prior to JCU with respect to transect location, survey speed and effort, observers and associated environmental survey conditions including the collection of water quality samples.

An appraisal of the adequacy of existing monitoring activities to achieve the objectives and requirements of RIMReP.

As stated for Objective 4 above, the only existing in-water megafauna monitoring activity that can be appraised are the dolphin surveys in north Queensland by JCU. Whilst they set a high standard both scientifically and with respect to high level of participation by Indigenous ranger groups, and no doubt present a 'Best Practice' model for this component of RIMReP, this positive assessment may not apply to the rest of the Reef (i.e. central and southern Reef) if we have discovered through desktop searches that these are the only documented monitoring programs available. In summary, the coverage in existing monitoring activity by Indigenous ranger groups in the Reef may vary between 11 per cent (5/44) and 20 per cent (9/44), and for those that satisfy RIMReP requirements only 11 per cent. However, without a Reef-wide regional plan with carefully thought out management and survey objectives specific to enhancement of the conservation status of the full range of culturally important marine megafauna species, it is difficult to place our overall assessment in this report into perspective given that there is currently no context.

Recommendations for the design of an integrated monitoring program as a component of RIMReP, specifically considering.

The management information requirements for culturally relevant megafauna species in the Reef to ensure that appropriate data and information are being collected to meet the fundamental objectives of RIMReP.

General and specific recommendations addressing management information requirements for culturally relevant megafauna species in the Reef collected by Indigenous ranger groups needed to satisfy RIMReP objectives are outlined in detail in the Recommendations section.

The spatial and temporal sampling design (including logistics) to ensure effectiveness and efficiency of participatory data collection.

As stated in Objective 5 above it is currently not possible to recommend a spatial and temporal sampling design to ensure effective collection of data by Indigenous ranger groups for RIMReP conservation and management purposes, and to simultaneously enhanced/improve levels of participation throughout the Reef. Nevertheless, the case studies presented in this review for in-water monitoring of marine megafauna, both within and outside the Reef, demonstrate clearly that there exists much technical expertise in Australia to help develop cost-effective and efficient monitoring programs for Indigenous rangers that would satisfy robust spatial and temporal design principles required by RIMReP. This activity forms one of the key recommendations of this report.

Resources and effort required to implement the recommended monitoring design (for example, likely funding sources).

In summary it was concluded that it would be premature to estimate appropriate resourcing levels required to implement participatory monitoring programs of culturally important megafauna species in the Reef given the paucity of background information. Additionally, more comprehensive consultation processes need to be undertaken to obtain further background information on objectives, activities, desirable outcome and agreed indicators for monitoring, above what was obtained from a rapid desktop audit, and these are detailed above.

Our review highlights also the critical role of consistent collection, management and safe storage of survey data and we suggest that, with respect to RIMReP objectives, these activities should secure equivalent resourcing and commitment to ensure that monitoring data are used to assess the efficacy of management responses.

14.0 Appendices

14.1 Appendix 1. Potential megafauna indicators for sea Country management by Indigenous rangers.

Summarised from Appendix 4 in Jarvis *et al*. (2018 draft) comprising published and unpublished sources of information.

Source	**Notes**
Shortland, T (2011) Cultural Indicators for Kauri Ngahere. Repo Consultancy Ltd.	Original info source for a case study presented in Forest Peoples Program report. Well-explained information on indicators and the processes used to identify appropriate indicators for Kauri Ngahere. This document also provides a bibliography from their review of cultural indicators.
Yuku Baja Muliku work plan - 2017	Lists work undertaken by Yuku Baja Muliku, including a range of monitoring projects (but not usually the specific indicators used).
Reporting Template	A reporting template apparently for use by Land and Sea Rangers or QPWS Departmental Staff. Sets out some possible indicators for the state of sea bird populations on Michaelmas Cay, as well as for involvement by Traditional Owner elders, knowledge exchange and so on. Not apparently Traditional Owner-driven.
Birdlife Australia eastern bird survey form	Provides examples of the types of indicators that could be used to collect information about the state of birds. Not apparently Traditional Owner-driven.
Michaelmas Cay Survey Form	Detailed field data sheet presenting a range of indicators used by QPWS to record information about sea birds on Cays. Not apparently Traditional Owner-driven.
Bayliss P, Woodward E and Lawson TJ (2015). Integrating Indigenous knowledge and survey techniques to develop a baseline for dugong (*Dugong dugon*) management in the Kimberley: Milestone Report 2/2 of Project 1.2.5 of the Kimberley Marine Research Program Node of the Western Australian Marine Science Institution, Western Australian Marine Science Institute, Perth.	Project Milestone report on results and outcomes of project. Main aim was to help develop culturally appropriate and more effective monitoring and decisions support tools for dugong management. Used Bayesian approach to integrate indigenous knowledge and western scientific knowledge. Indigenous knowledge was gathered using 2 hour interviews; Interview report held in confidence, so the indicators used are not known. Not apparently Traditional Owner-driven.
McMillen, H. L. et al. Small islands, valuable insights: systems of customary resource use	Discusses values of traditional knowledge in the context of resilience. Considers limitations of traditional knowledge as well.

