**Symposium #193**

**Advancing an ecosystem-based approach to Marine Spatial Planning in South Africa**

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## Advancements in ecosystem-based approaches to Marine Spatial Planning in South Africa

**Amanda Lombard, Rosemary Dorrington, Kelly Ortega Cisneros, Gwenith Penry, Lorien Pichegru, Jodie Reed, Kaylee Smit, Estee Vermeulen**

South Africa's large exclusive economic zone includes the Indian, Atlantic and Southern Oceans. Management of this ocean space has traditionally been undertaken within sectors, leading to conflict amongst sectors, and between sectors and the need for environmental protection. As the demand for ocean space and marine resources increases, in response to a growing oceans economy, a more integrated approach to management is required to ensure that both ecological and socio-economic objectives are met. Marine spatial planning (MSP) has emerged in many countries as an effective process to achieve this integration, and in 2016, South Africa became the first African country to draft MSP legislation. In this Symposium, we present seven trans-disciplinary research projects that address challenges for implementing an ecosystem-based approach to MSP in South Africa. We discuss the analysis of microbial community dynamics as a measure of marine ecosystem health and the response to environmental change; the use of biological traits to assess ecosystem condition of rocky reefs; a model to assess the impacts of warming and ocean acidification on the southern Benguela food web and fisheries; spatial management options for marine fisheries in South Africa; the use of low-cost fishing exclusions to improve the conservation of a top predator; the assessment and development of sustainable boat-based marine tourism; and the development of a system-dynamics model to support marine spatial planning in Algoa Bay, South Africa. We conclude with lessons learned, and recommendations to advance ecosystem-based approaches to MSP globally, within a systems-thinking framework.

## Microbial community dynamics: a sensitive tool for assessing marine ecosystem health and the response to environmental change

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Microbial communities, accounting for up to 90% of the total biomass of the oceans, play a critical role in driving global biogeochemical cycles. Community analysis of microbial biomass reveals extraordinary taxonomic diversity with distinct communities in different water masses. Their diversity is reflected by metabolic versatility that allows marine microbes to respond rapidly to changes in their physical and chemical environment, including anthropogenically-driven change. These responses, including shifts in the diversity and structure of microbial communities and their metabolic activity, can be used as a sensitive tool for assessing ecosystem health, anthropogenic impact and responses to climate change. We recently launched a multi-disciplinary project to develop a marine spatial plan (MSP) for Algoa Bay to inform South Africa's new MSP process. The first objective is to produce a bioregional plan. This requires fundamental knowledge of the extent and distribution of biodiversity, the ecosystem processes that sustain this biodiversity and the anthropogenic factors that impact ecosystem functioning. Algoa Bay is influenced by oceanographic features including warm subtropical waters from the Agulhas Current, upwelling of cool, nutrient-rich bottom waters and significant nutrient-rich freshwater inflow. In a bottom-up approach, we used next generation sequencing analysis to characterise the pelagic and benthic bacterial and phytoplankton communities of the Bay, including the Sundays and Swartkops estuaries. The data provide insight into

macro- and mesoscale variability that reflect the complexity of freshwater and marine influences and anthropogenic impact with important implications for the development of a bioregional plan for the Algoa Bay system.

**Impacts of warming and ocean acidification on the southern Benguela food web and fisheries**

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South African marine environments are forecast to experience an increase in sea surface temperature of ~ 3°C and a decrease of ~ 0.3 pH units by the end of the century. Sensitivity to acidification is intensified when taxa are simultaneously exposed to increased seawater temperature. The warming and acidification forecast for South Africa can be expected to have detrimental effects on a number of species and potentially on the ecosystem as a whole. The effects of acidification and warming were evaluated for the southern Benguela system using climate projections of temperature and pH derived from the NEMO-MEDUSA 2.0 model under the RCP 2.6 and 8.5 emission scenarios. In the simulations, because of limited information, acidification is assumed to affect only the mortality of plankton, squid and macrobenthos. Of the drivers examined in this study, warming had the greatest effect on species biomass and the effect was mainly negative. The magnitude of the effects of warming were stronger under the RCP 8.5 than under the 2.6 emission scenario. Our results suggest that the southern Benguela system is likely to experience substantial changes in the abundance of some species important to the region's fisheries as a result of climate change. Future planning for fisheries needs to account for these changes including management measures that strive to maintain the resilience of key species and the system as a whole. Our results reinforce the importance of including consideration of the indirect and combined impacts of climate change and fishing in management and planning.

