POSSIBLE IMPACTS OF THE GREENHOUSE EFFECT ON COMMERCIAL PRAWN POPULATIONS AND FISHERIES IN NEW SOUTH WALES

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INTRODUCTION

The Prawn Fisheries

Penaeid prawns are currently the second most important fisheries resource in New South Wales, being worth ~$25 million annually at the point of first sale. Four species comprise over 99% of commercial landings (Table 1).

Eastern king prawns are exploited offshore from the Swains Reefs off southern Queensland (21°S) to the Gippsland Lakes in eastern Victoria (38°S). The fishery operates year round north of South West Rocks, NSW (fig.1) and between summer and winter south of there. School prawns are exploited offshore between Noosa Heads in southern Queensland (26°S) and Gippsland Lakes from spring through to winter. Commercial and recreational estuarine fisheries for both of these species operate between Noosa Heads and Gippsland Lakes between spring and autumn. Likewise, greasyback prawns are caught between Noosa Heads and Gippsland Lakes from spring to autumn, but they are exploited only in estuaries. Royal red prawns are fished between Tweed Heads in northern NSW (28°S) and Bermagui in southern NSW (36°S) but only offshore. The seasonality of this latter fishery varies between regions but tends to become more year round further to the north.

COMMON NAME	SPECIES NAME	LOCATION	LANDINGS	
			Tonnes	%
Eastern king	*Penaeus plebejus*	O	762	34
		E	173	8
School	*Metapenaeus macleayi*	O	312	12
		E	736	32
Royal red	*Haliporoides sibogae*	O	224	11
Greasyback	*Metapenaeus bennettae*	E	56	2

Table 1 Species composition of the landed prawn catch in New South Wales. The weight and value contributed by each species are shown. The location of the catch has been separated into ocean (O) and estuary (E).

Penaeid Prawn Life Cycles

The above four species differ in the variety of habitats they utilise during various life cycle stages. The life cycles of eastern king and school prawns are examples of the most common form found amongst penaeids. These incorporate both estuarine and oceanic dependent stages (fig. 2). The planktonic larvae are spawned offshore and, after about a month, postlarvae enter inshore coastal and estuarine nursery grounds. After spending several months (generally through autumn and winter) in these habitats, juveniles gradually move offshore, become sexually mature, spawn, and thereby complete their life cycle. Similar life cycles are pursued by greasyback and royal red prawns; however, these are completed in the estuarine and oceanic environments, respectively.

The Eastern King Prawn (*Penaeus plebejus*)

The eastern king prawn is endemic to waters off the east coast of Australia. It has been recorded from Hayman Island (20°S) to north-eastern Tasmania (42°S) and eastwards to Lord Howe Island (Ruello 1975). The species occurs in waters out to a depth of 240 m and constitutes a single stock (Ruello 1975). Its life cycle is characterised by northerly movements over record distances for adult crustaceans (Ruello 1975, Montgomery in press).

Spawning occurs offshore between January and June (Dakin 1938) in depths greater than 50 m off northern New South Wales and south-eastern Queensland (Racek 1959). Laboratory studies indicate that salinities greater than 25‰ are required for spawning to take place (Preston 1985). Postlarvae enter estuaries year round but peak abundance occurs between autumn and spring (Young & Carpenter 1977, Coles & Greenwood 1983). The estuarine nursery habitat of

