CHAPTER 9

9. General Discussion

Many scientific investigations of the past decades have discussed the relationships between prawns, fish and mangrove waterways (estuaries, inlets and creeks). Mangrove forests are in all likelihood the most productive (in terms of net primary productivity) of all natural ecosystems (Ong, 1982). There has been consistent evidence of the ecological value of mangroves as a feeding and nursery grounds for a large number of fish and prawns. Furthermore inshore areas constitute a crucial part of the life-support system of off-shore populations by providing nursery and feeding areas (Jansson *et al.*, 1988).

In Malaysia, mangroves comprise about two percent of the total land area in the country (Ong, 1982). About 96% of the total area of mangrove forests in Peninsular Malaysia occur on the west coast and at the southern tip whilst only 4% occur on the east coast (Tang *et al.*, 1984). About 39% of the total mangrove forests occur in the state of Perak, 25% in Johor, 22% in Selangor and 9% in Kedah. The utilisation and management of mangrove forests, therefore, are of direct importance to these four states.

Since the pioneering work of W.E.Odum and E.J.Heald in Florida in the late 1960s there has been a general belief amongst mangrove scientists that mangrove forests are essential for the conservation of inshore marine fish stocks which are harvested by commercial operations (Robertson, 1991). Comparative analysis of the tissue carbon of the common consumers captured in the inshore and offshore waters in Selangor indicate that prawns in mangrove inlets derived an average of 65% of their carbon from mangroves trees (Rodelli *et al.*, 1984). Eleven species of fish were also found to have derived an average of 60% of their carbon from mangroves.

Data from this study indicates that the total number of fish species caught using bagnet at the three mangrove creeks (Sites I, II and III) was thirty-eight, belonging to twenty-three families (Table 4.3). The prawn catches consisted of three families, comprising nine species (Table 5.3).

The correlation analysis of the total wet weight of fish catch against tidal heights at Sites I and III showed negative correlation (Table 4.1). However, for prawn, Site I showed an increase in total catch (weight) with increasing tidal height (Table 5.1).

Many factors can effect the distribution of fish and prawns in mangrove creeks. It is difficult to compare the number of species collected in different studies, due to variation in the abiotic environment, habitat heterogeneity, sampling techniques and sampling effort. The number of species collected from the small creeks in this study was relatively high compared with other studies mangroves inlets/estuaries. For example in Kenya, 83 species were collected in Tudor Creek (Little *et al.*, 1988). In Australia, 55 species were recorded in the Trinity Inlet System of northern Queensland (Blaber, 1980). In Puerto Rico, 59 species were collected (Austin, 1971). In Queensland, 45 species were recorded in Serpentine Creek (Quinn, 1980), whilst in salt-marsh creek in temperate, only 22 species were collected (Shenker and Dean, 1979). Studies in coastal lagoon, Mexico also recorded poor species, 45 species (Warburton, 1978).

The lack of any marked gradients in salinity or temperature between the creek and ocean may account for the high species richness, as more stenohaline species may be able to enter the creek from the ocean. This is probably the case of relatively more species found in Sites I, II and III.

Studies by Sasekumar *et al.* (1992) also provided evidence indicating the importance of mangrove creeks as habitats for fish and prawns. The above study found 119 species of fish and 9 species of prawns in mangrove creeks and inlets, 39 species of fish and 11 species of prawns in the intertidal mudflat and 102 species of fish and 15 species of prawns in Angsa Bank and Klang Straits. The number of species collected was even higher in the above study and in Philippines, where 128 species were collected in the mangroves of Pagbilao (Pinto, 1988). This trend was also observed in north-eastern Queensland, Australia, where 133 species were recorded (Robertson and Duke, 1987).There was marked fluctuations in environmental parameters like salinity and temperature in mangrove habitats (Little *et al.*, 1988).

