

Research & Reviews : Journal of Ecology and Environmental Sciences

An Evaluation of the Marine Zoning and Aquaculture Plans in the Great Sandy Region, Australia: Indicators for Successful Integrated Coastal Zone Management

Danielle Scriven

A Marine Affairs Program, Faculty of Science, Dalhousie University, 1355 Oxford Street, Halifax, Nova Scotia, Canada

Research Article

Received date: 15/07/ 2015

Accepted date: 20/08/ 2015

Published date: 25/08/2015

*For Correspondence

Danielle Scriven, A Marine Affairs Program, Faculty of Science, Dalhousie University, Life Sciences Centre, 1355 Oxford Street, Halifax, Nova Scotia, Canada

E-mail: danielle.scriven@dal.ca

Keywords: Great sandy region, Fraser Island, Integrated coastal zone management (ICZM), Indicators.

Abbreviations: DEEDI – Department of Employment, Economic Development and Innovation, GBRMP – Great Barrier Reef Marine Park, GSMPZP – Great Sandy Marine Parks Zoning Plan, GSRMAP – Great Sandy Regional Marine Aquaculture Plan.

ABSTRACT

The Great Sandy Region is a pristine sandy area off the eastern coast of Queensland, Australia. Due to the unique make-up of the region, integrated coastal zone management (ICZM) is evident: there are many management plans in place to ensure the longevity of the region's natural resources. In this paper, qualitative environmental indicators were used to evaluate the strengths, weaknesses, and gaps in the Great Sandy Marine Park Zoning Plan (GSMPZP) and the Great Sandy Regional Marine Aquaculture Plan (GSRMAP). The GSMPZP is extremely comprehensive in nature, yet fails to define its overarching goal, and failed to involve the public during the planning process. Conversely, the GSRMAP demonstrated public participation and transparency throughout its planning process, yet fails to define maximum culture density of the aquaculture sites: this has serious implications for the health of the surrounding environment. It is recommended that, in the future, the GSMPZP adopt an adaptive management practice and involve the public in the planning process. Additionally, it is recommended that the GSRMAP explicitly defines maximum allowable culture density, and monitors the region closely after aquaculture begins to avoid regional environmental degradation.

INTRODUCTION

The Great Sandy Region

The Great Sandy Region is located off the eastern shore of Queensland, Australia, and spans approximately 840,000 hectares ^[1]. The Great Sandy Region is made up of Fraser Island, Noosa North Shore, the Cooloola sandmass, Hervey Bay, and the Great Sandy Strait ^[2,3]. The entire region is made up of wind-blown sand-masses, unique to anywhere else in the world ^[4]. The majority of dunes in the region are held in place by extensive vegetative coverage, most notably as rainforests on Fraser Island. Due to the sensitive composition of the area, and large number of tourists to the region each year, the sand dunes are susceptible to damage. Physical consequences include: shoreline instability, erosion, and a changing interaction between the dunes and the beach during severe storms ^[5].

Fraser Island and UNESCO Certification

Fraser Island is a unique place within the Great Sandy Region. It is the world's largest sand island, and is situated less than

5 km east from the coast of Queensland, Australia ^[6,7]. The island extends for 120 km, and hosts more than 300,000 visitors per year ^[5,6]. The biodiversity of the island is exceptional, and includes one of the largest and genetically purest dingo populations in the world ^[8,9]. Many management plans exist within Fraser Island and the Great Sandy Region to protect the fragile area from damage and to preserve its inherent beauty.

In 1992, Fraser Island was inscribed as a UNESCO World Heritage site ^[10]. The justification for including Fraser Island as a World Heritage site was twofold, according to original documents ^[11]. First, Fraser Island was inscribed for: “outstanding examples representing significant ongoing geological processes, biological evolution and man’s interaction with his natural environment” ^[11]. For instance, dune formation on Fraser Island is an ongoing geologic process, with formation beginning 730,000 years ago ^[4]. The diversity, age, and structure of Fraser Island’s dunes are exceptional and distinctive from anywhere else in the world ^[11]. Second, Fraser Island was inscribed for containing “unique, rare or superlative natural phenomena, formations or features of exceptional natural beauty” ^[11]. The combination of rainforests growing on sand dunes, wind-blown and colourful sand cliffs, swamps, freshwater lakes, and clear sandy oceans and beaches is believed to be unique to the world ^[4,6,11].

Aboriginal history is rich in the Great Sandy Region and on Fraser Island. Fraser Island has been occupied by Butchalla aboriginal peoples for at least the past 5,000 years, with some sources claiming more than 6,000 years ^[1,8]. Despite the length of occupation, aboriginal populations on Fraser Island never exceeded more than 2000 to 3000 people, even during peak periods ^[4]. Fraser Island was not colonized by Europeans until the 18th century. In May of 1770, Captain Cook sighted Fraser Island, although some (unconfirmed) sources believe that the Portuguese may have made landfall as early as 1521 ^[12]. Once the Europeans began colonizing the region, the natural landscape of Fraser Island underwent dramatic changes: in the years to follow, resource exploitation, including mining and logging, overtook Fraser Island. All of these exploitative activities ceased, however, when Fraser Island was nominated for UNESCO listing in 1991 ^[11].

