1 Introduction

1.1 Biology

In the Indo-West Pacific, banana prawns (Penaeus merguiensis) are distributed from the Persian Gulf to Thailand, Hong Kong, the Philippines, Indonesia to New Guinea, New Caledonia and northern Australia (Grey et al. 1983). In Australia they are distributed from Shark Bay and Exmouth Gulf in Western Australia through the Northern Territory, the Gulf of Carpentaria and the Queensland coast to northern New South Wales.

The biology and population dynamics of banana prawns have received considerable research attention (Dredge 1985; Munro 1975; Staples 1985; Staples and Vance 1985; Staples et al. 1985; Vance et al. 1985). Adults are trawled in schools in depths between 16 and 25 m (Grey et al. 1983). Adult females broadcast eggs into the water column (i.e. there is no brood). The eggs have a diameter of approximately 0.27 mm and are thought to be demersal. Fertilisation takes place externally and hatching to a pelagic non-feeding nauplius stage occurs within 1–2 days after spawning. Over the next 2–3 weeks, the young prawns develop through a protozoea stage, followed by a mysis stage and a postlarval stage that settles out of the water column into a benthic phase. Postlarval banana prawns settle in mangrove-lined, muddy estuaries and over the following 2–3 months grow into juveniles. Juveniles are tolerant of a broad range of salinities and may ascend several kilometres upstream to almost freshwater. When they are about half the length of adult size they leave the estuary and continue to grow, mature, mate and spawn in open offshore waters. Dall et al. (1990) put forward four general prawn life cycle types, based on the affinity that species have for an estuarine phase and suggested that P. merguiensis falls into the Type 2 life cycle, preferring estuaries or estuarine-like environments during part of their development.

1.2 Environment

Biological studies of banana prawns in the Gulf of Carpentaria revealed that a number of environmental factors may affect the various life cycle stages (Figure 1.1). Although it is not well known whether this life cycle and the environmental drivers in tropical regions are applicable in subtropical waters, Meager et al. (2003) found similar seasonal patterns of postlarval and juvenile catches and environmental effects in Logan River, a subtropical estuary in South East Queensland. Meager et al. (2003) also found that the period of postlarval and juvenile recruitment was more restricted in the Logan River than in tropical regions. The present study considered the following environmental variables for which data were available: a) rainfall, b) river flow and c) air temperature.
Rainfall

Rainfall is highly correlated with offshore commercial catches of banana prawns in the south-eastern Gulf of Carpentaria (Staples et al. 1994; Vance et al. 1985). It has been suggested that rainfall has different effects on different stages of the banana prawn life cycle:

- high rainfall increases emigration of juvenile banana prawns from the estuaries (Staples 1985; Staples and Vance 1987; Vance et al. 2003; Vance et al. 1998; Vance et al. 1985)
- increased rainfall prevents immigration, settlement and survival of postlarvae (Barrett and Gillespie 1973; Barrett and Gillespie 1975; Meager et al. 2003; Staples and Vance 1987)
- rainfall runoff may increase the overall productivity due to increased nutrient input, which may contribute to increased growth and survival rates of prawns (Robins et al. 2005; Staples and Vance 1985; Vance et al. 2003).

However, the influence of rainfall on juvenile emigration from the estuaries to offshore waters tends to vary depending on geographical areas with local climate patterns (Meager et al. 2003). Off the western peninsula of Malaysia, where rainfall is consistently high throughout the year, rainfall has little influence on emigration of juvenile banana prawns (Ahmad-Adnan et al. 2002). In contrast, off the east coast of Queensland, Meager et al. (2003) found low juvenile catches in the Logan River following high rainfall (low salinity), which indicates that rainfall stimulates the
emigration of juveniles to offshore waters in this subtropical estuary. Loneragan and Bunn (1999), on the other hand, failed to detect any significant effect of river flow (low salinity) on offshore commercial catches in the Logan River. In the Fitzroy River, the largest catchment on the Queensland east coast, a significant positive correlation was found between summer rainfall (and river flow) and offshore annual catches (Robins et al. 2005).

**River flows**

Although river flow and rainfall effects could be assumed to have equal influence on prawn catches, there is evidence to suggest that flows are the more influential. Glaister (1978) found a significant correlation between river flow and school prawn catches in northern New South Wales, but not with rainfall. He suggested that flows were more influential because they not only include rainfall effects, but also other factors such as catchment size. Vance et al. (2003) also highlighted the influence of catchment size, which is captured in flow events, on offshore banana prawn catches in the Gulf of Carpentaria.