Differences in the species composition of the small creeks and big creeks/inlets are probably due largely to habitat structure since salinities, temperature and turbidities are similar. Those species found in this study were chiefly small residents and juvenile species. The species exclusive to the inlet areas consisted largely of species from a wide variety of families. This may be the reason for less species occurring in small creeks than big creeks/inlets.

The nursery function of inshore waters and estuaries of the Indo-Pacific region for juvenile fish is well-documented (Blaber and Blaber, 1980; Day *et al.*, 1981; Lenanton, 1982) and it has been postulated that such areas provide suitable food, shelter, absence of turbulence and a reduction of predation, which are advantageous to juveniles of many species (Blaber *et al.*, 1985). Big creeks/inlets provide more area for the above features rather than small creeks and thus may cause more species captured here.

Davis (1988) assumed that each species has a particular response to environmental fluctuations, which results in a dynamic and complex fish community entering the mangrove swamp. Individual species may respond in different ways to the combination of environmenal chánges (as well as to each other). Ordination techniques can help identify basic trends in the fish community's response to these environmental gradients (Davis, 1988). Individual species respond in different ways to tidal sequence. Higher tides provide greater assistance for the upstream movement of juvenile fish and also enable them to penetrate further into upper swamp areas. The tidal fish trap would also have more water passing through it on higher tides, which would result in greater catches of fish, assuming fish densities are constant.

Data on fish and prawns from this study indicated that abundance (in terms of total wet weight and biomass) was variable throughout the year of sampling and was not restricted to any particular month. Generally, spatial factors contributed more to differences in fish community structure (Robertson and Duke, 1990). Whereas the seasonal succession of species into marsh and estuarine habitats may be a reflection of a breeding pattern of the fish species and the dispersal abilities of their juveniles (Davis, 1988; Weinstein, 1979).

The percentage abundance of fishes for monthly observations at Site I showed the dominant families were Ambassidae, Mugilidae and Engraulididae (Table 4.2). Ambassidae was also dominant at Site II followed by Engraulididae and Clupeidae (Table 4.2). At Site III, Ambassidae was still the dominant family and co-dominated by Engraulididae and Clupeidae (Table 4.2). Ambassidae, Clupeidae and other small fishes are also represented in the mangrove creek, Tudor (Little *et al.*, 1988). The same families of Ambassidae, Clupeidae, Engraulididae, Leiognathidae, Eleotridae and Mugilidae were also found at mangrove inlets in Selangor (Chong *et al.*, 1990; Leh and Sasekumar, 1989; Sasekumar *et al.*, 1992).

All the above fish families found in mangrove creeks are schooling fish which are small in size. Large schools of small fishes offer protection from predators, while schools of predatory fishes presumably have an advantage in finding prey (Moyle and Cech., 1982). According to Wootton (1992) many schooling/shoaling species are also migratory. Typically, migrations are suitable for feeding and reproduction.

The Ambassidae was only represented by *Ambassis gymnocephalus* at Sites I, II and III. Site I was dominated by *Liza melinoptera, Thryssa kamalensis* and *Ilisha megaloptera* (Table 4.3); Site II was dominated by *Stolephorus tri, Ilisha megaloptera* and *Liza melinoptera* (Table 4.3) and Site III by *Stolephorus tri, Ilisha megaloptera* and *Thryssa mystax* (Table 4.3). *Ambassis gymnocephalus* was found in all the monthly catches (Fig. 4.1). *Ilisha megaloptera* was not found on the first sampling occasion both at Sites I and II. However this species occurred in all the monthly sampling at Site III (Fig. 4.1). Results for the other co-dominant species at Sites I, II and III did not show any monthly pattern (Fig. 4.2 and 4.3).