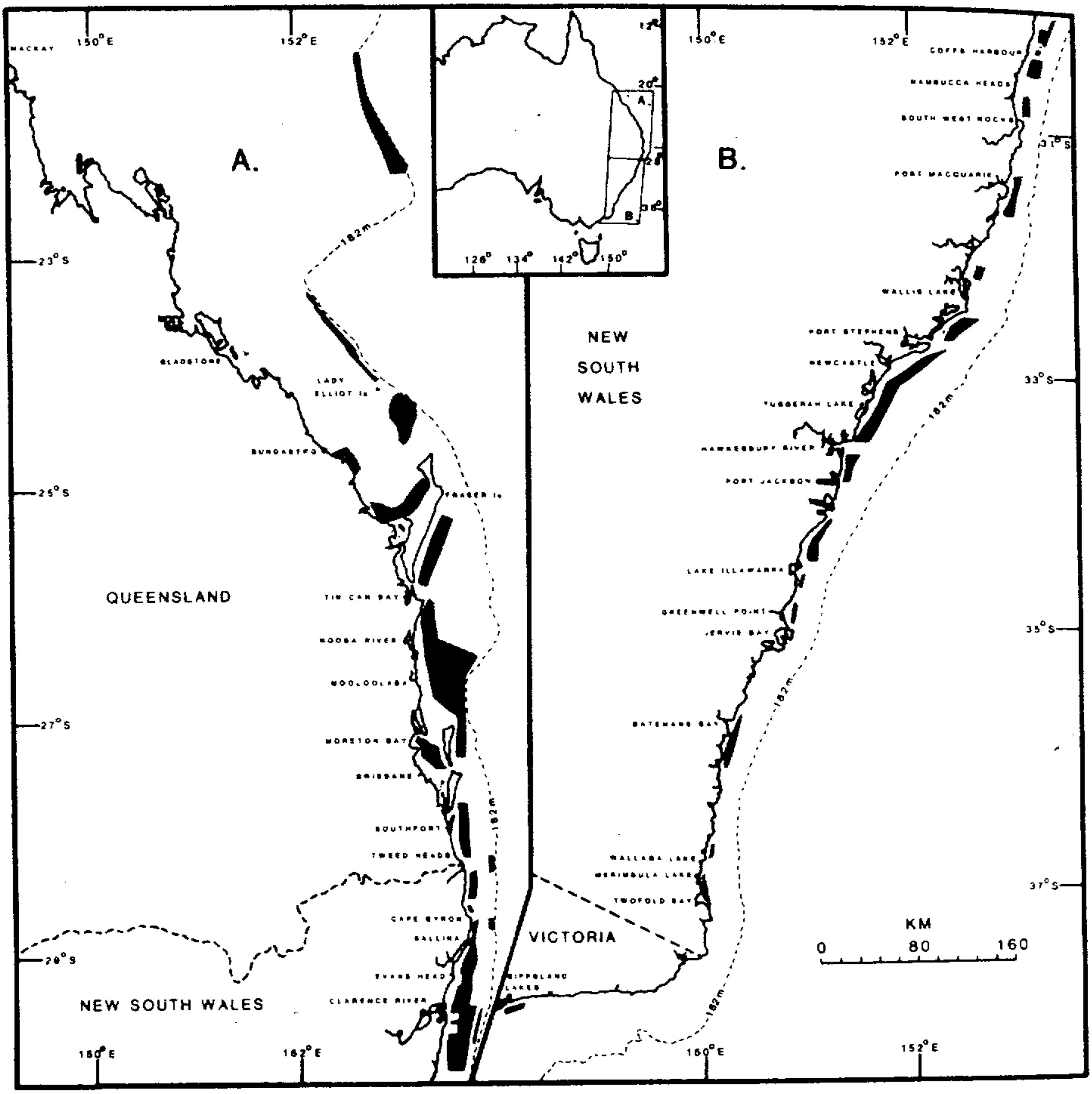

Figure 1 Geographic distribution of inshore prawn fishing grounds off the east coast of mainland Australia.

eastern king prawns generally comprises shallow areas (less than 2 m depth) with a strong marine influence (Young 1978). Eastern king prawns settle in both seagrass beds and on bare substrata (Young & Carpenter 1977). Juveniles can tolerate salinities as low as 3‰ but adults are less tolerant (surviving in salinities as low as 7‰ (Dall 1980)). Their preferred habitat is therefore well within their tolerance range for salinity. It is also possible for eastern king prawns to complete their whole life cycle in offshore waters (Young & Carpenter 1977, Coles & Greenwood 1983).

The School Prawn (*Metapenaeus macleayi*)

The school prawn is also endemic to waters off eastern Australia. It has been recorded from Tin Can Bay (26°S) to Corner Inlet (39°S) and occurs in waters to 55 m depth (Racek 1959). Once offshore, school prawns move only relatively short distances from their estuarine habitat (Ruello 1977, Glaister 1978a). Consequently, several stocks are present over the species' distribution (Ruello 1977).

