6.9 Project 3.2.2: Ecosystem impacts of human usage and the effectiveness of zoning for biodiversity conservation –an overview

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Project Overview
NMP, established in 1987, is a Multiple-Use Marine Park with several different types of management zoning. The zonings are intended to achieve a wide range of goals, but particularly to preserve biodiversity and ecological values within the park. In practical terms the main impact of zoning on human usage has been to restrict levels of commercial and recreational fishing within the park. A review of the NMP Management Plan beginning in 2000 led to the release of a revised Management Plan in 2005 which extended the park southward and increased the area within the park contained within sanctuary zones. However, there was some controversy at the time over the scientific basis on which to plan the size and placement of sanctuary zones along with their overall effectiveness as a biodiversity conservation tool.

This project was designed to assess the effectiveness of the zoning scheme at NMP by measuring the distribution and abundance of organisms on the reef and assessing their variation in the context of both previous and current zoning (size, age, configuration) and habitat. This was accomplished through a series of subprojects that focussed on various species groups in the lagoon system (fish (3.2.2a, 3.2.2e, 3.2.2f), rock lobster (3.2.2d), intertidal invertebrates (3.2.2b)) and ecological processes (herbivory and trophic cascade effects (3.2.2c)). This overview reports describes the collective findings and discusses the effectiveness of the zoning scheme. For specific information on a species group or topic, see the relevant subproject (below)

Objectives
The overall aim of this project was to assess the effectiveness of sanctuary zones in the lagoon system of NMP in protecting biodiversity and coral reef health. Sub projects were designed to address the following management questions which sought a better understanding of the current status of biodiversity and patterns of distribution throughout the park and evidence of the appropriateness of current management strategies:

- What is the species diversity, abundance and distribution of key flora and fauna in selected representative habitats;
- How do exploited (historic and current) and unexploited areas of NMP compare in regards to the above question;
- How do the movement patterns, life history and habitat use of key fished species interact with design of sanctuary zones to determine zone effectiveness;
- Do variations in the abundance of key predatory species measurably affect prey populations;
- Do variations in predator abundance indirectly affect reef ecosystem structure including the abundance of grazers, algae and corals and corallivorous gastropods (*Drupella*);

- Are current management arrangements/regulations appropriate for preserving the biodiversity represented within the park;
- What should management targets be for key species and ecological processes within the park; and
- What species/processes should be monitored in order to most cost effectively ensure targets are met.

Key Findings

The assessment of the zoning of NMP has in general confirmed that the zoning implemented in 1991 has achieved positive outcomes in terms of biodiversity protection and that the recent re-zoning is likely to achieve further conservation outcomes as intended. It also highlights the need for ongoing evaluation of marine park effectiveness in relation to both zoning and overall management as there are indications from a range of sources that there may be aspects of park configuration requiring further management action in order to realise park management goals.

Surveys confirmed that the expansion of sanctuary zones to include additional habitats and regions in the north and south of the park has led to the inclusion of a broader suite of fish assemblages, lobster populations and intertidal invertebrates. It has also broadened the diversity of ecological processes such as herbivore trophic groups, which also vary from the north to the south of the park. Similarly, the expanded inclusion of reef slope habitats has resulted in a much more representative system of no-take areas since reef slope fish and, invertebrate assemblages and ecological processes are all distinct from those on reef flat and reef slopes. At still finer scales distinctive assemblages of fish were also found among sub-habitat types within the lagoons. Overall the findings have generally confirmed that the rezoning of the park has achieved a more comprehensive representation of ecological processes and biodiversity. Further, surveys have provided information that can be used to inform future revisions of park zoning intended to more fully represent NMPs marine biodiversity.

Assessments of fish populations across a range of previously established sanctuary zones revealed higher biomass of targeted species spangled emperor (*Lethrinus nebulosus*), yellowtailed emperor (*Lethrinus atkinsoni*) and cod (*Epinephelus rivulatus)* across multiple sanctuary zones. Other species showed significant increases in specific sanctuary zones, a pattern that depended on regional variation in the distribution of some species (e.g. mangrove jack *Lutjanus argentimaculatus* at Bundegi). The size of these effects was relatively small, generally less than a doubling in biomass. Importantly, surveys also revealed that for some taxa the differences between sanctuary zones and fished areas were smaller than variations in targeted species biomass related to gradients in fishing pressure, with sharks, trevallies, groupers and emperors showing significantly higher biomass in areas with low fishing pressure.