Three families of prawns were common in the bagnet catches, i.e Penaeidae, Palaemonidae and Sergestidae (Table 5.2). Penaeidae is the dominant family at Sites I, II and III (Table 5.2). Palaemonidae is co-dominant in almost all the collections compared to Sergestidae (Table 5.2). *Penaeus merguiensis* is the numerically dominant species followed by *Metapenaeus brevicornis* in all the study sites. Palaemonidae and Sergestidae were represented by *Macrobrachium* sp. and *Acetes* sp. respectively (Table 5.3). The absence or occasional presence of *Acetes* sp. in this study may be due to the sampling gear, which is not consistent with the small size of *Acetes* sp. According to

Ikematsu (1957), the annual yield of *Acetes* sp. seemed to be correlated with the heaviest spawning season and also with the catch of fish and crustaceans which feed on *Acetes* sp. (Ikematsu, 1957). On the other hand, their presence is highly seasonal.

Results for species composition showed there were only 8 species of prawns. This trend, of few species but high standing stock, is also observed in nursery areas elsewhere. Five species of penaeid prawns were observed in the Merbok mangrove systems of Kedah, Malaysia (Khoo, 1989); 8 species of penaeids and one caridean were found in mangrove creek-inlet, Selangor, Malaysia (Chong *et al.*, 1990); 10 species of penaeid prawns were found in Moreton Bay, Queensland, Australia (Young, 1978) and two penaeids, eight carideans and one sergestid were observed in Alligator Creek (Robertson and Duke, 1987).

The small number of prawn species in mangrove habitats could due to three factors: (1) niche occupation being limited to the epibenthic surface of the substrate, (2) the substrate being comparatively homogeneous (in this case, a largely silt-clay one) and (3) a lack of euryhaline species (Chong *et al.*, 1990). Sediment type and organic carbon have been known to influence the distribution of prawns (Branford, 1981; Williams, 1958), as do the effect of salinity (Dall, 1981; Gunter *et al.*, 1964; Mair, 1980) and presence of coastal vegetation (de Freitas, 1986; Young, 1978).

The between sites variation in species composition in terms of species richness (D), diversity (H') and evenness (J') are shown in Table 4.4 (fish) and in Table 5.4 (prawns). Site III had the highest fish species richness, diversity and evenness followed by Sites I and II. However, the evenness of species between Sites I and III is due to the close location of these sites.

The monthly similarity (D) of species between Sites I and II showed the highest similarity of species was caught in early September 1992 (Table 4.5). Sites I and III showed more catches with the same species in July 1993 (Table 4.5).

The between-sites variation for prawns showed Site I supported a higher species richness, diversity and evenness compared to Site II (Table 5.5). Site I also had a higher species composition when compared to Site III, except for evenness index (J′) which showed that both sites had the same abundant species (Table 5.4). The monthly similarity of species (D) between Sites I and II showed that the highest similarity was observed in October 1992 (Table 5.5). This similarity index between Sites I and III on 18 August 1993 indicates that many similar species were caught in the two sites (Table 5.5). The similarity D values between Sites I and II and between Sites I and III were about the same, indicating that all these sites had almost the same species (Table 5.6).

The between-sites variation in environmental parameters amongst the creeks was small. Such variation has largely been attributed to salinity and temperature differences (Austin, 1971; Little *et al.*, 1988; Weinstein, 1979). There were only small differences in environmental parameters between the study sites (Table 1.0) and lack of any apparent differences in the composition of fish and prawn communities is to be expected.

Diversity index H' and evenness J' have been successfully used in temperate estuaries to analyse temporal pattern in fish assemblages (Haedrich and Haedrich, 1974; Livingstone, 1976). The small range in these indices found in the present study for fish and prawns suggests that they may be less usefull in tropical mangroves where seasonality and structural changes in the community are less obvious. Philips (1981) found no significant changes in H' and J' in Jiquilisco Bay, El Salvador and Yanez-Arancibia *et al.* (1980) found that J' did not detect changes in commmunity structure even though there was seasonality in nursery use in Terminos Lagoon, Mexico.

Fishes in the early years often show more numerous males or equal in number to females. As the fish age,the males suffer a higher mortality so that older fish are nearly always female. These findings could be typical of many temperate freshwater and marine fish (Mann, 1973, 1974, 1976a, 1976b). Some fish species change sex part way through their lives. Some individuals are born female but become male on reaching a certain size.