**Spatial management options for marine fisheries in South Africa: a review of legal instruments**

*Jodie R Reed, Amanda Lombard and Kerry Sink*

The spatial nature of ecosystems, natural resources and human activities requires that their management should incorporate spatial strategies. This includes fisheries management and, as such, ecosystem-based fisheries management is fundamentally a spatially explicit approach. Numerous benefits of spatial fisheries management have been demonstrated, including conservation benefits as well as increases to fishery yields and profits. In order for South African fisheries management to fully adopt an ecosystem-based approach, the full range of spatial management tools needs to be identified and considered for implementation. We investigated spatial management options by reviewing current legislative tools for spatial management in the ocean. Seven Acts and Bills were reviewed, including the Marine Living Resources Act, the National Environmental Management Act (including Integrated Coastal Management and Marine Protected Areas components), the Mineral and Petroleum Resources Development Act, the Draft Aquaculture Bill and the Marine Spatial Planning Bill. We identified ten spatial legislative tools that may be used to improve place-based management in the ocean, including measures that could be used to implement marine spatial planning. Results showed eight of the legislative tools identified have relevance to fisheries management. Key opportunities to support improved spatial fisheries management were identified by assessing the potential to meet multiple objectives in management of ocean space through implementation of these existing legal instruments in South Africa. The potential to contribute to stock and bycatch management, conflict management and ecosystem interactions were identified for four fisheries as case studies and future research needs and management actions are advanced in this regard.

**Low-cost fishing exclusions improves penguin conservation in Africa**

**Pichegru L, McInnes A, Ginsburg T, Traisnel G, Reason N, Ryan, PG**

No-take zones can be important tools within an ecosystem-based approach to achieve sustainable fishing and re-establish ecosystem integrity. However, the potential benefits of these exclusion zones for vagile species such as small pelagic fish and top predators remain questionable. In South Africa, the population of the endemic African penguin *Spheniscus demersus* has halved since 2004. They predominantly feed on sardines and anchovies which are also the target species of the purse-seine commercial fishery. Since 2008, a 20 km radius experimental purse-seine fishing exclusion has been initiated around two pairs of penguin colonies with alternating closure regimes in three-year cycles. Here, we report results of the experiment around two of the largest African penguin colonies, Bird and St Croix islands in Algoa Bay, currently supporting over half of the global population. Between 2012 and 2017 we collected information on the birds' foraging performance and reproductive success and the acoustically-determined relative abundance of pelagic fish around their colonies. We related these to fishing exclusion patterns and size of catches in the bay, while controlling for monthly environmental conditions. In parallel, we compared fishing patterns (locations, landings) during and outside closures to estimate the potential socio-economic cost to the industry. Our results show that while costs to the fishing industry remained relatively low, fishing exclusions largely benefitted penguins in terms of breeding success and foraging performance. Results of the experiment support the expansion

of similar measures to improve the conservation status of African penguins and other predators reliant on small pelagic fish.

**Applying a system-dynamics approach to support marine spatial planning in Algoa Bay, South Africa**

**Estee Vermeulen, Amanda Lombard, Ursula Scharler and Louis Celliers**

The recent introduction of marine spatial planning (MSP) legislation in South Africa (SA) provides an opportunity to learn from global and local history, data and experience, and to make sensible, equitable decisions about the future management of SA's marine environment. To date, a feasible method for translating this attractive concept into operational management practice in SA has not yet emerged, thus creating a niche to develop practical tools to make the MSP process more tangible. The Algoa Bay project aims to develop a local-scale marine spatial plan that will inform the development of plans for larger areas within SA's national MSP process. The biophysical, socio-economic and legal systems within Algoa Bay are complex. MSP typically requires a thorough analysis of legal frameworks and human and environmental requirements. This study will test the feasibility of using a system-dynamics approach to model the interactions within the complex marine environment in Algoa Bay. The first stage of the study will focus on the environmental assessment through the development of a biophysical system-dynamics model, using available data, spanning all habitats, physical oceanographic processes and levels of biodiversity. Once spatially explicit socio-economic data becomes available in the second stage of the study, the model will integrate the new data to quantify and evaluate trade-offs between human and environmental needs. The objective of the model is to provide an interactive decision-support tool for stakeholders and decision makers to evaluate the outcomes of different management strategies, under global change scenarios, to inform ecosystem-based marine policy development.