Source	Notes
and resilience to climate change in the Pacific. *Ecol. Soc.* **19**, 44 (2014).	
Gidarjil Development Corporation http://www.gidarjil.com.au/what-we-do/caring-for-country	Website lists Caring for Country objective and associated activities.
Djunbunji Land and Sea Program http://www.gidarjil.com.au/what-we-do/caring-for-country	Website contains Indigenous Protected Area, including info about priority concerns.
Dawul Wuru Aboriginal Corpopration and Yirrganydji People (2014) *Yirrganydgji Kulpul-Wu Mamingal "Looking after Yirrganydji Sea Country"*	Sets out many of the concerns (for example, lack of recognition of Traditional Ownership, exclusion of Traditional Owners from governance arrangements) that may be addressed through appropriate implementation of Traditional Owner- driven monitoring. Doesn't specifically identify suitable indicators but Section on Key Concerns mentions a range of issues amendable to monitoring.
Jackson M. *et al.* (2015) Developing collaborative marine turtle monitoring in the Kimberley region of northern Australia. *Ecological Management and Restoration* **16**, 163-176	Provides background info supportive of using/integrating traditional ecological knowledge into conservation research and management. Describes 3 day form held by the North Australia Indigenous Land and Sea Management Alliance which included discussion of Traditional Owner-based indicators of marine turtle populations, although survey methodology seemed to be largely based on western science (Traditional Owner knowledge informed locations).

14.2 Appendix 2. Examples of selected potential indicators related to Traditional Owner well-being.

Summarised from Appendix 5 in Jarvis *et al.* (2018 draft) comprising published and unpublished sources of information.

Summary of examples from reviewed data sources		
Overarching Issues	**Example Approaches**	**Example indicators**
Create more opportunities to support transfer of cultural knowledge to young people.	Yuku Baja Muliku Junior Ranger program with school-age children. Girringun Rangers engage with Elders in planning and management and operate a Junior Ranger program. Gidarjil undertake surveys with Elders and archaeologists seasonal calendars.	Number of Elders participating in survey; knowledge or stories exchanged. Number children/elders engaged in on-country activities/ programs; number of events.
Create more training and skill- building opportunities and take up for Traditional Owners in relation to: b) Land and sea country management. c) Employment and economic business related to monitoring.	Yuku Baja Muliku develop and implement Ranger training program; facilitate one exchange visit with another Indigenous Ranger group Collaboration between Land and Sea rangers, Traditional Owners and western scientists to build capacity in scientific data collection Girringun engage with relevant authorities to plan to lead action on natural disaster recovery Gidarjil participate in Regional Ecosystem Bio-condition survey with DERM	Number of new qualifications/ training sessions/ exchanges/ participation in survey team
Create more employment opportunities and take up of these by Traditional Owners in monitoring programs as: a) Land and Sea rangers b) employees in other programs	Indigenous peoples, selected according to cultural protocols[2] conduct monitoring of sustainable use of resources, the protection of cultural heritage sites, sensitive habitats.	Area of land and sea country patrolled

