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Effects of Tides on the Diversity and Quantity of Juvenile Fish in Coastal Areas.

(Kesan Pasang Surut atas diversity dan kuantiti anak ikan di persisiran pantai.)

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Abstrak

Kajian atas density dan diversity larva ikan telah di jalankan di pesisiran pantai pantai barat Pulau Pinang. Kawasan ini, yang di pinggir oleh hutan bakau, adalah satu kawasan penting untuk perikanan pesisiran pantai Ini adalah satu daerah perikanan pesisiran pantai yang menumpu tangkapan ata ikan dan udang khasnya *Penaeus merguiensis*. Objektif kajian ini adalah untuk menilai kepentingan kawasan pesisiran pantai ini sebagai tapak semaian anak ikan.

Persampelan iktioplankton dilaksanakan untuk menentukan komposisi spesies dan perbezaan yang wujud dalam pertaburan larva ikan dari segi jarak dari pantai dan kesan pasang surut. Larva ikan dari 26 taxon telah disampel. Larva ikan dari Famili Engrauliddae dan Clupeidae mendominasi tangkapan. Zon yang di pinggir oleh hutan bakau, ia itu zon antara pasang surut, hasil tangkapan larva ikan yang paling banyak. Banyaknya larva semakin kurang apabila jarak dari pantai bertambah. Tinggi banyaknya larva ikan dekat pantai adalah bekaitan dengan bekalan makanan yang mencukupi dan tahap perlingdungan. Kajian ini telah jelas bahawa kawasan ini mempunyai nilai semaian anak ikan yang tinggi dan langkah wajar perlu diambil untuk memilihara kawasan ini.

Abstract

Studies of density and diversity of fish larvae were carried out in the coastal area of the West Coast of Penang Island. This area, which was fringed by a mangrove forest, from Pulau Betong to the mouth of Kuala Sungai Pinang is an important coastal fishing area. It was an important coastal fishing district which concentrated on fish and prawn catches mainly *Penueus merguiensis*. The objective of this study was to evaluate the importance of this coastal area as a fish nursery area.

Ichthyoplankton sampling was carried out to determine species composition as well as differences that existed in the distribution of fish larvae with respect to the distance from shore and tidal phenomena. Fish larvae from 26 taxan were sampled. Fish larvae from families Engraulidae and Clupeidae dominated the catch. The zone fringed by mangroves which was the intertidal zone had the highest larval abundance. Larval abundance was reduced as the distance from shore increases. The high abundance of fish larvae in the near-shore area was due to abundant supply of food as well as the level of protection provided. Signnificantly more fish larvae were caught during high spring tide. This study revealed that this area has a high nursery value and relevant steps need to be taken to ensure that the coastal fishing industry can be sustained through conserving this area.

1.0 INTRODUCTION

Throughout the tropics, mangrove forests are being removed at an alarming rate by clear-felling for production of wood chips, development of aquaculture ponds or to provide land for farming, housing or tourist projects (Robertson and Duke, 1990). Here, in the West Coast of Penang Island, clearing is most evident for the accommodation of increasing aquaculture ponds for prawn farming. Successful management of these coastal resources requires detailed knowledge of the role of mangrove forests in inshore productivity. Of particular importance is a clear understanding of the manner in which fish use mangrove forests and mangrove-lined waterways as nursery grounds and feeding areas.

Boesch and Turner (1984) have pointed out that it is a proven fact among estuarine scientist that coastal zones are important nursery sites for juvenile fish and crustacean fish. The intertidal and subtidal zones with their characteristics provide food and shelter as well as refuge. The importance of mangroves as fish habitats is becoming well established in some regions in the world (Robertson and Duke, 1987, Robertson and Duke, 1990, Staples *et al.*, 1985, Thayer *et al.*, 1987). Proper measures have to be taken to ensure these nursery areas are preserved as it directly affects the fishing industry at large in the area. Studies on larval composition and distribution in Malaysian waters are lacking and due to this the understanding of the role of mangroves as nurseries is not adequate. Early studies conducted by Delsman (1945) have not been followed up since.

This study was aimed at studying the larval composition in the coastal waters as well as to detail the importance of the mangrove coastal area as a nursery for fish.. Spatial factors are one of the most important aspects affecting the distribution of fish and prawn larvae. Robertson and Duke (1990) argued that spatial factors contribute more to larval distribution as compared to other factors such as seasons. They also concluded that mangroves and estuaries play an important and eminent role as nurseries. The post-larvae and juveniles of several Engraulid and Clupeid moved into the mangroves extensively during ebb tides to feed on zooplankton. Tzeng and Wang (1992) stressed the importance of estuaries as the intermediate for energy transfer between river and sea, which was vital for commercial fish in coastal areas that rely on estuaries as nurseries as well breeding grounds.