Management Strategies in the Great Sandy Region

As an attempt to protect the resources in the area, the Great Sandy Region is subject to many regulations integrated into several management strategies. Management plans in the region include: the Great Sandy Region Management Plan, the Great Sandy Region Marine Aquaculture Plan, the Marine Parks (Great Sandy) Zoning Plan 2006, the Fraser Island Dingo Conservation and Risk Management Strategy, a beach camping plan, and a 4x4 vehicle use plan.

Plans for Evaluation

The two plans analyzed in this paper are the Great Sandy Marine Parks Zoning Plan (GSMPZP) and the Great Sandy Regional Marine Aquaculture Plan (GSRMAP). These two plans were chosen for evaluation as they are closely intertwined. For instance, the zoning plan stipulates what types of aquaculture are permissible in the Great Sandy Region, and which locations aquaculture is allowed to occur in. The significance of evaluating these two plans is twofold. First, the zoning and aquaculture plans directly affect marine resources in the region; critical evaluation can allow for the recognition of management gaps or shortfalls in each plan. The plans can subsequently be revised to address the gaps or shortfalls, allowing for more effective management. Second, integrated coastal zone management (ICZM) in Queensland is comprehensive; critically evaluating these management plans might provide ICZM ideas for managers in parts of the world where ICZM is needed or is not successful.

The GSMPZP was developed in 2006 by the Department of National Parks, Recreation, Sport and Racing, a division of the Queensland Government. The GSMPZP stemmed from the creation of Queensland’s Marine Parks Act in 2004 ^[13]. The GSMPZP divides the Great Sandy Marine Park into five different zones, and specifies allowable uses and activities within each zone. The five zones within the Great Sandy Marine Park are: general use zone, habitat protection zone, conservation park zone, buffer zone, and marine national park zone. Within each zone, uses are specified according to the level of permission granted to each user. There are nine areas set aside for special management, with some areas operating on a temporal scale ^[14]. These areas include, but are not limited to: go-slow areas, turtle monitoring areas, and whale management areas ^[15].

The GSRMAP was prepared by Fisheries Queensland, a division of the Department of Employment, Economic Development and Innovation (DEEDI). The GSRMAP was approved in 2010, and came into effect in 2011. The GSRMAP acts as a guideline for identifying appropriate aquaculture sites within the Great Sandy Region, and also functions as a reference for management ^[16]. The GSRMAP is a non-statutory framework for aquaculture management, but the provisions set forth by the plan are enforceable under existing legislation ^[16].

The only type of aquaculture supported by the GSRMAP is non-intensive aquaculture, otherwise termed extensive aquaculture, whereby no additional feed is added to the water to support species’ growth ^[16,17]. This type of aquaculture is allowable under the conditions set forth in 2006 by the ^[14]. Because the impacts associated with non-intensive aquaculture are considered to be low, an environmental impact assessment is not required (GSRMAP). Key species the GSRMAP allows to be cultured include: scallops, sea cucumbers, oysters, and pearls ^[15]. All of the sites proposed for aquaculture in the Great Sandy Region are in Hervey Bay. Hervey Bay covers an area of 3800km², and is protected from ocean swells by the southern portion of the Great Barrier Reef ^[18].

The purpose of this paper is to evaluate the effectiveness of the Great Sandy Marine Parks Zoning Plan and the Great Sandy Regional Marine Aquaculture Plan. By applying a set of ICZM indicators from a variety of sources, the strengths, weaknesses,

and gaps of each management plan are analyzed, and recommendations for future management are made. The effectiveness of each plan is analyzed by examining indicators, and exploring how they are used for ICZM evaluation. Drawing on the analysis, the accomplishments, drawbacks, and gaps within each plan are highlighted, and recommendations are made for future improvements to each plan, elaborating on how management could be more effective in the future.

MATERIAL AND METHODS

Indicators for Effective Evaluation

Indicators are measurable attributes that are used for the monitoring or assessment of environmental programs ^[19,20]. There are many indicators that can be used to evaluate the effectiveness of any given coastal management strategy. Depending on the management plan in question, the relevancy of indicators can change from strategy to strategy. In fact, no single set of indicators is applicable to all situations; they must be tailored to the environmental, governmental, and socio-economic conditions at play ^[21].