Summary of examples from reviewed data sources		
Overarching Issues	**Example Approaches**	**Example indicators**
c) contractors d) cultural advisors/mentors	Yuku Baja Muliku Rangers patrol to deter unlawful take of fish, turtle and dugong, illegal camping, to regulate visitor use and maintain campgrounds Girringun patrol Traditional Use of Marine Resources Agreement (TUMRAs) area, work with marine management and compliance agencies to delivery TUMRA implementation plan.	
Understanding the effects and sustainability of traditional fishing, hunting and harvesting practices in the context of other uses and management of the Reef [2]. Depletion of traditional marine resources	Djunbunji seek to monitor their use of dugong and sea turtle. Djunbunji seek to develop agreements to share resources among Djunbunji people, based on their monitoring and management. http://www.forestpeoples.org/customary-sustainable-use-studies Improve awareness of the importance of Traditional Owner knowledge and systems of customary sustainable use.	Are common marine resources managed sustainably, through locally supported customary management systems?
Marine turtle numbers	Yuku Baja Muliku monitor using EHP protocols Girringun monitor and tag nesting turtles with JCU and others Gidarjil monitor and relocate nests, tag, undertake habitat management of turtles at Mon Repos with EPA	
Dugong numbers	Girringun establishing culturally assured and agreed dugong monitoring with JCU	Yuku Baja Muliku record the number of dugong sightings while undertaking other work at Archer Point.
Concern about habitat loss and degradation for sea turtles and dugong, especially seagrass meadows	Undertake seagrass monitoring for example,, YBN and Girringun use Seagrass Watch methodology	

Summary of examples from reviewed data sources		
Overarching Issues	**Example Approaches**	**Example indicators**
	(Yuku Baja Muliku: 4x/year at 2 sites, 3 transects per site; Girringun at Goold Island).	
Crocodile numbers (saltwater, freshwater)	Yuku Baja Muliku undertake at least 2 spotlight croc surveys in Annan River using Charles Darwin Uni methodology[7]	Number of crocodiles
Dolphin numbers	Girringun establishing culturally assured and agreed monitoring system for dolphins with JCU	
Effects of priority introduced species (for example, crown of thorns starfish) or other threats (for example, ghost nets) on natural systems and Traditional Owner cultural economy, for example, food systems.	Yuku Baja Muliku monitoring ghost nets, illegal camping Girringun survey and record marine debris; feed into Tangaroa Blue Guna monitoring of Lionfish in Panama, involving working with commercial fishers to develop participatory mapping	Percentage of households in the community with stable food supply throughout the year Percentage of the food species sourced in the past that are still present at a site. Would you return to the site in the future to harvest/hunt?
Management of marine animal strandings	Example: Gidarjil work with QPWS to respond to strandings	
Declining coral health due to crown of thorns, bleaching and so on [25]		
Alternation of natural flow, dredging and dumping, acid sulphate soils etc. in catchment areas	Effects on marine and terrestrial species; nursery areas	
Excess nutrients and pollution entering freshwater and marine waters		

14.3 Appendix 3. Integrating Indigenous and scientific knowledge of dugongs

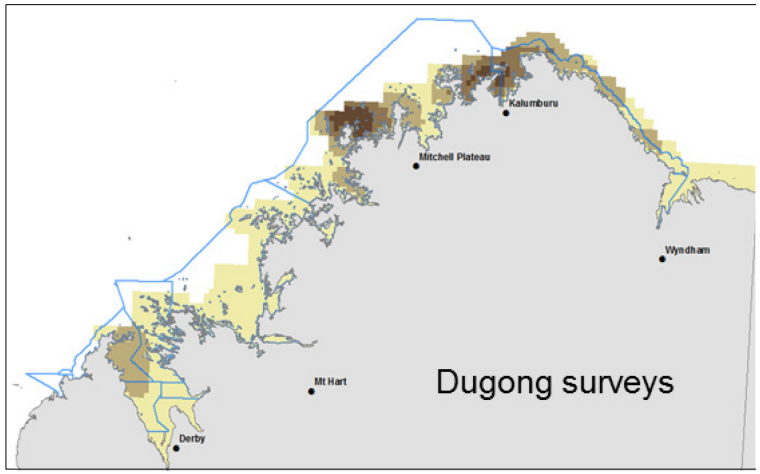
The Western Australian Marine Science Institute dugong project in the North Kimberley (2012-2016) provides a case study for integrating Indigenous and scientific knowledge of dugongs (see Bayliss and Hutton 2017 for a summary). The project aimed to develop culturally appropriate and potentially more effective monitoring and decision support tools for the co-management of dugong populations requiring new approaches. The use of Bayesian probability methods that recognise both the intrinsic value of expert knowledge and quantitative data was one approach that was assessed, and has been used extensively to integrate knowledge from a variety of sources. For example, McGregor *et al.* (2010) integrated Indigenous Ecological Knowledge of traditional wetland burning practices on Kakadu National Park with scientific knowledge of vegetation-fire responses using a Bayesian Belief Network. Bayesian Belief Networks that graphically and transparently highlight the contributions of all knowledge sources is a powerful tool that facilitates stakeholder engagement and communication for natural and cultural resource management (for example, van Putten *et al*., 2013; Bayliss *et al.,* 2018). The Bayesian approach has proved versatile in almost every ecological field that involves making decisions in the face of risk and uncertainty, and variability in scientific data and complex social and biophysical systems.

