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The Marine Planning Framework for South Australia: A new ecosystem-based zoning policy for marine management

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Abstract

The Marine Planning Framework for South Australia is a new large-scale, ecosystem-based zoning policy for management of development and use in the marine environment. Utilising the Geographic Information System (GIS), the model establishes four ecologically rated zones, derived from known ecological criteria. A series of goals, objectives and strategies represent the desired outcomes for each of the ecologically rated zones. A Performance Assessment System (PAS) will subsequently evaluate the success of the marine plans. Implementation will be supported by a collaborative whole-of-government approach. Marine plans will facilitate the delivery of long-term protection to the marine environment as a whole ecosystem, whilst enabling a broad range of activities to occur in a sustainable manner.

Keywords: Marine spatial planning; GIS; Ecologically sustainable development; Ecosystem-based management; Adaptive management

1. Introduction

Rapid human population growth over the last few centuries has placed increasing pressure on the world's ecosystems [1–3]. The need for prudent management of this growth to ensure ecological sustainability has long been recognised for land-based systems. Cities and states commonly plan for development of commercial, residential, and agricultural activities through municipal zoning systems [4]. Only in recent years has the application of zoning models for the marine environment been recognised [5–7].

Efforts to manage the marine environment in the last few decades have traditionally relied on marine protected areas (MPAs) and fisheries management regulations. These approaches have explicit goals that are generally limited to specific species (e.g. fisheries regulations) or small areas recognised to have particular environmental values (e.g. MPAs) [6,8]. Although these approaches achieve their goals, they are limited in scope and insufficient in accommodating multiple uses and managing cumulative effects in the marine environment [9]. With the increasing pressure on marine ecosystems from human development and resource extraction, it has been recognised that large-scale, ecologically based zoning approach to marine management is imperative [5,7,10–13].

Large-scale ocean-zoning plans for the sustainable use of marine environments have recently been initiated by diverse jurisdictions around the world (national and state initiatives), motivated by different goals and outcomes. The United Kingdom has draft national legislation to authorise marine spatial planning in order to provide "an integrated, policy-based approach to the regulation, management, and protection of the marine environment" [14–16]. Belgium is using marine spatial planning to provide for a strategic and integrated framework for ecosystem-based, sea use management [17]. In Canada there have been efforts to implement Large Ocean Management Areas under the 1997 *Oceans Act* for all of Canada's marine regions in order to ensure the maintenance of the natural function of the ecosystems [18]. The Eastern Scotian Shelf Integrated Management Initiative is a result of this [19] and ocean zoning continues to be discussed further for the northwest Atlantic [20]. In the

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USA, many efforts have been made to initiate the concept of ocean zoning to the federal government to overhaul the ad hoc measures currently in place for marine activity management [7,10,12,21–24]. Joint planning initiatives are occurring between the United States and Canada for the large-scale ocean zoning of the Gulf of Maine [4,25]. New Zealand is working on an Ocean Policy to manage environmental effects of activities in the country's Exclusive Economic Zone from 12 to 200 nm from the coast [26], and China has legislation for marine function zoning plans in its territorial sea for the "purpose of strengthening the administration of the use of sea areas and promoting rational development and sustainable utilisation of sea areas" [27].

Smaller jurisdictions within nations (e.g. states) are also initiating large-scale marine planning concepts to manage development and use within the 3 nm jurisdictional limits (e.g. Massachusetts [28] and California [13] in the USA). Even though these jurisdictions contain the least amount of area, they are most important for the large-scale marine zoning programs as they experience the highest intensity of impacts from land-based influences. To date, there have been no attempts to develop a spatial zoning system for coastal waters.

In Australia, over 80% of the population lives on or near the coast [29]. Historically, the management of the coast and marine environment in Australia has been based on "sectoral" planning with agencies executing their roles and responsibilities without the full consideration of other existing or potential users and without any focus on functioning of the marine ecosystem. At least 27 separate pieces of legislation exist for the State of South Australia for governance of activities in the marine environment from aquaculture to ports to petroleum exploration. In 2004, the State Government of South Australia adopted the *Living Coast Strategy for South Australia* as the integrating framework for the ecologically sustainable use of its marine environment, an area that encompasses nearly 60,000 km^2 and is bounded by 4000 km of coastline [30]. One product of this initiative has been the *Marine Planning Framework for South Australia* released in 2006 [31].