Studies of the mating system on reefs in the western Atlantic have shown that males, which are brightly coloured, establish spawning territories on reefs (Warner *et al.*, 1975). The females will visit these sites and spawn with the largest and most colourful of the males. This lek-type system, where males must be big to gain territory, means that small young males are at a great disadvantage. In many species, fertility increases most with size. As a result individuals are born males and become female at a later age. The sex change may be genetically controlled by some environmental factor, such as the loss of a dominant male from the harem (Warner *et al.*, 1975).

The sexual differences in size must result from differences either in growth rates prior to maturity or in age at maturity and subsequent growth (Clarke, 1983). This seems to be adapted to maximizing the biomass and consequently the egg production of females from the food or energy available to the population. Mature males could suffer higher mortality rates, perhaps because they can spawn frequently than do females and are exposed to predation in the process. The possibility that males grow slower cannnot, however be discarded. If males do spawn more frequently than females, energy available to males for growth may be less because they would spend less time feeding. Furthermore, in spite of lower costs for gamete production per spawning, the fraction of energy devoted to reproduction by male could be greater than female (Clarke, 1983).

Sex composition of the common fish specimens found at three mangrove creeks show that most were immature and of undetermined sex (Table 6.0). Most of the specimens had undetermined sex: for example, *Hilsa* sp., *Ilisha megaloptera, Leiognathus brevirostris, Leiognathus equulus, Secutor insidiator, Liza melinoptera, Scatophagus argus* and *Chelonodon fluviatilis*. *Ambassis gymnocephalus* had more females than males for all the three sites during sampling months. *Stolephorus tri* had more females than males at Site I, while the reverse was found more in Sites II and III. Consequently, the sex-ratio did not showed any obvious pattern due to the large number of undetermined sex of specimens.

A similar pattern of sex compositon was found in prawn species at Sites I, II and III (Table 6.1). *Penaeus merguiensis* occurred with more males than females. However the majority of this species were of undetermined sex. *Macrobrachium* sp. had more females than males, whereas more males were found for *Metapenaeus brevicornis*. No females of *Penaeus penicillatus* were observed at Sites I, II and III.

In all the fish and prawn species examined at the study sites, the sex ratio did not show any significant ratio due to more specimens of undetermined sex caught in the samples. When only mature-sized females were considered with mature-sized males, the sex-ratios were more nearly even (Clarke, 1983).

There have been only few studies which have attempted to quantify the connection between mangroves and fisheries, in terms of (i) the number of fish and prawn species using mangroves as nursery areas, (ii) the number of fish and prawn species feeding in mangroves (Sasekumar, 1991). Studies in Selangor mangroves indicated that the mangroves function more importantly as feeding grounds than as nursery grounds for juveniles of commercially-important fish species (Chong *et al.*, 1990). However, mangroves (and adjacent mudflats) are important nursery areas for all commercially important prawn species and a number of fish species (Chong *et al.*, 1990; Chong and Sasekumar, 1981; Robertson, 1991).

Most of the fish collected in the creeks were of undetermined sex, followed by immature stages (stages I and II) (Table 6.2). The engraulids, *Thryssa mystax* (Fig. 6.0) and *Thryssa kamalensis* (Fig. 6.0) and Leiognathidae, *Leiognathus brevirostris* (Fig. 6.1) and *Leiognathus equulus*, (Fig. 6.1) were immature stages. Studies from mangroves in

Matang, Perak and Merbok, Kedah also observed a high proportion of juveniles in the catches of bagnets; some of these were juveniles of commercially important fishes (Khoo, 1989). Maturity studies however, indicate that the majority of the stages of some species are not spatially separated, and both juveniles and adults are ubiquitous in their distribution (Fig. 6.2 and 6.3). As a result, it is difficult to choose the truly migratory species. Chong *et al.* (1990) found only five species were using this habitat as nursery areas and are considered truly migratory. The present study provides convincing evidence that creeks function more as feeding areas for fish than as spawning areas.

