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# MAINTAIN OR MODIFY—ALTERNATIVE VIEWS OF MANAGING CRITICAL FISHERIES HABITAT

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## Summary

Recently fisheries management in Australia has shifted to emphasise management of resources within the principles of ecologically sustainable development. This has resulted in management to sustain fish stocks, maximise economic efficiency when harvesting those stocks, and a trend towards granting property rights to the fishers. To achieve the goal of management to sustain fish stocks, a major focus of fisheries agencies has been to preserve the critical habitats upon which the long-term productivity of the fisheries depends. For penaeid prawns this has meant that seagrass (tiger prawns), and mangroves (banana prawns) have achieved special status to fishers, fisheries biologists, managers and legislators. Is this justified? Is this the appropriate management strategy to preserve critical fisheries habitat? We examine these questions using two case studies: cyclones, seagrasses and tiger prawns in the Gulf of Carpentaria and king prawns in the Peel-Harvey estuarine system in Western Australia.

It is clear that a greater understanding of the key processes operating in the coastal zone is a critical requirement for fisheries management. It is not enough to just map, monitor and maintain subsets of these systems based on coarse distribution and abundance studies of prawn populations. With increasing pressure on the coastal zone from competing interest groups, fisheries managers need a greater understanding of the factors which determine the carrying capacity of nursery habitats for juvenile penaeid prawns, and the factors which limit the distribution of key fisheries habitats within coastal ecosystems. Fisheries scientists and managers need to develop the knowledge base and management procedures for the implementation of ecosystem management.

## Introduction

The Australian Fishing Zone occupies an area 16% larger than the Australian continent. This is the third largest fishing zone in the world. Commercial fisheries in this zone were worth approximately A$1,200 million in 1991–92 (gross value), of which 80% was exported (Anon 1992). This was made up of a diverse array of single and multispecies fisheries, with over 150 commercial species. Most of these fisheries are regional or local, and most stocks are dependent upon near shore or coastal nursery habitats.

Recently fisheries management in Australia has shifted to emphasise the management of the resources within the principles of ecologically sustainable development. This has resulted in management to sustain fish stocks, maximise economic efficiency when harvesting those stocks, and a trend towards granting property rights to the fishers (Anon 1991). To achieve the goal of management to sustain fish stocks, a major focus of fisheries agencies has been to preserve the critical habitats upon which the long-term productivity of the fisheries depends.

For penaeid prawns this has meant that seagrasses (the critical nursery habitat for tiger prawns, Figure 1) and mangroves (the critical nursery habitat for banana prawns, Figure 2) have achieved special status to fishers, fisheries biologists, managers and legislators; whereas other key habitats have not received the same special status e.g. shallow sandy substrates (a critical nursery habitat for king prawns, Potter *et al.* 1991). Is this justified? Is this the appropriate management strategy to preserve critical fisheries habitat? We examine these questions using two case studies: cyclones, seagrasses and tiger prawns in the Gulf of Carpentaria and king prawns in the Peel-Harvey estuarine system in Western Australia.

## Cyclones, seagrasses and prawns—Gulf of Carpentaria

The Gulf of Carpentaria is a large, rectangular (approx. 3.7 x $10^5$ km$^2$), shallow (<70 m), tropical embayment between 11–17.5° S latitude and 136–142° E longitude (Rothlisberg and Jackson 1982). The area has marked seasonality in temperature, salinity, rainfall and wind regimes (Poiner *et al.* 1987). Rainfall is restricted to the north-western monsoon in summer (December to February) and there is a very dry period from May to October during the south-east trade winds (Poiner *et al.* 1987).

Commercial prawn fishing in the Gulf of Carpentaria began in the late 1960s and initially concentrated on the banana prawn (*Penaeus merguiensis* de Man) (Somers *et al.* 1987). Tiger prawns (*Penaeus esculentus* Haswell and *P. semisulcatus* de Haan) are now the most important component of the catch, with 3000 to 4000 tonnes caught each year, mostly in the Western Gulf (Somers *et al.* 1987). The juvenile stages of both species of tiger prawns are most commonly found in seagrass beds (Figure 1) (Staples *et al.* 1985). The seagrasses of the Gulf of Carpentaria were mapped in 1982, 1983 and 1984. There were approximately 906 km$^2$ of seagrass beds in the Gulf, fringing 671 km of coastline, and consisting of eleven different seagrass species (Poiner *et al.* 1987).