A major constraint to the identification of important dugong areas in the Kimberley for future monitoring and management purposes is the inherent uncertainties and measurement errors normally associated with the collection of observational data over very short time frames. Hence, a Bayesian approach was used to integrate “instantaneous” slices of scientific data with Indigenous Knowledge accumulated over millennial time-scales that encompassed all seasonal conditions. Bayesian probabilities of the likely occurrence of dugongs in the Kimberley were derived from three available and different knowledge sources for each five-kilometre grid cell that covered the survey area. These were: (i) the 2015 aerial survey data (Figure A6a; probabilities derived from re-scaled abundance data from zero to maximum value); (ii) a seagrass map derived from satellite images (here only the “likely” seagrass class, Figure A6b; probabilities were derived from the per cent cover of seagrass/grid cell; and (iii) the intersection of cultural hunting areas with the data grid (Figure A6c; hunting areas were allocated a probability of 1.0 and non-hunting areas 0). Derivation of the joint intersection (Pj) where all three sources of dugong knowledge occur together using Bayesian statistics is illustrated in Figure A7 (note: Pj can occur in other combinations, just 1 or just 2 or all 3; see equation).

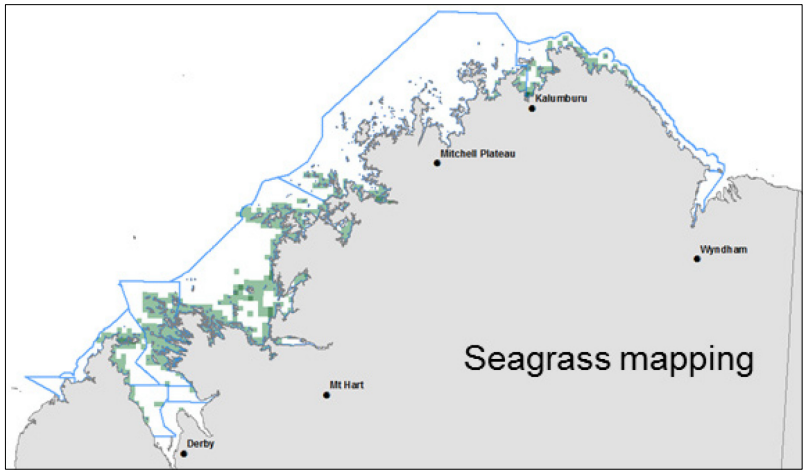
Figure A8 maps the combined probabilities of dugong occurrence across the survey grid using all currently available knowledge sources, and highlights important areas. Whilst it is only a “first pass” probability map it can be continually updated with new information (called “priors”) such as: dugong cultural maps for other sea countries; increased calibration and validation of the preliminary seagrass map; and additional aerial surveys in smaller areas in other seasons to capture possible seasonal differences. The Bayesian approach to mapping probabilities of dugong occurrence that integrates all available spatial knowledge sources, particularly Traditional Ecological Knowledge, may be a useful approach to identifying important dugong areas in the Kimberley given inherent limitations associated

with “one-off” baseline scientific surveys. For example, because of the high cost of undertaking broad-scale aerial surveys over large geographic areas they are generally done at low sampling intensity (approximately six per cent in the Kimberley), in one month (season) and, on average, about 10 years thereafter depending on funding. A powerful advantage of the Bayesian approach, however, is that it facilitates continuous updates with new information, or “priors”, which is simply adaptive monitoring and management (Holling, 1978; Walters, 1997). In particular, it would be important to update cultural hunting maps through interviews with a wider range of hunters and to elicit more targeted and specific information on the seasonal use of hunting sites, associated catch and effort statistics and Traditional Ecological Knowledge specific to seasonal patterns in dugong distribution and abundance.