Chua (1973) also found that the nekton caught in Ponggol estuary, Singapore come in to feed rather than to spawn. By coincidence peaks of total fish catch occurred during peaks of copepod abundance. The partial and total correlation between these two are both positive and significant. Most of the fish caught here were either juveniles or species of small size. Hence, the close correlation between fish catch and copepod count indicates a prey-predator relationship. Furthermore, very few fish eggs and larvae were collected in the estuary throughout the year. This strongly suggests that the fish do not enter the estuary for the purpose of spawning as is the case in many other estuaries throughout the world.

Only a small percentage of prawn specimens caught in the creeks were matured (0.13% at Site III) compared to maturing/subadult stages (2.68%, 3.84% and 0.52% at Sites I, II and III respectively) (Table 6.2). Many specimens were immature at stages I and II (68.42%, 58.63% and 70,18% at Sites I, II and III respectively) (Table 6.2). This indicate that almost all the prawn species occurred as juveniles in mangrove creeks. Juveniles of common species (*Penaeus merguiensis, Penaeus penicillatus* and *Metapenaeus brevicornis*) which occurred in abundance and used the creeks as their nursery area were considered as truly migratory (Fig. 6.4 and 6.5).

The value of mangrove areas as nurseries for some fish species and prawns has been substantiated (Chong 1980; Macnae 1974; Odum and Heald, 1972) and a positive correlation has been found between the commercial yields of prawns and extent of mangrove forests (Martosubroto and Naamin, 1977; Sasekumar and Chong, 1987; Turner, 1977). Mangroves can provide a good nursery site for two main reasons : there is an abundance of food supply and it affords protection to the young (Dolar *et al.*, 1991).

Mangrove sites have long been considered major feeding sites for juvenile fish and crustaceans because of the production of large quantities of detrital material (Odum and Heald, 1975). For example, banana prawns (*Penaeus* *merguiensis*) are known to feed on bacteria and small animals inhabiting the mud. They utilize the mangrove creeks during the first few months of their life history (Robertson and Duke, 1987). The extensive root system of mangroves may also provide shelter and protection for juveniles. Structures provided by intertidal macrophytes may reduce predation on macrocrustaceans or fish as demonstrated by Minello and Zimmerman (1983) who reported that marsh-grass structure reduced predation rates on prawns by two of the common predatory fish in the habitat.

Analysis of carapace length classes of *Penaeus merguiensis* indicated that the frequency of occurrence for the most common class at Sites I (Fig. 6.6) and III (Fig. 6.8) was different from Site II. The common size class in Site II was 1.35cm to 1.50cm (Fig. 6.7). The most abundant size class of *Penaeus penicillatus* at Site I (Fig. 6.9) was larger compared to Sites II (Fig. 7.0) and III (Fig. 7.1). The same class of *Metapenaeus brevicornis* was observed at this study site (Fig. 7.2-7.4). Sites II (Fig. 7.6) and III (Fig. 7.7) observed the same abundant class for *Macrobrachium* sp.

Prawn species found within the study sites are largely juveniles as observed in mangrove inlets in Queensland (Robertson and Duke, 1987) and in Selangor (Chong *et al.*, 1990). Spatial partitioning of juvenile prawns in mangrove estuaries has been observed in East Africa (de Freitas, 1986).

The relationship between mangroves and juveniles of prawns has been attributed to two main factors, i.e. high food abundance and shelter from predators (D'Cruz and Sasekumar, 1989; Sasekumar *et al.*, 1989, 1992). Mangroves with extensive sea grass cover could well provide ample hiding places. However, Sungai Sementa Kecil has no such cover, it would therefore be assumed that this particular inlet had a high abundance of food. Penaeids are opportunistic generalists in their food habits, being able to consume a variety of animal and plant matter and bacteria (Chong and Sasekumar,1981; Leh and Sasekumar, 1984; Moriarty, 1976).