The indicators used to evaluate the effectiveness of the marine zoning and aquaculture plans in the Great Sandy Region have been accumulated from four separate sources: Pickaver, Gilbert, and Breton ^[22] Olsen ^[23]; Stojanovic, Ballinger, and Lalwani ^[24]; and Zafrin and Rosier ^[21]. Relevant indicators were chosen from the aforementioned sources because no two environmental indicator lists are the same, and thus, not every indicator is applicable to each management plan. By choosing indicators from a variety of sources, robustness and relevance during evaluation was ensured. In total, 33 indicators were chosen to evaluate the management plans in the Great Sandy Region. The indicators have been integrated into tables associated with each stage of the ICZM process to ensure a comprehensive analysis of the entirety of each plan, from the initiation stages to the evaluation and monitoring stages. All indicators utilized were qualitative indicators, and it is important to note that qualitative indicators are considered an acceptable alternative to quantitative indicators ^[20].

Pickaver, Gilbert, and Breton ^[22]

Pickaver, Gilbert, and Breton developed an indicator set to measure the progress of ICZM in Europe. Though developed for use in European ICZM, the indicators are appropriate to analyze coastal management around the world. The authors state that indicators are: “commonly used as management tools to define the nature and size of problems, set goals for their solution and track progress towards these goals” ^[22]. As a result, the authors developed a comprehensive list of 26 indicators to describe the progress of European ICZM. Ten of these indicators have been identified and integrated into **Tables 1 - 4** to evaluate the GSMPZP and the GSRMAP.

Table 1. Indicators to evaluate the strengths and weaknesses of the initiation phase in both the Great Sandy Marine Parks Zoning Plan (Zoning) and the Great Sandy Regional Marine Aquaculture Plan (Aquaculture).

Phase	Indicator	Zoning	Comments	Aquaculture	Comments
Initiation	1. Aspects of coastal management exist ^[22]	Yes	Great Sandy Marine Park, for instance, already exists	Yes	The Great Sandy and Hervey Bay regions previously supported sustainable aquaculture development
	2. Decisions about planning and management are governed by legal institutes ^[22]	Yes	Queensland Government; Department of National Parks, Recreation, Sport and Racing	Yes	Australian Government Department of Infrastructure, Transport, Regional Development, and Local Governments
	3. Funding is available for implementation ^[22]	Yes	Funding available from Queensland Government	No	Funding from government is not available. Funding is instead provided from commercial aquaculture investors
	4. Constituencies actively support the ICZM initiative (e.g., government, public) ^[23]	Yes	Department of National Parks, Recreation, Sport and Racing	Yes	Government supports aquaculture due to revenue opportunity
	5. Enabling legislation, policy or strategy ^[21]	Yes	Great Sandy Marine Parks Zoning Plan was developed as a result of the 2004 Marine Parks Act. Zoning Plan operates in accordance with Marine Parks (Declaration) Regulation 2006 and Marine Parks Regulation 2006 (State of Queensland, 2006c; 2006d)	Yes	For example, prepared by Fisheries Queensland (part of DEEDI), and operates in accordance with the Great Sandy Marine Park (2006) guidelines

Table 2. Indicators to evaluate the strengths and weaknesses of the planning phase in both the Great Sandy Marine Parks Zoning Plan (Zoning) and the Great Sandy Regional Marine Aquaculture Plan (Aquaculture).

Phase	Indicator	Zoning	Comments	Aquaculture	Comments
Planning	6. A long-term perspective plan has been developed ^[22]	Yes	No indication that marine zoning will cease in the future	Yes	Pilot projects must be 3 years in duration, GSRMAP scheduled for review every 10 years
	7. A sustainable development strategy is in place (includes precautionary and ecosystems approach) ^[22]	Yes	Restrictions on allowable uses in each zone demonstrates precaution	Yes	Queensland Government promotes sustainable aquaculture development, and promotes a risk-based management approach
	8. The institutional capacity necessary to implement the plan of action ^[23]	Yes	Department of National Parks, Recreation, Sport and Racing, Queensland Government	Yes	Department of Employment, Economic Development and Innovation (DEEDI)
	9. Clear and realistic goals identified ^[21]	No	Goals are specified within each zone, but there are no overarching goals listed; terms of reference lacking	Yes	"...to improve efficiency and certainty in the assessment and approvals process, whilst retaining the existing level of controls" (State of Queensland, 2011, p. 64)
	10. Collaborative, participatory, and transparent planning processes adopted ^[21]	No	Stakeholders not involved (or minimally involved) in planning phase; planning not transparent	No → Yes	Initially, permitting was done without community stakeholder involvement. This changed with the implementation the GSRMAP
	11. Effective stakeholder participation during ^[21]	No	See above (indicator 10)	Yes	Stakeholders were involved multiple times during the planning process

Table 3. Indicators to evaluate the strengths and weaknesses of the implementation phase in both the Great Sandy Marine Parks Zoning Plan (Zoning) and the Great Sandy Regional Marine Aquaculture Plan (Aquaculture).