On average five cyclones occur on the Australian coastline each year, although the frequency and track vary from year to year. In 1985 cyclone Sandy approached the coast at the Sir Edward Pellew group of Islands. Unlike many cyclones it travelled parallel to the coast, and finally crossed north of the Roper River (Poiner *et al.* 1989). The western Gulf of Carpentaria, including the area affected by cyclone 'Sandy', had been surveyed by CSIRO in 1984, immediately prior to the cyclone. The distribution of seagrass beds, their species composition, density, morphology and biomass were recorded. Following the cyclone, the affected area and nearby 'control' areas unaffected by cyclone Sandy were surveyed annually from 1985 to 1990, and then again in 1992. In the last four trips the juvenile prawn communities in inshore areas were sampled in the affected and control areas.

In 1985, immediately after the cyclone, the inshore seagrass beds in the area affected by the cyclone had disappeared. Seagrass in the deeper offshore water had been severely disturbed, but still survived. In 1986, there was still no seagrass inshore and the deep water beds had also disappeared. In all, 183 km$^2$, or 18-20% of the seagrass in the Gulf of Carpentaria was removed by cyclone Sandy (Poiner *et al.* 1989). Recolonisation was first recorded in 1987, two years after the cyclone, when a few shallow inshore areas were sparsely covered with patches of *Halodule uninervis* (Poiner *et al.* 1989). By 1988 about 20% of the area affected by cyclone Sandy had been recolonised by seagrass. *Halodule uninervis* and *Halophila ovalis*, which are of little value as habitat for juvenile prawns, were the predominant species. However a few isolated seedlings of the more useful *Cymodocea* *serrulata* and *Syringodium isoetifolium* were also recorded. In 1989 and 1990 the areal extent of seagrass did not change significantly, but there was an increase in species diversity of seagrass in the area colonised by *C. serrulata* and *S. isoetifolium*. By 1990, an area approximately 40 km long, south of the Limmen Bight River, had still not been recolonised.

In the area affected by cyclone Sandy the most common juvenile prawns observed in 1989 and 1990 were mostly small non-commercial species, mainly belonging to the genus *Metapenaeus*. In contrast, commercially important tiger and endeavour prawns were found in the undamaged seagrass beds (Thorogood *et al.* 1990).

Log book data and landing statistics from 1980 to 1991 were analysed to determine whether there was a decline in the catch of tiger prawns after the destruction of the seagrass beds. The catch of tiger prawns in the South western Gulf of Carpentaria fluctuates widely from year to year. From 1980 to 1984 the average annual catch of tiger prawns in both the affected and unaffected areas was about 250 tonnes (Thorogood *et al.* 1990). Since cyclone Sandy in 1985 the annual catch in the unaffected area has ranged from 100 to 350 tonnes, with an average of 200 tonnes, while the total catch in the affected area declined to about 40 tonnes in 1988 and 1989 (Thorogood *et al.* 1990), and in 1991 was 87 tonnes (Figure 3). That is, the loss through the cyclone, of seagrass as a habitat for juvenile prawns, may have resulted in a decrease in the commercial prawn catch in the fishery immediately offshore of the affected area of up to 80%, or 160 tonnes.

The total catch of tiger prawns in the whole of the Gulf of Carpentaria also fluctuates widely from year to year. The annual catch from 1980 to 1991 in the Gulf was 3,848 tonnes. So the conjectured loss of 160 tonnes of tiger prawns due to the effects of the cyclone is approximately 4% of the annual average catch for the Gulf, despite an 18–20% loss of seagrass in the Gulf.

Thus the severe effect on the juvenile prawn habitat and commercial prawn fishery is localised, and was not reflected in the total commercial catch. This begs the question: How much seagrass habitat can we lose before there is a severe effect on the fishery? Juvenile tiger prawn abundance can vary greatly between seagrass communities of different types and different tiger prawn species appear to prefer different seagrass habitat types, which probably explains the relatively small impact of Cyclone Sandy on the annual average catch for the Gulf.

## Peel-Harvey estuarine system

The Peel-Harvey Estuary (lat 32° 35' S, long 115° 45'E) is located 80 km south of Perth and is the largest estuarine system in south-western Australia, covering a surface area of about 130 km$^2$. It consists of two shallow (mostly 2 m deep) inter-connected basins (Peel Inlet and Harvey Estuary) and a short, narrow Entrance Channel linking the system to the sea (McComb *et al.* 1981). This estuary undergoes large fluctuations in salinity during the winter and spring months when approximately 90% of the annual rainfall is recorded in this region, and much of the Estuary can become hypersaline (up to 50 ppt) during late summer, early autumn (McComb *et al.* 1981; Loneragan *et al.* 1986). The Peel-Harvey system supports important commercial and recreational fisheries for a variety of species of fish and crustaceans (Potter *et al.* 1983; 1991).