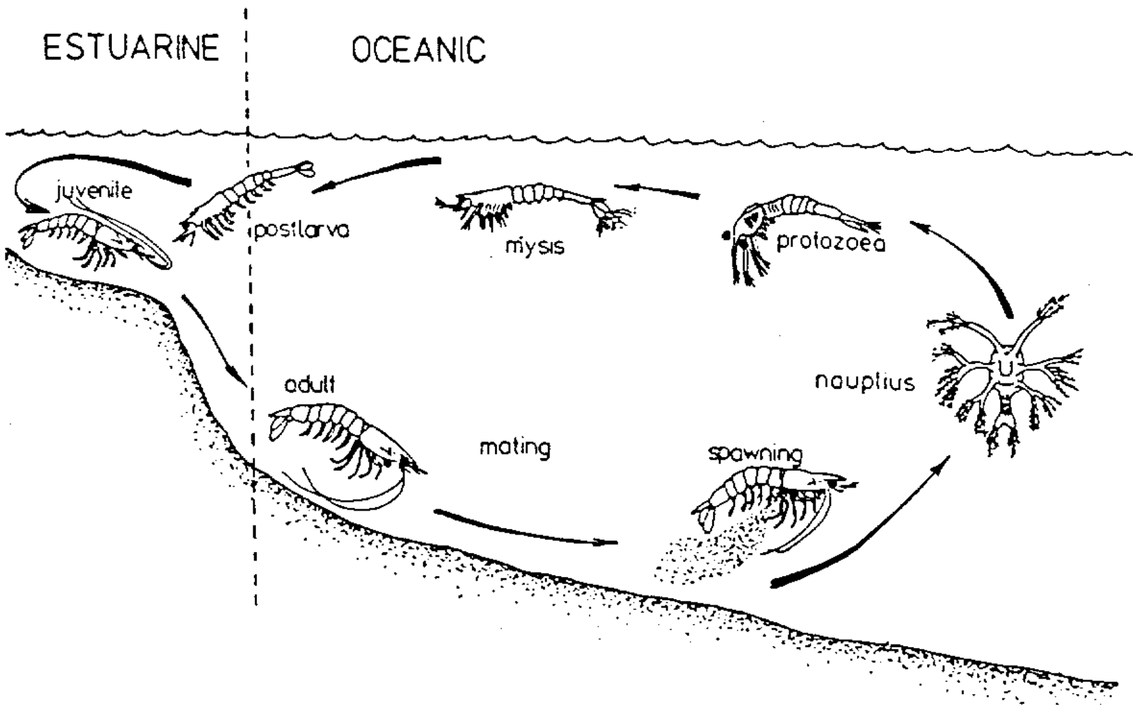

Figure 2 Generalised life cycle of a penaeid prawn.

Spawning takes place between summer and autumn in offshore waters (Racek 1959). Postlarvae enter estuaries from autumn to winter. Juveniles prefer a fine to medium sand substratum (Ruello 1973a) and settle in both seagrass beds and on bare substrata (Young 1978). The tolerance of school prawns to low salinities has not been studied, although Ruello (1971) found school prawns in salinities as low as 1‰. Juvenile prawns stay in the nursery habitat over winter, then move seaward from spring to summer. Both regional rainfall and river discharge are significantly correlated to annual prawn landings in the Hunter and Clarence River school prawn fisheries (Ruello 1973b, Glaister 1978b, e.g. fig.3). These fisheries collectively account for more than 41% and 72% (by weight) of the NSW estuarine and offshore school prawn landings, respectively.

The Greasyback Prawn (*Metapenaeus bennettae*)

Greasyback prawns have been recorded from Cooktown (15°S) to eastern Victoria (Kirkegaard & Walker 1970). Spawning can take place within either the estuarine or inshore marine environments (Preston 1985). This occurs between November and February in New South Wales (Racek 1959) and from October to May off southern Queensland (Dall 1958). Postlarvae are found in estuaries year round but peak abundances occur between March and June (Young &Carpenter 1977). Postlarvae and juveniles prefer a shallow "intermediate to riverine habitat" (Young 1978), but can occur in both freshwater and marine environments (Dall 1958).