Prawns exhibit a high degree of diversity, in their feeding and have been described as 'omnivorous scavengers' or 'detritus feeders'. Leh and Sasekumar (1984) found that prawns are omnivorous with a general diet of 30% plant and 70% animal matter. Although epibenthic postlarvae and juveniles which inhabit mangroves consume mostly organic detritus, there are indications that they prefer animal food if available. Organic detritus is considered a food supplement which is taken incidentally with animal prey or as a response to low prey abundance (Stoner and Zimmerman, 1988).

Fish can be classified broadly on the basis of their feeding habits as detritivores, herbivores, carnivores and omnivores. Within these categories fish can be characterized further as (1) euryphagus, having a mixed diet; (2) stenophagus, eating a limited assortment of food types, and (3) monophagus, consuming only one sort of food. A majority of fishes, however are euryphagus carnivores (Moyles and Cech, 1982).

Small fishes are abundant in estuaries and the availability of any particular type of food is likely to show considerable fluctuation in even short periods of time. As a consequence, most estuarine fishes are not specialized feeders (Moyle and Cech, 1982). A fish species can be a carnivore at one time and an omnivore at another, and the same can be said of the herbivore-omnivore group of fishes and may change their feeding habits if a particular food is limiting (Leh and Sasekumar, 1989). The macrofauna of the mangrove floor and pelagic resources in the waterways provide the main food sources for ingressing fish.

Results of the stomach fullness showed that *Ambassis gymnocephalus* was always in full stomach. *Stolephorus tri* was always in half to empty stomach while *Liza melinoptera* had almost the same percentages of poor and full stomachs (Table 7.0).

Fish were found to feed both on the pelagic and benthic food resources. *Ambassis gymnocephalus* as the numerically dominant species feed mainly on crustaceans such as mysids. Gastropods and arthropods also appeared in the stomach. Eventhough plant fragments, diatoms and unidentified debris occurred in high percentage of stomachs, however these constituted only a small volume (Table 7.1). This species is considered a zooplanktonivore. Leh and Sasekumar (1989) also found *Ambassis gymnocephalus* to be feeding on zooplankton. As a second numerically dominant fish species, *Stolephorus tri* is considered a carnivore as *Acetes* sp. is its major diet. Diatoms did not occur here, however unidentified debris and plant fragments occurred in small amounts (Table 7.1).

Unidentified debris occurred in significant quantities in the diet of *Liza melinoptera*. This species is a detritivore. The protruding and suctorial mouth of this species is adapted for feeding on bottom sediments (Chong, 1977). So, a high percentage of grit was observed in the stomach. The efficient filtering device by the modified gill rakers and pharyngeal teeth are the reasons for selection of minute components (Chong, 1977; Wootton, 1992). Since the detritus does not consist wholely of macroplant material, the fish presumably grazes on plant roots, dead leaves and other substrates which are rich in microscopic organisms (Table 7.1).

This study of mangrove creeks showed the importance of the habitat as a place for feeding and nursery grounds for fish and prawns. The faunas (fish and prawns) generally occur in greater numbers and biomass in mangrove habitats than in adjacent near shore habitats (Blaber *et al.*, 1989; Chong *et al.*, 1990; Robertson and Duke, 1987; Thayer *et al.*, 1987). Data from this study also suggests the well being of these important components of the Malaysian finfish, prawn and other shellfish fisheries are dependent on the continued existence of the mangrove ecosystem. Briefly, the managers of mangrove ecosystems have to ensure the sustainable use of this valuable resource.

Studies should be carried out in many more mangrove creeks and coastal waters of Malaysia to obtain an appreciation of their ecological and economic values. More effective sampling gears should be used to sample fish and prawns and their juveniles that visit the mangrove creeks. Furthermore, the feeding analysis of many species of fish have to be done to understand the role of mangrove creeks as feeding habitats. Such information will enable the authorities to conserve mangrove habitats and manage the resource sustainably.