Phase	Indicator	Zoning	Comments	Aquaculture	Comments
Implementation	12. Scientific and technical information is available to a lay audience without losing its validity ^[21]	Yes	The Queensland government has created a Great Sandy Marine Park Visitor Guide, which informs visitors of the zones and appropriate activities for each zone	Yes	The Government of Queensland has set up a website dedicated to explaining the GSRMAP in layperson's terms, while still maintaining its scientific validity (Queensland Government, 2012).
	13. Changes in behaviour of institutions and interest groups (e.g., collaborative planning) ^[23]	Yes	For example, the activities of tourists and tourism operators are restricted spatially and temporally in the whale management area	Yes	Collaborative planning now occurs between: DEEDI; Department of Agriculture, Fisheries, and Forestry; inter-agency working groups; focus groups
	14. Changes in behaviours directly affecting resources of concern (e.g., elimination of destructive fishing) ^[23]	No	While the plan has been implemented, resource exploitation still occurs	Yes	Non-intensive aquaculture development only
	15. Investments in infrastructure supportive of ICZM policies and plans ^[23]	N/A	No information available for evaluation	No	Guidelines in place, but infrastructure such as waste disposal is the responsibility of the commercial developer
	16. Diverse activities among institutions and projects are effectively coordinated ^[21]	Yes	The region is intricately zoned	No	GSRMAP allows only non-intensive aquaculture, commercial sites not yet announced (submissions currently being considered)
	17. Enforcement-appropriate penalties for non-compliance ^[21]	No	Plan does not explicitly state which governing body is responsible for enforcement	No	GSRMAP is non-statutory

Table 4. Indicators to evaluate the strengths and weaknesses of the monitoring and evaluation phase in both the Great Sandy Marine Parks Zoning Plan (Zoning) and the Great Sandy Regional Marine Aquaculture Plan (Aquaculture).

Phase	Indicator	Zoning	Comments	Aquaculture	Comments
Monitoring and Evaluation	18. Assessment of progress towards meeting sustainability goals is continuously made ^[22]	Yes	Plan was developed in 2004, commenced in 2006, and was updated in 2013	No	GSRMAP not set to be evaluated for 10 years; likely not soon enough to gauge progress
	19. Coastal zone monitoring sees a trend towards sustainability of resources and an overall improvement in coastal habitats and biodiversity ^[22]	Yes	Areas for special management improve the overall well-being of the species the GSMPZP was zoned to protect	No	The effects of non-intensive aquaculture on surrounding biodiversity have yet to be evaluated, but will likely be negative
	20. All specified actions have been implemented with problem areas given special attention ^[22]	Yes	Nine areas for special management identified and implemented	No	While the subject of non-intensive aquaculture has indeed been given special attention, aquaculture has not yet been fully implemented in the Great Sandy Region; thus the 'specified action' of implementing aquaculture has not yet occurred
	21. Re-evaluation of progress in implementing ICZM beings again automatically ^[22]	No	No indication that the GSMPZP is currently measuring its progress or using information gathered for re-evaluation	Yes	Demonstrated initially with the implementation of the GSRMAP
	22. Improvements in coastal ecosystem qualities ^[23]	Yes	Concentrated effort to protect at risk species, such as grey nurse sharks, whales, and turtles	No	Aquaculture is generally associated with ecosystem degradation (Cheshire, 2006)
	23. Improvements in societal qualities ^[23]	No	Places restrictions on areas of access	Yes and No	Job creation; loss of once unrestricted areas
	24. Equilibria among social and environmental qualities ^[23]	No	Enhanced quality of environment is the result of decreased use of coast by stakeholders (i.e. decreased social quality)	No	Difficult to predict, but environmental quality may decline as use of the region increases; no equilibria between environment and social quality

Olsen ^[23]

Olsen's indicators are different from other sets developed, in the sense that his indicators are split into First, Second, Third, and Fourth Order outcomes. For use in the analysis, these 'order outcomes' were translated into the phases of ICZM management: initiation, planning, implementation, and monitoring and evaluation. This was done with relative ease, as the indicators within the order outcomes are indicative of different phases of ICZM. According to Olsen, an example of a First Order outcome is: "constituencies that actively support the [ICZM] initiative" (2003). This particular indicator would generally be seen during the initiation phase of ICZM, and thus it appears in **Table 1**, the table dedicated to the initiation phase. Eight of Olsen's indicators have been integrated into **Tables 1 - 4**.

Stojanovic, Ballinger, and Lalwani ^[24]

Stojanovic, Ballinger, and Lalwani developed yet another set of ICZM indicators. The indicators that these authors developed are different from those used in the evaluation of ICZM stages, and they have been grouped into **Table 5**, separate from the ICZM phases. The indicators that Stojanovic^[24] developed have been grouped as 'ongoing' indicators, as they are witnessed throughout the duration of the plan. For instance, two indicators that Stojanovic ^[24] developed are 'cooperative' and 'adaptive'. These particular indicators are necessary throughout the duration of the plan for coastal management strategies to be effective. Nine indicators from Stojanovic et al. have been integrated into **Table 5**.