Taken across both these comparisons, these surveys provide evidence that sanctuary zones are protecting targeted species, and that recreational fishing has had a measurable effect on populations of targeted species at Ningaloo. This conclusion is further supported by comparisons of density of spangled emperor in our study with densities estimated by similar surveys in 1987. Densities of spangled emperor at Osprey Sanctuary zone in 2006 are approximately half of the densities recorded in 1987, while in adjacent recreationally fished areas densities were around 10% of the 1987 levels. Similarly, populations of rock lobsters appear to be much lower than historical levels in the park, despite the cessation of commercial lobster fishing in the 1980s, with western rock lobster relatively abundant only in a small section of one of the no-take areas of the park.

There were few indications that indirect effects of fishing are having a substantial impact on food webs at Ningaloo. While some small predatory fish species (e.g. wrasses) were less abundant inside no-take zones, possibly due to competition or predation by protected target species, these effects did not extend to other trophic groups and most herbivorous fish, invertebrates (urchins and *Drupella*), corals and macroalgae showed no consistent trends between no-take sanctuary zones and recreationally fished areas.

Parrotfish were found by several independent surveys to be more abundant in no-take zones. The mechanisms responsible for this pattern are not clear, but it is important to understand them if this finding is to be fully used to inform management practices aimed at promoting the resilience of coral reef ecosystems. Fish herbivory (as opposed to invertebrate herbivory) was found to be a very important process on Ningaloo Reef, which probably enables corals to thrive. Parrotfish were found to be important grazers on the reef, but there were numerous other groups such as Kyphosids (drummers) and Acanthurids (surgeonfish) which were found to be more important in some circumstances, particularly in terms of grazing on large macroalgae. Ecosystems at Ningaloo benefit from a large suite of grazing species which are more diverse than grazer assemblages on equivalent coastal reefs at similar latitudes on Australia's east coast, and by comparing the biomass of grazing fish and macroalgae we have shown that biomasses of 100 $kg.ha^{-1}$ may be required to maintain low macroalgal biomass on these reefs.

Tracking of fish using acoustic tagging at NMP have revealed the importance of particular habitats for key species as well as the timing of important behaviours such as spawning. Tracking has shown that the habitat utilization areas of most of the species tracked has been smaller than was assumed prior to this study. Based on measurements of individual movement patterns obtained through acoustic tracking it appears that most of the sanctuary zones within NMP are of a size adequate to protect a significant proportion of the fish populations. For example the mean diameter of core habitat areas for a range of groupers of less than 1 km, and for spangled emperor 2.5-3-5 km. While the majority of sanctuary zones are larger than this, the linear extent of sanctuary zones in the northern part of the park is approximately 2.8km, about the same as the size of the area encompassed by the movements of an individual spangled emperor. Movements of other species such as gold spot trevally (*Carangoides fulvoguttatus*) are larger than this however and smaller sanctuary zones may not be adequate to protect such species. The sizes of sanctuary zones for some habitats, such as reef slopes, may be too small relative to the areas encompassed by the movements of the species that inhabit them. Planning for future sanctuary zones could incorporate these measurements into modelling approaches to provide a basis for determining optimal size of sanctuary zones.

Management Implications

Key recommendations from the project relate to both direct management actions and recommendations for further research. It is important that future reviews of zoning take these findings into account in order to ensure the comprehensiveness, adequacy and representativeness of overall park zoning. Additional actions across the park and not restricted to zoning may also be required in order to adequately address some issues such as overall declines in fish and lobster abundance. Further research and monitoring is recommended in order to assess the effectiveness of newly created sanctuary zones before zoning reviews are undertaken, or any more general steps to conserve populations at risk are taken. This project has also revealed likely trophic interactions that have the potential to impact on the overall biodiversity of the park and to be used in the context of ensuring the resilience of the NMP ecosystem. These interactions are not yet understood and should be further investigated in order to assess whether further management actions are required at NMP, and whether any insights gained can be used in the context of marine parks in other parts of Western Australia.

Findings from this research has direct application to the management framework for NMP and can best be summarised by the points below that should be considered in the next review of the NMP Management Plan