Juveniles move towards the seaward end of the estuary between spring and summer (Dall 1958, Racek 1959, Coles & Greenwood 1983) and will move downstream also during times of flood (Dall 1958). Dall (1980) concluded that this species was a highly efficient osmoregulator (with little difference between juveniles and adults) and that this characteristic was necessary for its basically estuarine life cycle.

The Royal Red Prawn (*Haliporoides sibogae*)

Royal red prawns are recorded across the Indo-West Pacific. Off eastern Australia, they have been recorded in waters from central Queensland to north-eastern Bass Strait in depths from 275 m to 820 m (Graham & Gorman 1985, Potter & Dredge 1985). Little is known of the biology of this species, although two spawning periods have been identified off New South Wales, namely March-April and July-August (Graham & Gorman 1985).

GREENHOUSE EFFECTS

This paper assesses possible environmental changes associated with the Greenhouse effect and potential impacts on each of the four prawn species mentioned above. Possible changes considered are a more consistent southward flow of the East Australian Current below latitude 32°S; a temperature rise of 2-4°C with a 10 to 20 year lag for ocean temperatures; a sea level rise of between 0.2 and 1.4 m; increased wave action as a result of increased wind speeds south of latitude 36°S; and an increase in the level of rainfall over summer with associated changes in salinity regimes and frequency of flooding. Each effect has been considered separately, ignoring complex ecological processes such as changes in predator/prey relationships. Possible future changes in management regimes, fishing methods and marketing strategies that may be necessary because of greenhouse-induced climate change have not been considered in this paper.

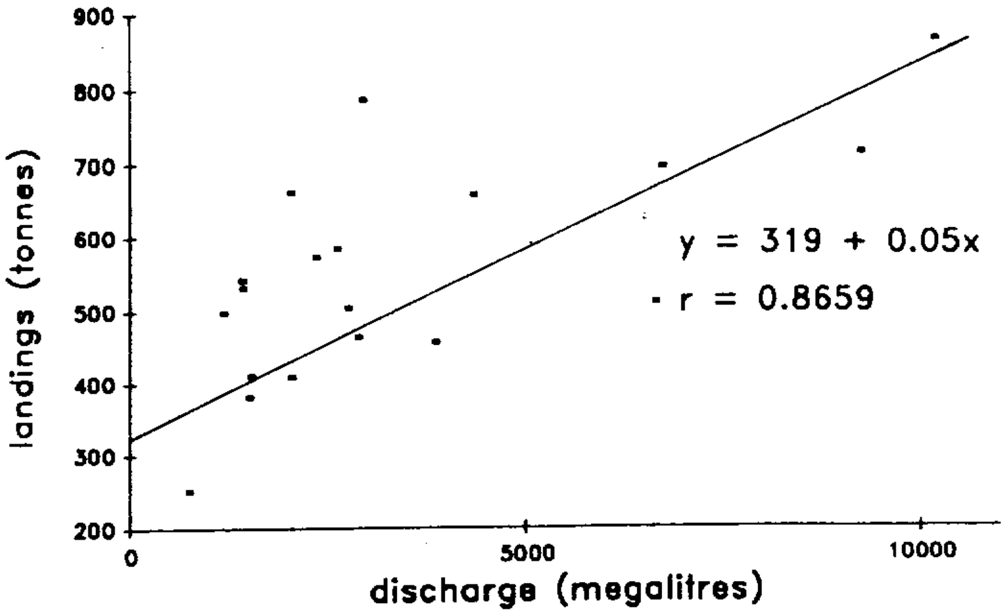

Figure 3 Relationship between river discharge and annual school prawn landings for the Clarence River region between 1966-67 and 1985-86. The correlation is that determined by Glaister (1978b) for the years 1966-67 to 1975-76.