Here we discuss the contents of the *Marine Planning Framework for South Australia* policy. We describe the principles of the Framework, the ecologically based zoning model, the Performance Assessment System (PAS) that will be used to assess the effectiveness of marine plans, and how the marine plans will be implemented.

2. Principles of the Marine Planning Framework

The *Marine Planning Framework for South Australia* (MPF) is underpinned by three key principles: ecologically sustainable development (ESD), ecosystem-based management and adaptive management. Ecologically sustainable development in this context is defined as using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be improved [32]. The ESD principle also incorporates the precautionary principle, in which, if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. The principle of ecosystem-based management is based on the importance of recognising ecosystem structures and functions and then responding to signals from the ecosystem in order to manage anthropogenic activities and uses. Adaptive management is described for use in this policy as a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. These principles will be applied through the development, implementation and review processes of the marine plans.

The MPF provides the structure and direction for the planning and management of activities in South Australia's marine environment. The resulting marine plans will establish an overarching strategic guide for State and Local Government planners and natural resource managers with the aim of ensuring a healthy, diverse and productive marine environment for both current and future generations.

3. The marine planning model

Assumptions were developed based on managing activities within the assimilative capability of the ecosystem in order to guide the development of the marine planning model. The key assumptions behind the model are that the data available should reasonably reflect the ecological parameters fundamental to the function of the ecosystem and its biological diversity and the spatial distribution of the ecological parameters of the ecosystem.

The aims of the model are to zone the planning area based on ecological criteria and identify and define the spatial boundaries of the zones.

3.1. Marine bioregions, biounits and marine plan boundaries

The marine plan boundaries are based on ecological bioregions. In South Australia, there are eight defined marine bioregions as part of a national system which were determined by distinctive patterns of biodiversity at a scale of 1000 km^2 [33]. These bioregions also contain smaller divisions called marine biounits, which are defined on the basis of coastal physiography, topography and major marine physical habitat or seascape features and habitat distributions at a scale of 100 km^2 (Fig. 1). For the purpose of marine planning, South Australian waters encompass all estuarine and marine waters from the highest astronomical tide (including stranded samphire swamps) to 3 nm out to sea including all bays and gulfs. The MPF provides for six marine plans across the eight bioregions covering all State waters. These areas include the Far West, West Coast, Lower Spencer Gulf, Spencer Gulf, Gulf St. Vincent/Kangaroo Island, and South East (Fig. 2).

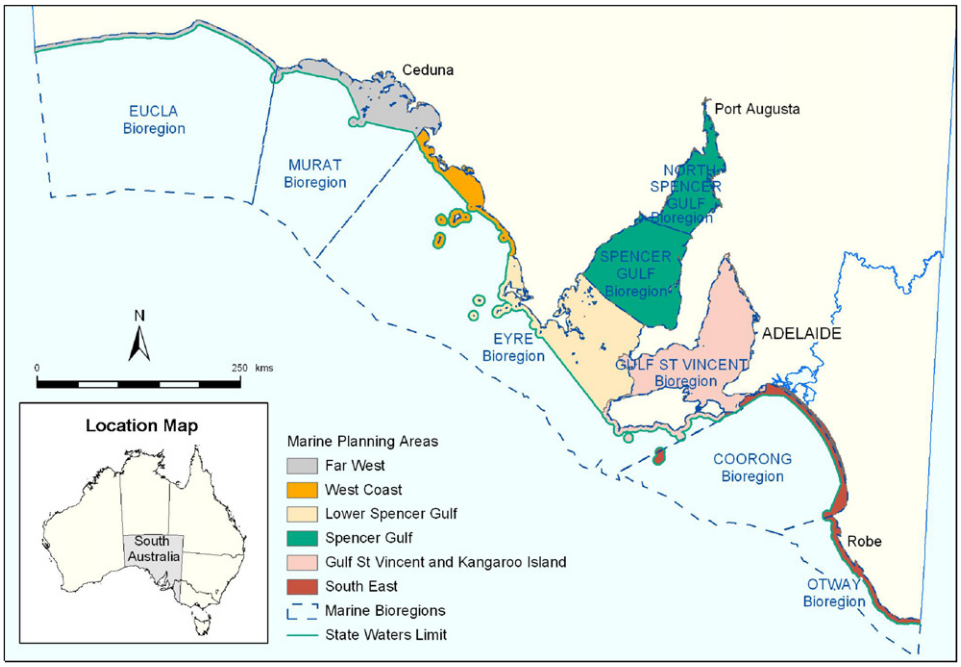

Fig. 1. Marine plan boundaries and bioregions for South Australia.