**Temperature**

Temperature may influence the survival of larvae and settlement of postlarvae (Haywood and Staples 1993; Staples and Heales 1991; Vance et al. 1985). Temperature may also affect the behaviour of adults, particularly during the period of emergence from the sediment (Vance et al. 2003). Vance et al. (1985) found a significant positive correlation between winter temperature and annual banana prawn catch in the Mornington Island and Groote Eylandt areas in the Gulf of Carpentaria. This may be a result of higher egg production and survival of larvae in these areas from winter spawnings. Vance et al. (1985) also found a significant negative correlation between summer temperature and annual prawn catch in the Karumba region, where the water temperature regularly exceeds 30 °C. The laboratory study conducted by Staples and Heales (1991) revealed that such high temperatures might increase the mortality of juvenile banana prawns, which could explain the negative effect. However, Vance et al. (2003) failed to detect any significant effect of summer temperature on prawn catch in any regions in the Gulf of Carpentaria, possibly because summer temperature was confounded by summer rainfall, which was a dominant environmental variable in the Gulf. In subtropical Queensland, where the seasonal variation in water temperature is much higher than in tropical waters, higher temperatures were associated with the higher juvenile catches in Logan River (Meager et al. 2003).

1.3 **Spatially defining sub-stock areas**

The affinity banana prawns have for shallow estuarine and coastal habitats, combined with logbook information on their distribution and their apparent inability to undertake significant migrations suggests that the fishery is likely comprised of sub-stocks or populations along the coast. While sub-stocks are unlikely to be completely
independent of each other, those separated by large distances are likely to be more independent than adjacent sub-stocks. In the present study, logbook data on reported landings were used with information on catchments and river systems to define sub-stock areas. Logbook grids (30' × 30' grid) where banana prawn catches were reported were identified and allocated to a sub-stock. Each sub-stock was comprised of 2–7 grids.

About 96% of all landings for the period 1988–2004 have been reported from nine sub-stock areas shown in Figure 1.2.

Figure 1.2. Nine sub-stock areas that comprise the Queensland banana prawn fishery. The average reported annual catch of banana prawns (1988–2004) is provided for each 30' × 30' grid.
1.4 Research history of the Queensland banana prawn fishery

The Queensland banana prawn fishery has received relatively little research attention and has not previously been quantitatively assessed. Five studies have been undertaken: two biological studies (Dredge 1985; Meager et al. 2003), two on bycatch (Hyland 1985; Stobutzki et al. 2000) and one bioeconomic evaluation of the beam trawl fishery (Campbell and Reid 2000; Reid and Campbell 1999).

Although no formal assessment was undertaken, Dredge (1985) suggested the fishery was heavily exploited, based on a comparison of the number of vessels operating on the Queensland east coast and the Gulf of Carpentaria. Dredge described size modal progressions, movements and reproductive biology of *P. merguiensis* in the Burnett River estuary and suggested the population displays two generations each year, one based on spawning from February to May, the other based on spawning from August to December. Dredge also suggested that some adult banana prawns over-winter in the river, returning from offshore to inshore, and then contribute to the spring spawning.

Hyland (1985) quantified beam trawl catch rates of banana prawns and other estuarine prawn species from the Caboolture, Pine, Brisbane and Logan Rivers using a voluntary logbook program before the mandatory CFISH program commenced in 1988. Hyland also described the bycatch from the Logan River, recording 93 species, with 12 species comprising 90% of the weight. Stobutzki et al. (2000) described the bycatch from the Queensland banana prawn otter trawl fishery and recorded 316 taxa with 25 species accounting for 80% of all individuals. The bycatch community structure varied with location and formed distinct groupings along a latitudinal axis. It was estimated that about 4500 t of bycatch was produced annually for a reported otter trawl catch of about 580 t of banana prawns.

Reid and Campbell (1999) and Campbell and Reid (2000) undertook a bio-economic analysis of the Queensland beam trawl fishery, which includes significant catches of banana prawns. The value of the recreational fishery and the value of marginal increases in catches of target species were estimated under the scenario of closing the beam trawl fishery. They concluded that any marginal benefits from closing the fishery would not justify the costs.

1.5 Objectives

The objectives of this assessment were to:

1. collate historical, commercial and recreational catch and effort data available for the banana prawn fishery on the Queensland east coast
2. investigate the influence of environmental factors (i.e. rainfall, river flow and air temperature) on banana prawn catch rates
3. describe the trend and current status of the banana prawn stock on the Queensland east coast
4. advise on management, monitoring, reporting and/or further research required to improve or enable future assessment of the Queensland banana prawn fishery.