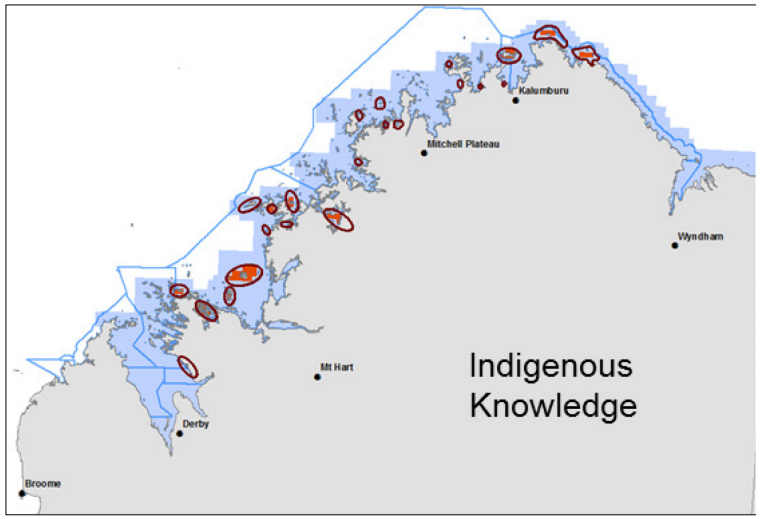
(a)



(b)



(c)



(d)

Probability of dugong occurrence by cultural site by GRID
Pc
0
1
Probability of dugong occurrence by seagrass by GRID
Psg
0
0 to 0.15
0.15 to 0.30
0.30 to 0.60
Probability of dugong occurrence by aerial survey by GRID
Pd
0 to 0.25
0.25 to 0.50
0.50 to 0.75
0.75 to 1.00

Figure 5 a-c. Integrating Indigenous and scientific knowledge using Bayesian probabilities: (a) probability of dugong occurrence across a 5-kilometre grid based on corrected density estimates derived by aerial survey; (b) probability of occurrence of likely seagrass based on percentage cover; and (c) probability of occurrence (1.0 or zero) based on known cultural hunting sites (from published Healthy Country Plans). Joint probabilities were derived for each 5-km grid cell. The location of Native Title sea country boundaries are shown. From Bayliss and Hutton (2017).

The Bayesian probabilities are joint conditional probabilities (Pj) of the interaction between the three for all possible combinations (Pc cultural; Psg seagrass; Pd dugong abundance), as illustrated in the Venn diagram (Figure 6) below and the formula.

$$Pj = Pd + Psg + Pc - (Pd * Psg) - (Pd * Pc) - (Pc * Psg) + (Pd * Psg * Pc)$$

Figure 6. Venn diagram showing the joint intersection (Pj) when all three sources of dugong knowledge occur together (note: Pj can occur in other combinations, just 1 or just 2 or all 3; see equation). From Bayliss and Hutton (2017).

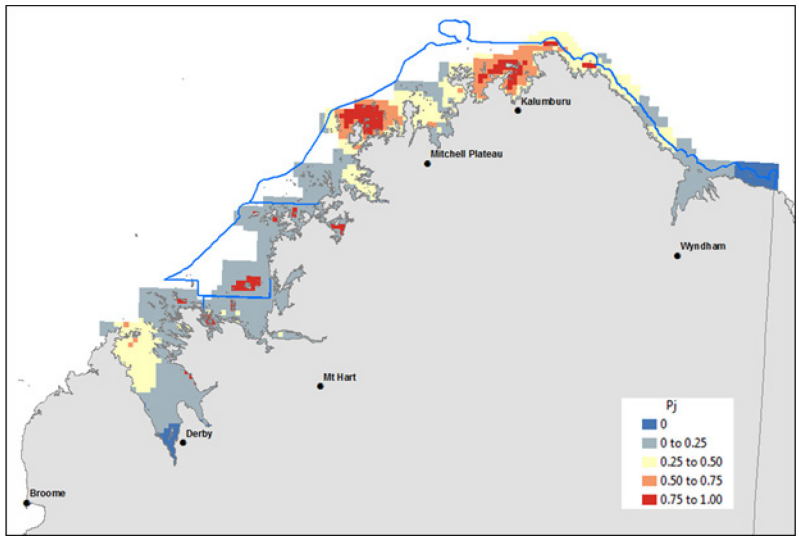


Figure 7. Likelihood of dugong occurrence. Map of Bayesian probabilities of dugong occurrence across a 5-kilometre survey grid combining Indigenous Ecological Knowledge (hunting sites), a Landsat-derived map of seagrass extent and 2015 aerial survey data. The boundaries of State marine parks in the North Kimberley are shown. Red colours denote high probabilities of occurrence and blue colours low. From Bayliss and Hutton (2017).

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