3.2. Methodology

The steps in the development of a marine plan are briefly described below and the detailed methodology and background information is in review [34].

3.2.1. Step 1: data collection

The first step in the development of a marine plan involves a process of data identification, collection, collation, and the creation of a series of maps depicting economic, social and cultural values of the planning area. Data were collected from a variety of sources such as published literature, information from community members and groups, private businesses, and other government agencies. The development of a model that is robust, transparent and repeatable requires the collation and analysis of existing information within a Geographic Information Systems (GIS) format. GIS are computer-based systems used for the manipulation and analysis of spatially distributed data and is the backbone to production of the marine plans.

3.2.2. Step 2: sorting spatial data

Once data were collected on environmental, economic, social and cultural heritage, it is compiled in GIS spatial layers. The environmental data were used for the development of the marine plan and social, economic, cultural and heritage data were used to support it.

3.2.3. Step 3: create GIS layers

The environmental layers in the marine plans contain information on habitats and uniqueness of the area.

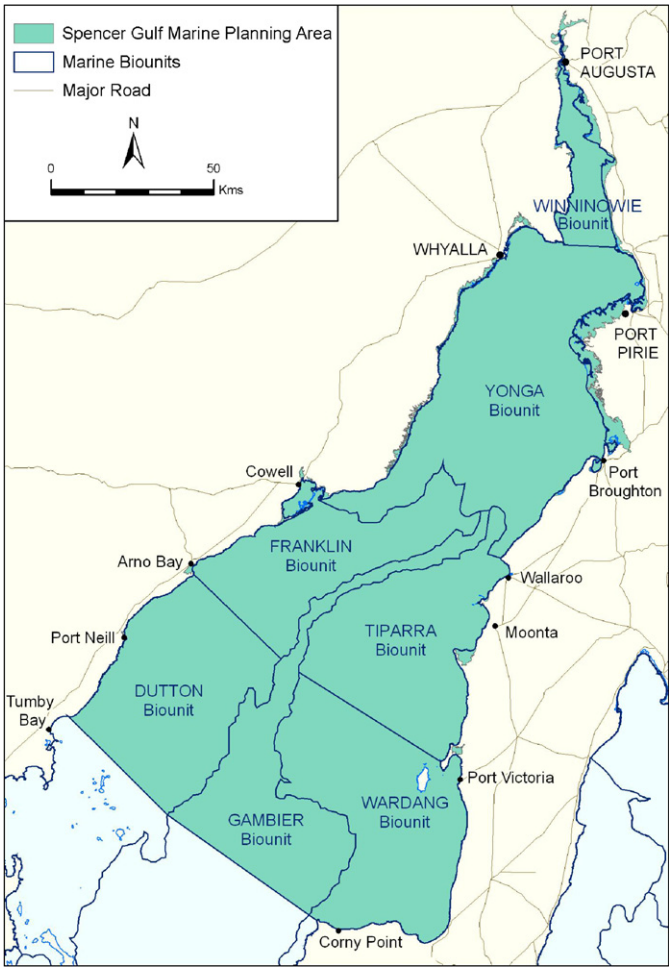

Fig. 2. Biounits for Spencer Gulf marine planning area.

Habitat layers include data on the presence of reef, seagrass meadows, soft sediment communities, mangrove forests, and saltmarsh. Uniqueness layers include information on migratory wader birds and shorebird breeding/roosting sites, fish spawning and nursery areas, endemic species, and rare and endangered species. Each environmental layer created is referred to as an ecological variable.

3.2.4. Step 4: create planning unit spatial layers

Using GIS, the state waters are divided into a grid of $5 \times 5\,km^2$ units, termed planning units (PUs) allowing for spatial summary of data. An example of the PUs for the Spencer Gulf Marine Plan can be seen in Fig. 3. The PU system simplifies the use of a large planning area and decreases spatial errors by considering the range of 'capture scales' in the data (i.e. benthic habitats were

Fig. 3. Spencer Gulf marine planning area and $5 \times 5\,km^2$ planning units.