Since the late 1960s, the Peel-Harvey Estuary has shown increasing signs of eutrophication due to the high levels of nutrients in the run-off derived from the agricultural lands in the catchment of the system. Initially there was a very high biomass of macroalgae, particularly the goat weed *Cladophora montagneana*, in the 1970s. However, in the 1980s and early 1990s the biomass of goat weed in the system declined dramatically and there have been virtually annual blooms of the cyanobacteria *Nodularia spumigena* during the summer months (McComb *et al.* 1981; Lukatelich and McComb 1986).

The estimated total annual biomass of *Cladophora* reached a peak of 26 000 t in 1979 and has been lower than 2 000 t throughout most of the 1980s and early 1990s (Lukatelich and McComb, unpublished data). This species covers the bottom and in the 1970s formed very dense, deep beds which smothered the substrate in large areas of the Peel-Harvey Estuary. The large banks of this species and the breakdown of macroalgae in the shallows have caused odour problems for residents and tourists in the region. A macroalgae harvesting program has been undertaken to remove some of the extensive beds of macroalgae in an attempt to alleviate some of this problem.

## Western king prawns, *Penaeus latisulcatus*

Adults of the western king prawn *Penaeus latisulcatus*, are found on sandier substrates in the Gulf of Carpentaria and Exmouth Gulf, Western Australia than tiger prawns (Penn and Stalker 1979; Somers 1987; Dall *et al.* 1990). This species is much sought after by both recreational and commercial fishers in the Peel Harvey Estuary who catch the large juveniles as they emigrate from the estuary on the ebb tides at night, mainly between March and July of each year (Potter *et al.* 1991). Commercial catch data show that catches in the 1960s were much higher than those in the 1970s when *Cladophora* reached very high biomasses in the system (Figure 4) (Potter *et al.* 1991). Following the decline in biomass of *Cladophora*, the commercial catches increased greatly in the 1980s (Figure 4) (Potter *et al.* 1991).

The marked decline in catches is probably due to the loss of extensive areas of the sandy substrate, the required nursery habitat of this species (Penn and Stalker 1979; Dall *et al.* 1990; Potter *et al.* 1991). Although the biomass of other species of macroalgae has been high in the estuary after 1979, it has not reached the same levels as that reached by *Cladophora*. Moreover, these other species of macroalgae do not smother the substrate or form as dense and extensive beds as *Cladophora*. It would appear that although the system is still highly eutrophic in the 1980s and early 1990s, the recovery of the sandy nursery grounds of the western king prawn in the Peel-Harvey Estuary has led to a recovery of the commercial catches of this species.

## Discussion and conclusions

In the relatively pristine Gulf of Carpentaria, the site of Australias major tiger and banana prawn fisheries, a natural decline of around 20% (183 km$^2$) of prime seagrass habitat resulted in a 4% (160 t) decline in the total catch of the fishery.

A simplistic analysis of the data would suggest the fishery can be sustained despite significant declines in coastal seagrass habitats. In the highly eutrophic Peel-Harvey Estuary, loss of sand substrate through smothering by a macroalga (*Cladophora montagneana*) in the 1970s, led to a marked decline in catches of western king prawn (*Penaeus latisculatus*). In the 1980s the system is still highly eutrophic but with the decline of the macroalgae and partial recovery of the sand habitat, catches of king prawns have recovered. It is clear from both of these studies we do not understand in detail the relationship between prawns and their nursery habitats or the factors that limit the distribution of habitats themselves.

Without suitable nursery areas, there would be no prawn fisheries. But to protect nursery areas and hence the long-term productivity of a fishery, a fishery manager has to know what it is that needs protecting. What exactly are the nursery habitats and what is it that makes some habitats more suitable than others? Juvenile tiger prawns are most abundant on seagrass beds, and juvenile banana prawns are most abundant in mangrove-lined estuaries. Indeed, in the Northern Prawn Fishery, there is good agreement between the distribution of the main tiger prawn fishing grounds and the distribution of coastal seagrasses, and between banana prawns and adjacent mangrove-lined estuaries (Staples *et al.* 1985). However, juvenile tiger prawn abundance can vary greatly between seagrass communities of different types and different tiger prawn species appear to prefer different seagrass habitat types. In the case of banana prawns, no one yet knows whether different types of mangrove communities support different population densities but, based on the strong regional variability in commercial catches, we suspect that this may certainly be the case. Just as importantly, no one yet knows what limits the distribution of the nursery habitats themselves . Clearly, it is important for fishery managers to know what the most suitable nursery habitats are so that they know *what* to protect; but it is just as important to know what factors make habitats suitable so that managers might know *how* to protect them. Where these habitats have been impacted and/ or are limiting the productivity of the fishery, obviously it would also be advantageous to know what factors limit the growth and colonisation of nursery habitat vegetation and hence the distribution of habitats themselves.