Zafrin and Rosier ^[21]

The final set of indicators used in the analysis was created by Zafrin and Rosier ^[21]. These indicators are unique in that they are indicators developed to evaluate ICZM in the region of examination: Queensland, Australia. The majority of indicators generated by Zafrin and Rosier were applicable to the evaluation of the GSMPZP and GSRMAP. Due to overlap of indicators between authors, however, only six indicators are credited to Zafrin and Rosier in **Tables 1 - 4**.

Table 5. Indicators to evaluate the strengths and weaknesses of ongoing indicators in both the Great Sandy Marine Parks Zoning Plan (Zoning) and the Great Sandy Regional Marine Aquaculture Plan (Aquaculture).

Phase	Indicator	Zoning	Comments	Aquaculture	Comments
Ongoing Throughout Plan's Duration	25. Learning ^[24]	No	The plan does not demonstrate learning, as indicated by a lack of adaptive management (see indicator 26)	Yes	Initial lack of stakeholder consultation regarding aquaculture: the GSRMAP rectified the gap
	26. Adaptive ^[24]	No	The plan does not demonstrate adaptive management	Yes	GSRMAP will conduct ecological studies to inform adaptive management
	27. Flexible ^[24]	No	Rigidity in location of varying zones is apparent	No	Only certain sites allowable for aquaculture; only non-intensive aquaculture permissible
	28. Precautionary ^[24]	Yes	Emphasized throughout the plan	Yes	Risk-based assessment is made evident throughout GSRMAP
	29. Multi-disciplinary ^[24]	Yes	Pulls from a variety of disciplines (i.e. tourism, sustainability, aquaculture)	Yes	Considers many aspects spanning several disciplines (i.e. fisheries, tourism, sustainable growth)
	30. Comprehensiveness (geographical) ^[24]	Yes	Marine park extends from Baffle Creek to Double Island Point, encompassing many different marine areas	Yes	Sites cover a large scale – 26 sites spanning 8,500 hectares in Hervey Bay
	31. Contingent (as a question: "is there a contingency plan in place?") ^[24]	No	No contingency plan for unforeseen circumstances (i.e. climate change)	No	No mention of what will occur if the GSRMAP is not successful
	32. Proactive ^[24]	No	The zoning plan was reactive	No and Yes	Plan developed reactively in response to the need for aquaculture planning; plan created prior to allocation of sites
	33. Cooperative ^[24]	Yes	Plan cooperates with, for example, Aboriginal rights	Yes	Cooperative between levels of government; between stakeholders; with existing plans such as the Zoning Plan

RESULTS

Analysis of the Great Sandy Marine Parks Zoning Plan and Great Sandy Regional Marine Aquaculture Plan

The aforementioned indicators from Pickaver ^[22], Olsen ^[23], Stojanovic ^[24], and Zafrin and Rosier ^[21] have been integrated into **Tables 1 - 5**, listed in the Appendix. Each Table is associated with a different phase of ICZM: initiation (**Table 1**), planning (**Table 2**), implementation (**Table 3**), monitoring and evaluation (**Table 4**), and ongoing indicators (**Table 5**). Relevant comments regarding each indicator have been inserted into the Tables where appropriate. The source author(s) of each indicator used for evaluation of the management plans is displayed after the indicator in each Table.

Indicators Associated with Initiation of the GSMPZP and GSRMAP

The indicators in **Table 1** correspond with the initiation phase of ICZM. During this phase, every indicator was successfully accounted for by the GSMPZP. The GSRMAP, however, did not have funding available for implementation. Analysis of the plan revealed that commercial investors interested in aquaculture in the region are responsible for funding the implementation of the project ^[16].

Indicators Associated with Planning in the GSMPZP and GSRMAP

Table 2 lists the indicators associated with the planning phase of ICZM. Analysis of **Table 2** shows that the GSMPZP is lacking in a few areas of the planning phase. For example, there is no indication anywhere in the GSMPZP that the planning process was collaborative, or that it involved local or stakeholder participation. This is a key shortcoming of the GSMPZP, and will be elaborated on further in Section 4.1 of this paper. Conversely, the strengths of the GSMPZP lie in its long-term approach to management, and in its commitment to the precautionary principle and ecosystem-based management. The areas within the Great Sandy Region requiring special management, such as the turtle monitoring and protection area, demonstrate the GSMPZP's commitment to managing with precaution.

Regarding the GSRMAP, **Table 2** demonstrates that every indicator in the planning phase is accounted for by the GSRMAP. One of the major strengths of the GSRMAP is indicator 10: "Collaborative, participatory, and transparent planning processes adopted" ^[21]. As this is a major strength of the GSRMAP, it will be further elaborated on in Section 4.2 of this paper.

Indicators Associated with Implementation of the GSMPZP and GSRMAP

Table 3 lists the indicators associated with the implementation phase of ICZM. Here, we see more flaws in the GSMPZP.