Table 1
Definition, goal and allowable impact definition for ecologically rated (ER) zones

ER zone	Definition	Goal	Allowable impact definition
ER 1	Contain the highest diversity of marine, coastal and estuarine habitats and species	Development and use are managed such that it will cause negligible impacts on biodiversity, habitats and ecological processes important to the health and productivity of ecosystem	Negligible: will not exceed negligible impacts to habitats or populations. Unlikely to be measurable against background variability. Habitat and ecosystem interactions may be occurring but it is unlikely that there would be any change outside of natural variation. Recovery measure in days to weeks.
ER 2	Contain a high diversity of marine, coastal and estuarine habitats and species	Development and use are managed to ensure minor impacts	Minor: will not exceed minor impacts to habitats or populations measurable against background variability. Recovery measure in weeks to, not more than six months.
ER 3	Contain moderate diversity of marine, coastal and estuarine habitats and species	Development and use are managed to ensure that moderate impacts	Moderate: will not exceed moderate impacts to habitats or populations. Measurable changes to ecosystem components without there being a major change in function (i.e. no loss of components). Recovery measure in months to, not more than 2 years.
ER 4	Available scientific data are inadequate to identify their importance to the maintenance of biodiversity, ecological health and productivity of the ecosystem	Development and use are preceded by research to improve knowledge	Precautionary principle: research will determine allowable consequences to habitats

mapped at 1:100,000 and saltmarsh habitat is mapped at 1:10,000).

3.2.5. Step 5: linking spatial layers

In the GIS system, the PU spatial layers are then linked to the ecological layers.

3.2.6. Step 6: grouping ecologically rated (ER) zones using GIS

GIS analysis, using the natural breaks method, group grid cells (PUs) into four zones, based on rating areas according to number of ecological factors (habitats and uniqueness) found in the PU. There are four categories of ER zones with "cascading" ecological importance, with one type of zone developed for areas with little or no information. Each cell is categorised according to the data it contained, distinguished by the relative importance of the contribution made by species, habitats and ecological processes to the healthy functioning of the ecosystem.

Each ER zone has specific goals, objectives and strategies that guide use and development within the environmental capability of that PU (Table 1). These zones are reviewed as additional information and understanding becomes available. This system is based on nationally recognised definitions that are used for the National Ecologically Sustainable Development Reporting Framework for Australian Fisheries [35] (Table 1).