- Lagoon and reef flat areas are well represented within the sanctuary zone system of NMP however many shoreline areas within sanctuary zones are exposed to fishing because of special purpose shore based angling zones. These zones may put populations of some fish (e.g. spangled emperor *Lethrinus nebulosus*) that use shoreline areas for feeding and/or migration within such sanctuary zones at disproportionate risk of capture.
- The differentiation of fish assemblages in the north of the NMP and MIMMA from those further south, and the verification that fish assemblages in reef slope habitats, and in deeper waters, are distinct from those in shallower reef flat and lagoon habitats, suggests that it is important to include these habitats in the network of sanctuary zones at NMP. Currently sanctuary zones in the northern section of the park include the lowest representation of these habitats of any region in the park, yet they are the most heavily fished and likely to be in greatest need of protection now and in the future.
- Sanctuary zones in the northern region of the park are among the smallest of any region, meaning that even for relatively sedentary species such as spangled emperor their effectiveness may be reduced. The linear extent of these zones may need to be increased in order to achieve restoration targets in this region since the mean size of the home range of an average spangled emperor for example is approximately the same size or larger than the sizes of the sanctuary zones, meaning that fish will likely spend a large proportion of their time outside zone boundaries, and therefore in areas where they are susceptible to fishing.
- Given the demonstrated impact of access to the park and fishing pressure on fish populations, no further development of access points should be undertaken without due consideration for the context of the stated goals of the marine park i.e. conservation and restoration of natural values of NMP.
- Uncertainty about the rate of recovery of lobster populations in the park and the spatially restricted nature of high density populations of western rock lobster in parts of Bateman Bay, may mean that additional sites, including similar suitable habitat may need to be identified for protection of this species at NMP.

Research findings also have application to the ongoing monitoring and research program within NMP to improve our understanding and management of marine resources over the long-term. The following subprojects provide baseline information along with suitable protocols and reference sites from which to implement a long-term monitoring program of a variety of taxa and ecological processes active at NMP.

- In many cases the rate of response of fish populations to protection from fishing has been shown to be rapid. The rate of response has the potential to provide significant information on the condition of the ecosystem, including resilience and response to disturbance. This means that there is a clear need to continue monitoring of at least a subset of sites if we are to be able to understand the nature of responses. The desirability of such data is well illustrated by reference to our measurements of change at the Osprey Sanctuary Zone. We know densities were different in 2006 than they were in 1987, but we have no idea what the densities were over the intervening 20 years, whether 2007 was just a “low” year, or 1987 a “high” one. Regular and ongoing assessment is therefore essential for providing the system understanding required to underpin adaptive management. Such studies need to be repeated, not replaced by alternative monitoring, at least until an effective cross calibration of methods has been achieved.
- There is no indication of cascading trophic effects on benthic organisms, however there was an indication that there are effects on populations of some small fish

prey/competitor species. In addition, the observation of higher abundances of key grazers inside sanctuary zones suggests that some complex indirect effects might be occurring, although the nature of these effects remain unclear. This suggests that while the effects of fishing at higher trophic levels have not yet had serious effects on overall ecosystem structure, there exists potential for indirect trophic effects to become important should predator densities change dramatically, or as a result of extreme natural events. Regular monitoring should continue to assess the density and population structure of key fish species, key invertebrates, algae and corals.

- The spatially restricted location of dense populations of western rock lobster populations, and strong influence of habitat on lobster abundance and population structure make western rock lobster populations at Ningaloo particularly vulnerable. These populations could be heavily reduced by the actions of a few individuals in a matter of days, probably without knowing that this is effectively the last population left at NMP. Ongoing monitoring, specifically targeting suitable habitats within a select group of existing and newly declared sanctuaries, is required in order to determine the health of lobster populations and the degree to which they may respond positively to protection by sanctuary zones.

In addition, a number of research opportunities have been identified that can extend the information learned so far into new areas applicable for the ongoing management of NMP:

- If seasonal spatial closures are to be used as a complement to sanctuary zoning, it is important to improve our knowledge of the timing and location of spawning behaviours of key target fish species such as *Lethrinus nebulosus* and groupers in NMP.
- Mechanisms should be sought to ensure the ongoing presence of the IMOS AATAMS tracking array and cross-shelf lines at NMP as a source of strategic science that can inform decisions in other parts of northwest WA.
- Mathematical models are tools increasingly being used to maximise the ability to understand the implications of how of fish habits and habitat use interacts with human uses of the park in order to assist management. The data obtained in this study provides the opportunity to include fish behaviour in these models, just as the models currently include human behaviour and thus to use this information to inform future management decisions relating to the zoning of the NMP.
- Higher grazer biomass in sanctuary zones may be evidence of a novel resilience mechanism. In order to capitalise on this as a potential management tool we need to better understand the mechanism underpinning it, or risk unintended outcomes. Understanding of the mechanisms underlying the lower biomass of parrotfish in fished areas should also be the focus of future research effort.

Data Resources

See individual sub projects

Knowledge Transfer

See individual sub projects for more detail, however overall this research has direct application to management framework strategies, research and monitoring and should be taken into consideration by personnel in Marine policy and Planning Branch, Marine Science Program as well as the regional District Office.