For example, exploitation of resources in the Great Sandy Region still occurs, indicating that the zoning plan is perhaps not completely effective in all areas ^[25]. Additionally, it is unclear who is responsible for enforcement of the GSMPZP. It is assumed that the Department of National Parks, Recreation, Sport and Racing, the governing body responsible for the GSMPZP's creation, would be responsible for enforcement, yet it is not made clear. On the other hand, there are multiple strengths associated with the implementation phase of the GSMPZP. For example, information on marine zoning is made readily available to the public, in layman's terms. The Queensland Government released the Great Sandy Marine Park Visitor Guide, so that visitors to the region can easily determine allowable activities in each of the marine zones ^[26].

There are several gaps associated with the GSRMAP's implementation phase as well. For instance, infrastructure investment is the responsibility of each commercial aquaculture developer. Any waste that develops during culturing will need to be disposed of, yet the GSRMAP does not mention how this will be coordinated both between and within aquaculture sites. Additionally, since the plan is non-statutory, penalties may not occur for aquaculturalists who do not properly dispose of their waste. This has serious implications for the surrounding environment, depending on the nature of the waste. Conversely, according to **Table 3**, there are some aspects of implementation that were successful. As with the GSMPZP, the GSRMAP makes scientific information available to the public in such a way that it is easily understood, without losing its validity. The Queensland Government has a comprehensive and readily accessible website where this is accomplished, and has answers to many of the questions commonly asked both by stakeholders and locals ^[27].

Indicators Associated with Monitoring and Evaluation of the GSMPZP and GSRMAP

Table 4 lists indicators associated with the monitoring and evaluation phase of ICZM. Monitoring and evaluation of the plans should be an ongoing process, and here some major weaknesses and gaps in both the GSMPZP and GSRMAP are identified. Perhaps the largest weakness associated with the GSMPZP is its lack of recognizing change within the ecosystem. For instance, the GSMPZP does not demonstrate adaptive management, and fails to account for a changing ecosystem. As this is a major flaw in the GSMPZP, it is further elaborated on in Section 4.2 of this paper. On the other hand, marine zoning within the Great Sandy Region will undoubtedly lead to an improvement in the state of the coast, ecosystem, and overall biodiversity. Specifically, the areas for special management target species whose existence may be threatened by human activities, such as fishing or recreational activities, in the region.

There are numerous weaknesses in the monitoring and evaluation phase of the GSRMAP as well. For instance, the GSRMAP will not be evaluated until 10 years after its implementation. As the potential environmental effects of aquaculture can be widespread and long-term, evaluation of the plan should be conducted sooner rather than later. Related to this, implementing aquaculture in the Great Sandy Region will likely have negative environmental effects, thereby not meeting the requirements of indicator 19, which is the improvement of coastal resources and biodiversity in the region ^[22]. Additionally, the GSRMAP places restrictions on areas for aquaculture development that were once unrestricted. This demonstrates a failure under indicator 23: improvement in some societal qualities (Olsen, 2003). On the other hand, the GSRMAP will lead to the creation of employment in the region, which demonstrates an improvement of societal qualities. This is but one example of the complexity that can be seen when evaluating the effectiveness of ICZM, an extremely challenging process ^[28].

Ongoing Indicators in the GSMPZP and GSRMAP

Table 5 is the final table of indicators for ICZM evaluation of the GSMPZP and GSRMAP. **Table 5** is unique, as it lists indicators that are ongoing throughout the ICZM process, and that are not restricted to a single phase. **Table 5** indicates that there are gaps in the GSMPZP. Specifically, the plan does not demonstrate adaptive management, as previously mentioned, nor is it proactive. A significant weakness of this plan is its rigidity: it fails to consider any yet unknown threats, such as climate change. On the other hand, the GSMPZP is precautionary, and the zoning map demonstrates that it is geographically comprehensive, apparent successes of the GSMPZP thus far ^[15].

The GSRMAP demonstrates many of the same strengths as the GSMPZP, such as its comprehensiveness and commitment to the precautionary approach. The significant difference between the GSMPZP and GSRMAP, however, is that the aquaculture plan stresses adaptive management, a noteworthy strength of the plan. The GSRMAP will be closely monitoring aquaculture in the Great Sandy Region, and making management changes as necessary and on an ongoing basis.

DISCUSSION

Great Sandy Marine Parks Zoning Plan – Strengths, Weaknesses, and Gaps

The major strength of the GSMPZP plan lies in its comprehensiveness. The objectives for each zone or special management area are specified in the plan, and define any potential access restrictions within each area. For example, the objectives of the whale management area are to protect humpback whale populations and to minimize distress to whales caused by humans ^[14,29]. This is a crucial area of management, as whales give birth in the warm waters of the Great Sandy Region, before migrating south to Antarctica with their new offspring ^[25,29,30]. Special management provisions and restrictions (i.e. on commercial whale watchers) are further defined within each section, indicating a level of foresight from the plan's inception. Objectives and restrictions are defined for each of the five zones and nine special management areas, demonstrating the comprehensiveness of this particular plan.