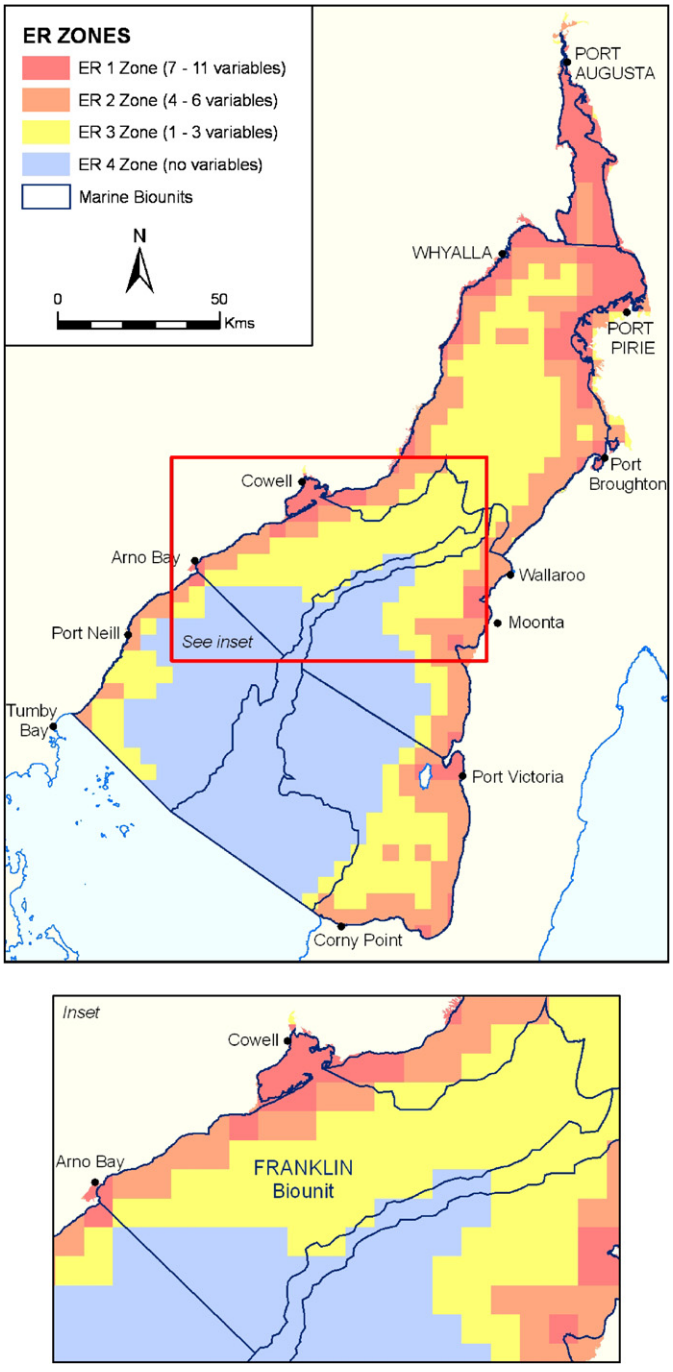

Fig. 4. Spencer Gulf marine planning area with ecologically rated zones. Franklin biounit inset.

3.2.7. Step 7: impacts analysis

To identify potentially impacted areas or areas already experiencing impacts, analysis is undertaken in GIS using known variables. Each variable represents an activity that has a discernible impact on any marine habitat, flora or fauna such as aquaculture, marine pest, and point source pollution. Each variable was assigned a value of one and all activities were viewed as having the same degree of impact. Data were presented to reflect areas of the highest concentration of use and not the degree of impact that each variable may have, either independently or cumulatively.

3.2.8. Step 8: graphically display analysis results

ER zone maps are produced as a result of the analysis and are presented by biounit (Fig. 4). Impact analysis using spatial data provided information on areas of high concentration of use that is also graphically displayed, complimenting the ER zone maps (Fig. 5).

4. Marine plans

Six marine plans will be produced as a result of this methodology and the Spencer Gulf Marine Plan has been completed [36]. The marine plans will contain: an explanation of the goals, objectives, and strategies of the zoning system (Table 1); a series of maps showing the zoning based on the above model (example in Fig. 4); a map representing the potential and present impacts (Fig. 5); and tables explaining the reason for zoning and current activities or impacts by biounit (example in Table 2). The marine plan is set up to be a simple, easy-to-use guide which will allow decision-making authorities to locate the marine area in which their development and use will occur and to then evaluate whether the activity will meet the goals, objectives, and strategies for the zoning within that area.

For example, in an ER1 zone, acceptable development or use is that which will not exceed a negligible level of impact to the biodiversity, habitats and ecological processes