It is clear that a greater understanding of the key processes operating in the coastal zone is a critical requirement for fisheries management. It is not enough to just map, monitor and maintain subsets of these systems based on coarse distribution and abundance studies of prawn populations. With increasing pressure on the coastal zone from competing interest groups, fisheries managers need a greater understanding of the factors which determine the carrying capacity of nursery habitats for juvenile penaeid prawns, and the factors which limit the distribution of the key fisheries habitats within coastal ecosystems. Fisheries scientists and managers need to develop the knowledge base and management procedures for the implementation of ecosystem management. We need to broaden our focus from the commercial industry and the populations of the target species and their critical habitats to a better understanding of the ecosystems within which the target species and their critical habitats are located (Anon 1991).

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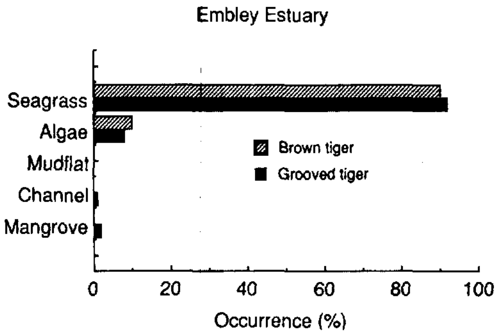

**Figure 1.** Percentage distribution of the catch of brown (*Penaeus esculentus*) and grooved (*P. semisulcatus*) tiger prawns in each of five habitats in the Embley River estuary, Gulf of Carpentaria.

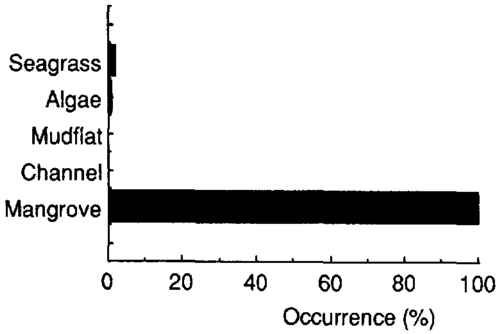

**Figure 2.** Percentage distribution of the catch of banana prawns (*Penaeus merguiensis*) in each of five habitats in the Embley River estuary, Gulf of Carpentaria.

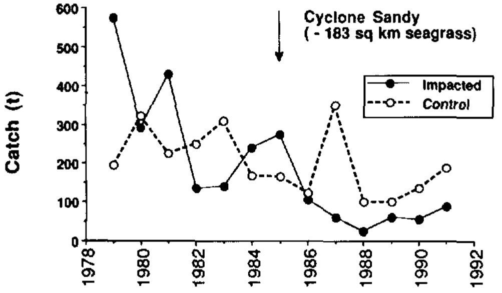

**Figure 3.** Catch of tiger prawns before and after cyclone Sandy in areas affected (impacted) and areas unaffected (control) by the cyclone.

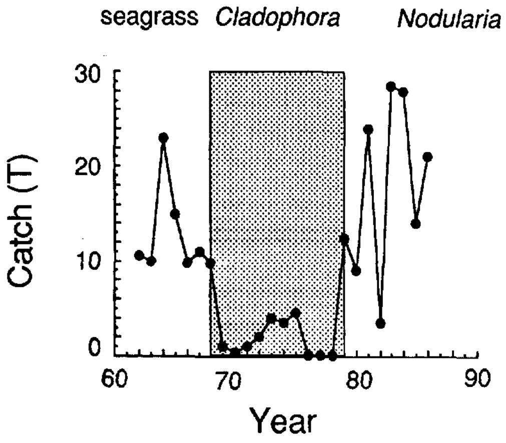

**Figure 4.** Catch of western king prawns (*Penaeus latisulcatus*) from the Peel-Harvey estuary before any algal blooms, during the blooms of the macroalgae *Cladophora montagneana* and during the summer blooms of the cyanobacteria *Nodularia spumigena* (redrawn from Potter *et al.* 1991).