While certainly comprehensive, the GSMPZP has some identifiable gaps. For instance, the plan fails to explicitly define the overarching goal of the program, leaving the reader with questions: what was the trigger in creating this zoning plan? Why was the zoning plan necessary in the first place?; and what does it hope to accomplish in the long-term? The terms of reference are not explicitly defined, and it is unclear what the long-term objectives of the zoning plan are. Presumably, sustainability of both living and non-living resources is one of the major goals of the zoning plan, yet it is not defined.

A further drawback of the marine zoning plan is the lack of public involvement during the planning phases. For instance, Fraser Island has a permanent population of 194 people, the majority of whom live near the coast in the region's largest city, Eurong^[31]. When the GSMPZP was released, residents had restrictions placed on their right to utilize resources in the region^[16]. This demonstrates a lack of public involvement, as the locals are no longer able to use the coastal area, a Conservation Park Zone, outside of Eurong for consumptive or recreational use^[14]. Although limited collection and recreation are allowed in the Conservation Park Zone, permits are often required for once unrestricted activities^[26].

Recommendations for the Great Sandy Marine Parks Zoning Plan

The GSMPZP appears to be effective in preventing ecosystem and species damage in response to the increased development and number of tourists in the region. There are, however, areas of the zoning plan that could be improved upon.

The first recommendation is to involve the permanent residents of the region in the evaluation of the GSMPZP. There is no evidence that the 194 residents of Fraser Island were initially involved in the zoning process. Residents of Fraser Island should be permitted to be involved with the evaluation of the GSMPZP and subsequent re-evaluation of zones if necessary. If the State of Queensland determines that the marine zones are appropriate for both residents and tourists, perhaps permission could be granted for residents to fish and collect marine resources on a limited scale. Also applicable to this recommendation is the involvement of any remaining aboriginal peoples in the region. The aboriginal populations are permitted to fish and collect for traditional use in the Great Sandy Region, but again, there is no indication that they were involved in the planning process. Without proper study and re-evaluation, the residents of Fraser Island may continue to be severely impacted by the GSMPZP.

Another recommendation for the GSMPZP is to adopt the practice of adaptive management. The Great Sandy Region is, by name, formed from sand. The sand formations are extremely susceptible to climate change, and other phenomena, such as cyclones^[4,32]. This means baseline information such as the highest astronomical tide (which incidentally determines the starting point for the different marine zones), is vulnerable to change^[4,15]. Despite this, the GSMPZP has made no mention of how the zones may shift in response to climate change. A practical example of management shifting to adopt the needs of the ecosystem has been seen in the Great Barrier Reef Marine Park (GBRMP): as sand and reef distribution patterns fluctuated, original zoning plans in the GBRMP did not adequately protect the flora and fauna in the region. Thus, the marine zones were altered to better protect the organisms in the region^[33]. It is recommended that the State of Queensland evaluates baseline data on an ongoing basis to determine the extent of climate change effects, and modifies the zoning plan in the Great Sandy Region as needed.

A further consideration for adaptive management is the potential shift in species abundance in response to climate change. Humpback whales, for example, migrate north from their feeding grounds in Antarctica to winter in Hervey Bay^[25,30]. It is entirely possible that, in response to a warming climate, humpback whales no longer migrate as far north, and the whale management area in the GSMPZP is no longer useful. This indicates a further reason why the GSMPZP should adaptively manage, instead of rigidly defining marine zones in the Great Sandy Region.

Great Sandy Regional Marine Aquaculture Plan – Strengths, Weaknesses, and Gaps

Aquaculture has been identified as a priority for Queensland, and primarily seeks to meet the increasing demand for seafood, both domestically and internationally^[16,34]. Prior to the implementation of the GSRMAP, aquaculture was a permissible activity under the GSMPZP, but there was no agreement as to what location would be best for a particular culture, or how each culture would be managed^[34]. Additionally, the licensing requirements for aquaculturalists were complex, and licenses were granted on a case-by-case basis. The GSRMAP streamlined the licensing process, and allowed potential investors a more thorough understanding of the licensing process^[16]. The GSRMAP successfully filled the aforementioned shortcomings, indicating that, even prior to its implementation, the plan would be more successful than the previous aquaculture management system.

A major strength of the GSRMAP was the public's involvement during the planning phases. Prior to the GSRMAP, stakeholders were not involved with aquaculture planning in the Great Sandy Region, and aquaculture applicants underwent a variety of steps to be granted a permit for a site, which was done without community stakeholder involvement^[34]. This lack of participation changed with the GSRMAP, and stakeholders were consulted throughout all phases of ICZM; this is a significant strength of the GSRMAP, as it indicates the State of Queensland's awareness that the stakeholders were not complacent regarding the lack of consultation^[16,34]. Focus groups with stakeholders were held, indicating collaborative planning, and public consultations occurred throughout the planning process, indicating both a transparent and participatory process^[16]. Increasing public consultation also suggests that the State of Queensland is capable of learning from previous mistakes, and integrates learning throughout the ICZM progress. Recall that Stojanovic^[24] regard 'learning' as an ICZM indicator for success. The State of Queensland is committed to ongoing learning, as demonstrated by substantial public involvement in the GSRMAP^[16].