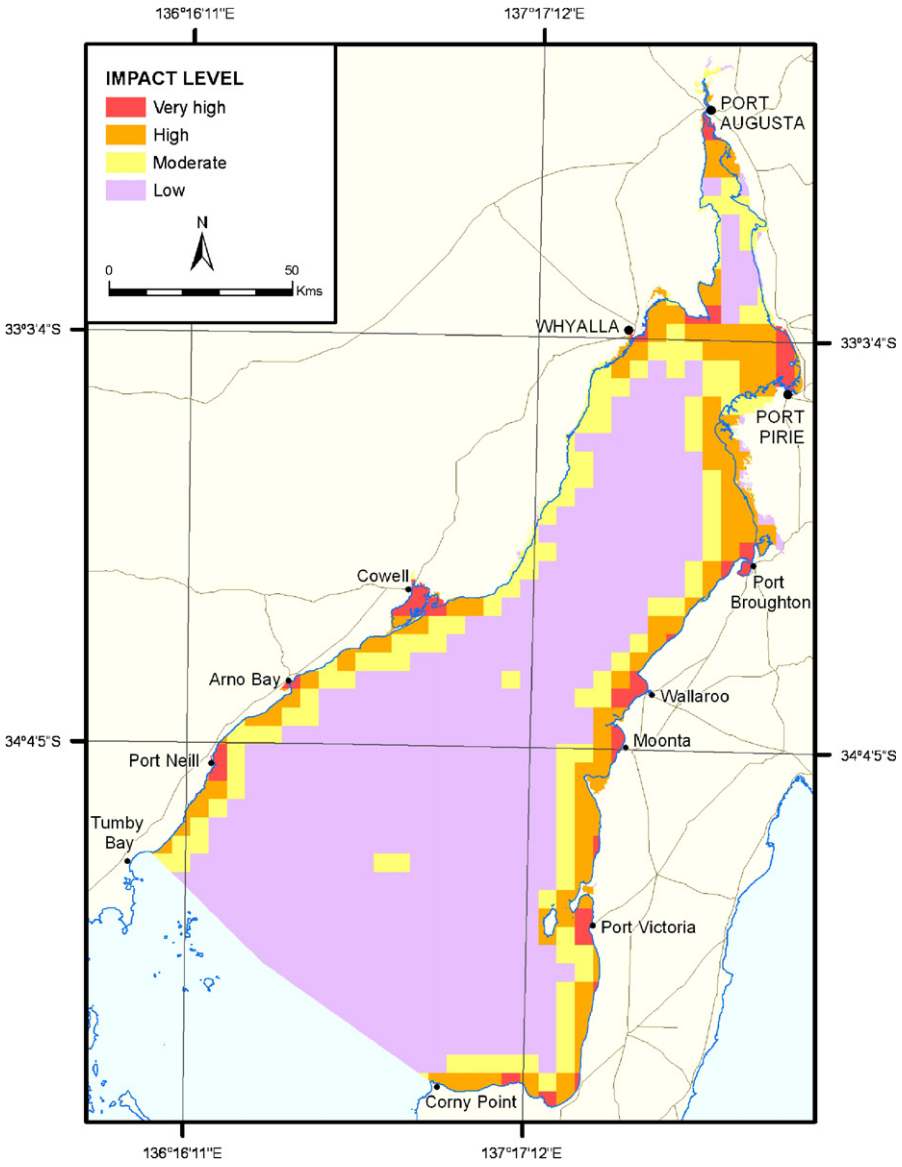

Fig. 5. Potential and present impacts map.

of the zone. For some forms of development, this may be achieved by applying appropriate conditions to a development approval. If this is not practical or feasible, locating the development within an ER2 or ER3 zone may be more appropriate.

Is it recognised that in some areas, impacts to the marine environment already exceed the benchmarks required to meet the ER zone goals and objectives. In these cases, the marine plan objectives may be used to minimise current impacts and plan for future management decisions in a manner consistent with the relevant ER zone objectives. Over time, these actions will assist to facilitate the restoration, where possible, of acceptable ecosystem conditions.

5. Performance Assessment System

Accompanying the MPF is a PAS, which has been developed to evaluate the effectiveness of each marine plan by assessing and reporting on the maintenance of ecosystem conditions [37]. The PAS has been developed in consultation with State Government agencies and non-government organisations involved in management and monitoring of the marine environment. It establishes an agreed approach to the monitoring of selected indicators to detect change, both natural and human induced, in the condition of South Australia's marine ecosystem, biodiversity, habitats, and species. When applied to the ER zone objectives, the results of monitoring will reveal the adequacy of management measures in conserving and facilitating responsible use of marine, estuarine and coastal resources.

The PAS will provide a coordinating mechanism, enabling all agencies to contribute to a state wide, collaborative approach to data collection, analysis and reporting on marine ecosystem condition. This is a necessary prerequisite for constructing a best practice, adaptive approach to management and reporting.

Table 2
Example of "Ecologically Rated Zoning Table" provided in the Spencer Gulf Marine Plan

Location of planning units	Zone	Reason for zoning		Current activities that impact
		Habitats	Uniqueness	
Franklin biounit (Fig. 4)	ER1	• Mangrove forest • Saltmarsh habitat • Intertidal mudflats • Sandy beaches • Soft sediment habitat • Rocky shores • Dense seagrass meadows • Macroalgal communities • Reefs	• Key biodiversity area • Franklin Harbor is on the register of the National Estate • Endangered marine algae • Seabird breeding grounds • Resident and migratory wader birds • Major spawning area • Major nursery habitat • Wetlands of National Importance	• Off road vehicles in dunes and saltmarsh habitat • Aquaculture • Trampling damage—intertidal areas and reefs • Taking of marine resources illegally • Propeller scouring • Dumping of rubbish and other items in the marine environment • Damage to cultural and heritage sites • Diffuse source pollution
	ER2	• Dense seagrass meadows • Soft sediment habitat • Macroalgal communities • Reef	• Major spawning area • Resident and migratory wader birds • Major nursery habitat	• Aquaculture • Propeller scouring • Anchor damage • Taking of marine resources illegally • Trampling damage—intertidal areas and reefs • Prawn trawl damage
	ER3	• Soft sediment habitats • Reef • Seagrass	• Spawning areas inshore • Nursery areas inshore	• Prawn trawl damage
	ER4	• Deep water habitat—no information	• No information	