POSSIBLE IMPACTS OF THE GREENHOUSE SCENARIO

Eastern King, School and Greasyback Prawns

The stimuli which influence prawns to emigrate from estuaries are not well understood. However, if they are temperature related, a 2-4°C warming in estuarine water temperatures may stimulate school and eastern king prawns to emigrate from estuaries earlier in the year than at present. Greasyback prawns may also move downstream earlier. Warmer marine water may also stimulate these species to spawn earlier in the year than at present, and eastern king prawns could spawn at higher latitudes.

A more consistently flowing East Australian Current may assist in providing less variable recruitment of prawn larvae to estuaries south of latitude 32°S. This and warmer seawater temperatures may provide for the geographical distributions of all three species to be extended southwards.

A rise in sea level has the potential to increase the area of nursery habitat available for juvenile prawns. Some flood plains may become permanently covered with saltwater and tidal influence might extend further upstream. Further, a rise in sea level coupled with an increase in wave action may result in some intermittently opening estuaries opening to the sea for longer periods, again providing more available nursery habitat.

Increased levels of rainfall over summer will cause increased runoff. This in turn has the potential to lower salinity, increase river discharge and increase the incidence of flooding. All three species appear to be capable of tolerating low salinities during the juvenile and adult phases of their life cycles. Lower salinities therefore should have little effect upon the survival of these life history stages, but may force eastern king and school prawns to emigrate from the estuarine habitat earlier and possibly to move further seaward. Greasyback prawns may also move further downstream and out to sea during periods of flood.

The survival of prawn larvae under conditions of varying salinity and water temperature will depend much upon the ambient conditions under which they hatched (Preston 1985). Salinity is the most important of these two environmental factors to the survival of larvae and has most effect up to the mysis stage of development (Preston 1985). The effect of lower salinities upon the survival of prawn larvae will depend therefore upon the stage of larval development. The period of highest eastern king and school prawn postlarval abundance is at a time when summer rainfall would be expected to have least effect upon salinity, and therefore less impact upon the larvae of these two species. Greasyback larvae are the most likely to be exposed to lower salinities and are the most capable of tolerating them. It is therefore possible that lower salinities will have only minor effects upon the survival of prawn larvae. Increased runoff and river discharge may cause increased siltation. Any change in the structure of the habitat substratum, whether it be within the estuary or offshore, has the potential to affect the distributions of all three species.

Changes to seagrass beds resulting from any rise in sea level and increase in turbidity (from increased runoff) may or may not affect the survival of prawns. All three species settle on bare substrata as well as on substrata covered with seagrass, though the relative importance of these two habitat types is unknown.

Increased rates of emigration (caused by high levels of river discharge) have the potential to result in greater aggregations of prawns. As a result, catch rates in the fishery may increase. There is the potential therefore, for annual landings of all species to increase, but particularly those of school and greasyback prawns.

Royal Red Prawn

Warmer seawater temperatures may have the potential to affect the geographic distribution of this species and its time of spawning. A more consistently southward flowing East Australian Current, containing warmer water, may extend the southern distribution limit. With a completely oceanic life cycle, it is unlikely that the royal red prawn will be affected by sea-level rise or increased wave action. Being distributed along the Continental slope, it is also unlikely that this species will suffer from potentially lower coastal salinities.

CONCLUSIONS

The greenhouse scenario as presented here has the potential to increase the annual landings of inshore prawn species. Landings of deepwater species such as royal red prawns should be unaffected. With increased emigration there is the potential for formation of greater aggregations of the inshore prawn species, particularly during times of flooding. As such effects may be completely independent of any increase in population abundance, any increase in the catchability of prawns has the potential to be detrimental to population abundance.

The possible rise in sea level and increase in wave action have the potential to increase the area of nursery habitat. This could result in increases in overall prawn abundance for all three inshore species. Prawn abundance will also be affected however, by changes in salinity. This will have the greatest effect during the larval phase of the prawn life cycle. The survival of enough postlarvae to take advantage of increased habitat area will depend upon the ambient conditions at hatching, the severity of any changes in the salinity regime, and whether prawn larvae enter coastal waters at a time when salinity is low. It is impossible to assess the interactions of these different processes in terms of prawn survival.

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