Doctor of Philosophy

Mud crab (*Scylla serrata*) and Marine Park management in estuaries of the Solitary Islands Marine Park, New South Wales.

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Abstract

Marine Parks have been designed to protect marine biodiversity and sustain wild fisheries in coastal ecosystems. They typically use zoning schemes to preserve the environment and biota while allowing access to recreational and commercial activities. However, there is seldom adequate scientific research to confirm whether zoning schemes are successfully protecting fish stocks or causing favourable demographic changes to fisher-targeted species.

The Solitary Islands Marine Park (SIMP) in New South Wales, Australia, was formed in 1998 to manage human activities and to ensure the sustainability of the marine environment. Mud crab (*Scylla serrata*) populations are exploited in the Wooli, Sandon and Corindi estuaries, which form part of the SIMP. When the park was declared, different zones were implemented, restricting fishing in some areas while allowing unrestricted activities in others. The 'no fishing' zones aimed to maintain the area in its natural state. In so doing, it was hoped that commercial and recreational use could continue while ensuring a sustainable future for mud crabs.

To assess the effectiveness of this zoning for protecting mud crabs, replicate fished and unfished zones were sampled each month from December 1998 (Wooli) and July 2000 (Sandon and Corindi) until August 2003 using commercial wire traps. The sampling program coincided with changes to the zoning schemes implemented by the NSW Marine Park Authority in August 2002 as part of a zoning review, which had otherwise been unchanged since 1991. This enabled the collection of pre- and post-zoning data and the assessment of mud crab population responses to areas which were reopened (Wooli and Corindi) or closed (Sandon) to fishing.

Methods of tagging success were validated for mud crabs. Anchor t-tags inserted into the posterior margin of the crab did not hinder crab movements or become detached during moulting. These tags were effective for long-term tagging studies to describe movement patterns, and were used throughout the study. Crab behaviour around traps was assessed in special tanks. Video analysis revealed that male crabs were initially dominant around baited

traps and entered first. However, all crabs of each sex entered the trap in a short period of time and did not escape.

The sampling program provided evidence that no-take zones were protecting mud crabs from exploitation in the SIMP, as these areas contained greater numbers of crabs in all size classes. Higher proportions of males were captured in the Sanctuary Zone sites, presumably because males dominated around traps and females travelled to the downstream, fished zone when migrating offshore to spawn. These Sanctuary zones provided spill-over of crabs to adjacent fished areas. The success of this spill-over apparently depends on flooding events during which low salinity pushes crabs further downstream. However, between floods, crabs were primarily caught at the zone border where the recreational fishing pressure was greatest.

Abundances of legal-sized crabs declined within two months of opening in areas that were previously closed to fishing in the Wooli and Corindi estuaries. These results suggest scope for refinement of reopening strategies for future zone openings. Reopening of sites also distributed fishing effort away from the Sanctuary Zone borders, enabling crabs to move further into the fished area. In a reciprocal manipulation, some areas within the Sandon Estuary were excluded from all fishing while others allowed the resumption of recreational fishing after previously being targeted by commercial fishers only. Results suggest that closures are an immediate and effective management tool for the recovery of fished mud crab stocks when populations become overfished. At the protected site, crab numbers and the average size of crabs increased within months of closing while there was no change in the number of crabs caught each month in the area where recreational fishing effort resumed.

Telemetry studies in the Corindi Estuary showed that the average daily distance moved, and the average distance moved by crabs from the release point, was greater in deep channel areas than in shallow *Zostera*-dominated channels. Therefore, there is a greater probability of spill-over if Sanctuary zones are implemented where deep channels form the border between fished and no-take areas. There would also be a greater chance that shallow areas could become locally depleted because areas would be slower to recover after exploitation.

Natural barriers such as rock bars were found to enhance the effectiveness of the zoning schemes as they generate social and environmental benefits. These areas are left open to fishing, meeting with public approval, while physically, fisher access is restricted upstream of the bar. Existence of a natural barrier at Wooli resulted in crab populations upstream of the rock bar being similar in abundance and size class distribution to those in Sanctuary Zones. Meanwhile, crabs declined in the site downstream of the bar by the first sampling period, three months after the zoning change. The area above the rock bar also provided a recruitment source of crabs to the heavily fished area downstream after flooding.

The results presented in this thesis help illustrate the effectiveness of estuarine protected areas in the SIMP for sustaining recreationally and commercially targeted species such as mud crabs. It provides information that can be used to justify the effectiveness of these areas to managing authorities and the public. I have been able to show how a management plan that recognises the biology of the species being protected (the mud crab), the behaviour of the fishers targeting that species, and the tools available (e.g. zones, gear restrictions, and natural barriers) can be integrated to design effective zoning schemes in MPAs.