This PAS is developed from the marine plan goals and objectives set for each ER zone (Table 1). These are expressed as outcomes in the PAS for each ecological variable (for example: seagrass), which are linked to criteria, performance indicators, benchmarks and monitoring protocols (Table 3). Monitoring of the performance indicators in relation to the benchmarks is designed to be able to distinguish between natural variability (such as seasonal changes) and changes caused by human activities. Existing monitoring programs are incorporated into and form the basis of the PAS, with clear guidance provided for the development of more comprehensive monitoring as resources permit.

Wide-ranging activities and the sustainable use of resources will generate a set of pressures and potential impacts on marine, estuarine and coastal systems. In order to establish the context and possible causal agents for any changes that may be observed over time, the level of specific pressures (potentially impacting activities or pollution sources) that may be related to changes in ecological conditions are assessed and reported within the context of the marine plan performance. Assessment of the performance indicators in each marine plan is not intended to replace the role of other agencies in regulating and managing sustainable uses, but will provide the broader context for policy decisions and responses.

Each of the six marine plans will have a companion PAS: the specifics for the Spencer Gulf Marine Plan PAS are being developed [38].

Table 3
Flow of decisions in the Performance Assessment System

Ecological variables	Outlined in the marine plans; for example seagrass
↓	
Goals and objectives	From each ER zone
↓	
Outcomes	Required for each zone; for example negligible loss of seagrass in ER1 zones
↓	
Criteria	To decide if the outcomes are achieved; for example, no reduction in area of seagrass
↓	
Performance indicators	Measured to inform the decision about each criterion; for example, measurement of seagrass area
↓	
Benchmark	Reference level for each performance indicator so that the decision about each criterion is accurate
↓	
Monitoring system	Provides data and information about benchmarks and changes in performance indicators over time; for example, remote sensing, swath mapping and aerial photography will be used for mapping areas of seagrass
↓	
Compliance	Of the performance indicators with benchmarks is determined
↓	
Corrective actions	Are triggered as required

6. Implementation

The MPF will be implemented as Government policy through a coordinated and strategic approach in collaboration with government agencies, local governments, key stakeholders and communities. It is intended for use by State and local Government, management agencies, authorities, boards and other relevant planning and natural resource management bodies; industrial and commercial users; and recreational users. Marine plans will be implemented through existing legislation and is proposed for inclusion in new purpose specific legislation, to be managed through comprehensive interim arrangements, and inter-agency cooperation.

The marine plans do not seek to control the ongoing day-to-day management of marine activities, but seek to direct the integration of the individual Acts that regulate different activities. For existing development and use, whether industrial, commercial or recreational, application of the marine plan will likely involve a review of current development and/or resource management plans that guide activities and practices. Future development and use will be guided at the planning phase by the relevant planning and/or management authority, according to the marine plan zoning arrangements. The plan and zoning system requires a "whole of government" and community approach towards the implementation, and will be periodically reviewed.

7. Conclusion

The zoning concept for marine planning and the associated Performance Assessment System could spur an overhaul in how governments regulate, manage, and monitor marine activities [12]. Unlike on land where boundaries of different user groups are apparent, the uses of the oceans overlap spatially creating conflicts in resource availability and sustainability that is not always apparent [11]. From lessons learned on land, ad hoc approaches to resource management leads to damaging and unsustainable practices. A whole-of-government, ecosystem-based approach to marine management is the only way to coordinate conflicting uses whilst maintaining environmental integrity for future generations.

Marine protected areas have served to protect specific habitats, and fisheries regulations have served to protect specific species stocks, but these types of management need to be coupled and coordinated for marine ecosystems where species are patchily distributed and fences are not feasible. We suggest that the *Marine Planning Framework for South Australia* is an important step for coordinating ocean management based on ecosystem capability whilst contributing to the long-term protection of the marine, coastal and estuarine environment.

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