An identifiable gap in the GSRMAP is the lack of information regarding maximum allowable culture density at each aquaculture site. In 2003, Crawford et al. demonstrated that shellfish farming has little effect on the benthic environment (e.g., changes to benthic bacteria, community composition, or organic enrichment). The authors make clear, however, that the density of the shellfish culture is crucial in determining the effects on the benthos^[35]. Throughout the analysis of the GSRMAP, no evidence was found indicating that shellfish culture density was regulated. The GSRMAP cites the Crawford^[35] study in its management plan, and states that: "...line shellfish farming [has] minimal benthic impact at the densities studied"^[16]. In Tasmania, however, the location of the Crawford^[35] study, the studied mussel culture densities are less than 12 kg/m, which is lower than what is seen in other locations. In areas of Japan, for instance, mussel culture density can reach up to 1,110 individuals/m²^[36]. Indeed, Crawford^[35] states that lesser impacts are to be expected in Tasmania, due to the low stocking densities. There can be significant shellfish culture density differences between sites, and if the risk of habitat disturbance is dependent on shellfish density, the GSRMAP needs to address and regulate this gap: however, should site rehabilitation become necessary, DEEDI and Queensland's Department of Environment and Resource Management (DERM) are responsible for ensuring that sites are rehabilitated as necessary (GSRMAP).

Recommendations for the Great Sandy Regional Marine Aquaculture Plan

The GSRMAP is an incredibly comprehensive document. At first glance, it appears as though extensive (no feed added) aquaculture in the Great Sandy Region will be effective. There are, however, gaps in the management plan where recommendations should be considered.

Firstly, it is recommended that the GSRMAP include regulations governing the maximum density of non-intensive aquaculture species. Thorough review of the GSRMAP indicates that there are no restrictions on the density of species that can be cultured in the Great Sandy Region. The GSRMAP states that non-intensive shellfish farming, at the densities studied in its reference paper^[35], has no effect on the benthos, and yet the plan fails to specify a maximum density for the Great Sandy Region. If damage to the benthos and surrounding environment is dependent on the density of the culture, a maximum allowable culture density should be defined. Perhaps, given the local variability in the natural environment, rather than being specified within the management plan, maximum culture densities should be specified within licensing agreements. Regardless of its placement within the management plan or the licensing agreement, Australia's goals of ecologically sustainable development and a green, clean, and safe image will not be achieved unless aquaculture culture density is regulated^[16].

Secondly, extensive and close monitoring is recommended. Currently, the GSRMAP is due to be reviewed every 10 years, which appears to be too long of a review period. In Taiwan, extensive aquaculture has been linked to increased localized jellyfish populations^[47]. Shellfish farming has been shown to provide surfaces for polyps to attach to, leading to increased jellyfish concentrations^[47]. Jellyfish can quickly rid a region of essential nutrients and other resources, and render an area ecologically unproductive in a short period of time. Due to the unknown nature of aquaculture in the Great Sandy Region, aquaculture, species biodiversity, and regional water quality should be monitored very closely during the project's pilot years. It is recommended that, to prevent ecosystem degradation, the GSRMAP is reviewed every three to five years instead of every 10 years.

CONCLUSIONS

Indicators are a useful tool to measure and evaluate the effectiveness of ICZM. By utilizing appropriate indicators from four different sources, this paper has analyzed both the strengths and the weaknesses of the Great Sandy Marine Parks Zoning Plan and the Great Sandy Regional Marine Aquaculture Plan. The GSMPZP is a comprehensive plan, yet failed to include public participation during the planning process, which is not ideal during ICZM. Additionally, the GSMPZP is an extremely rigid plan, and does not consider any changes which may occur to the region in the future. The analysis suggests that the Queensland Government involve the public during the plan's review, and to consider adaptive management, to ensure the future success of marine zoning in the Great Sandy Region. The GSRMAP is another example of a comprehensive management plan in Queensland. Though the GSRMAP clearly demonstrates public participation and adaptive management, it fails to consider maximum density of species being cultured, which could prove problematic for the region. In this case, it is recommended that the Queensland Government monitor the Great Sandy Region closely and frequently, to ensure that aquaculture inflicts no irreversible environmental damage in the Great Sandy Region. By considering potential future consequences and managing adaptively, the Queensland Government will ensure the Great Sandy Region remains a pristine area for generations to come.

ACKNOWLEDGEMENTS

I thank Dr. Lucia Fanning, for her support, advice, and comments on earlier versions of this paper. Additionally, I thank three anonymous reviewers whose earlier comments were useful in improving this manuscript. Finally, thank you to the Marine Affairs Program at Dalhousie University for encouragement in furthering this work.

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