Louis *et al.* (1995) proved that the distribution of the juvenile community follows spatial distribution. The juvenile community also shows an obvious preference for mangroves and sea grass inundated areas. Robertson and Duke (1987) concluded that juveniles and larvae of fish are more abundant in mangroves in a study to compare densities of larvae in mangroves. sea grass areas as well as sandy stretches. Young (1978) also emphasized that density per unit area usually increases in a community with sea grass. In a study conducted to compare muddy substrates and sandy substrates.

Robertson and Duke (1987) found significantly higher amounts of larvae in muddy areas. Tzeng and Wang (1992) postulated mangroves provide suitable food, protection, little or no water movement and lack of predators. It was their contention that these factors contributed to the high density of larvae in mangroves. Their research proved the hypothesis that the mangroves are linked with the food chain for juveniles and fish larvae that depend on estuaries. The mangroves provide suitable room to escape predators. Robertson and Duke (1987) identified mangroves as nurseries that are vital for the commercial fish and prawn industry in Australia. The results of their study revealed distinctly mangrove habitats as necessary for juvenile Penaeus merguiensis. The abundance of fish and prawn that varies with the different zones in estuaries showed the relative importance of nurseries. Staples et al (1985) who studied habitat preference of juvenile penaeid prawns found the prawns limited to estuaries that were fringed with mangroves. Young (1978) proved the nursery value of littoral zones besides reiterating the importance of space in relation to larval abundance.

The objective of this study was to study the composition of fish and prawn larvae in the West Coast of Penang Island. We chose to define the habitat preference of larvae in relation to distance from shore in order to study the importance of having mangroves as possible nurseries for fish and prawns.

2.0 MATERIALS and METHODS

The West Cost of Penang Island is a habitat with high diversity. The coast is fringed with a narrow 10 km mangrove stretch. Towards the sea, the mangroves proceed to become mudflats and eventually take on open sea characteristics. A few rivers form estuaries at the coast.

The sampling area was divided into three zones, A, B and C. Zone A was defined as the area from the coast to 200 meters seawards along the mangrove stretch. Besides the mangrove stretch, this zone incorporates the intertidal zone which is mostly only visible during high tides. The substrate is made of fine silt with particles less than 2~. Along the shore detritus, seeds and roots of *Avicenia* and *Sonneratia* spp are concentrated.

The fauna in Zone A is mainly mangrove but also marine organisms that migrate here. The productivity in Zone A is high and therefore able to carry a high diversity of life. Mudskippers (*Periopthalmus chrysosphilos*) and polychate worms, *Diopatra neopolitana*, *Glycera* spp. and *Nereis* spp. dominate the area. Snails such as *Cerithidea obtusa* and *Syncera brevicula* are abundant (Berry, 1964).Bivalves, *Donax faba* and sand crabs. *Hippa asiatica* are also present.

Zone B was defined as the area from the 200 meter distance from shore to 400 meters into the sea. Basically the zone is subtidal with mudflats and muddy bottom, with this area being submerged even during low tides. The fauna in this zone are mainly marine. Besides the coastal marine fishes, the crustaceans, *Acetes* spp. are abundant. Bivalves such as *Pinna* spp and *Paphia undulata* as well as polychates worms *Perinereis* spp are commonly found.

Zone C is the area from the 400 meter mark up to 800 meters from shore. This zone has a sandy bottom and distinct open sea characteristics. The depth of this zone is very much greater compared to Zones A and B. Marine organisms are abundant in this zone with a high abundance of *Penaeus merguiensis* and *Penaeus monodon*. Anchovies (*Stolephorus* spp.), *Thryssa mystax* and *Valamugil sehali* make up the dominant fish composition. Zone C is the major contributor towards the fishing industry in this area.

For this study sampling was carried out using a plankton net with a 1mm mesh size. The mouth was mounted with a flow-meter to determine the volume of water flowing through the net. The net was towed on the surface for a distance of about 100 meters parallel to the shore. Six replicates were taken for each zone.

Samples were transferred into plastic bags and fixed in 10 % formalin. A few drops of Rose Bengal were added to stain the fauna to facilitate sorting them from debris. Samples were then sorted out in the lab with forceps for counting and identification. The larvae were then preserved in 70% alcohol. Larvae was identified using references by Arvin (1977), Delsman (1971), Janekarn and Boonruang (1986), Leis and Rennis (1983) and Vatanachai (1979). Identification up to the lowest possible taxon level was done using four characteristics: morphometrics. meristics, pigmentation and unique larval characteristics.

Total number of fish larvae and species caught was summed and changed to concentration, individuals per 1000 m^3. To note the significance of the fish and crustacean larvae abundance data, multi-factorial ANOVA statistical analysis was done using Statgraf.

Shannon-Weiner diversity indices were used to determine the diversity of larvae caught whereas Pielou's evenness indices were used to look at the evenness of larvae distribution.

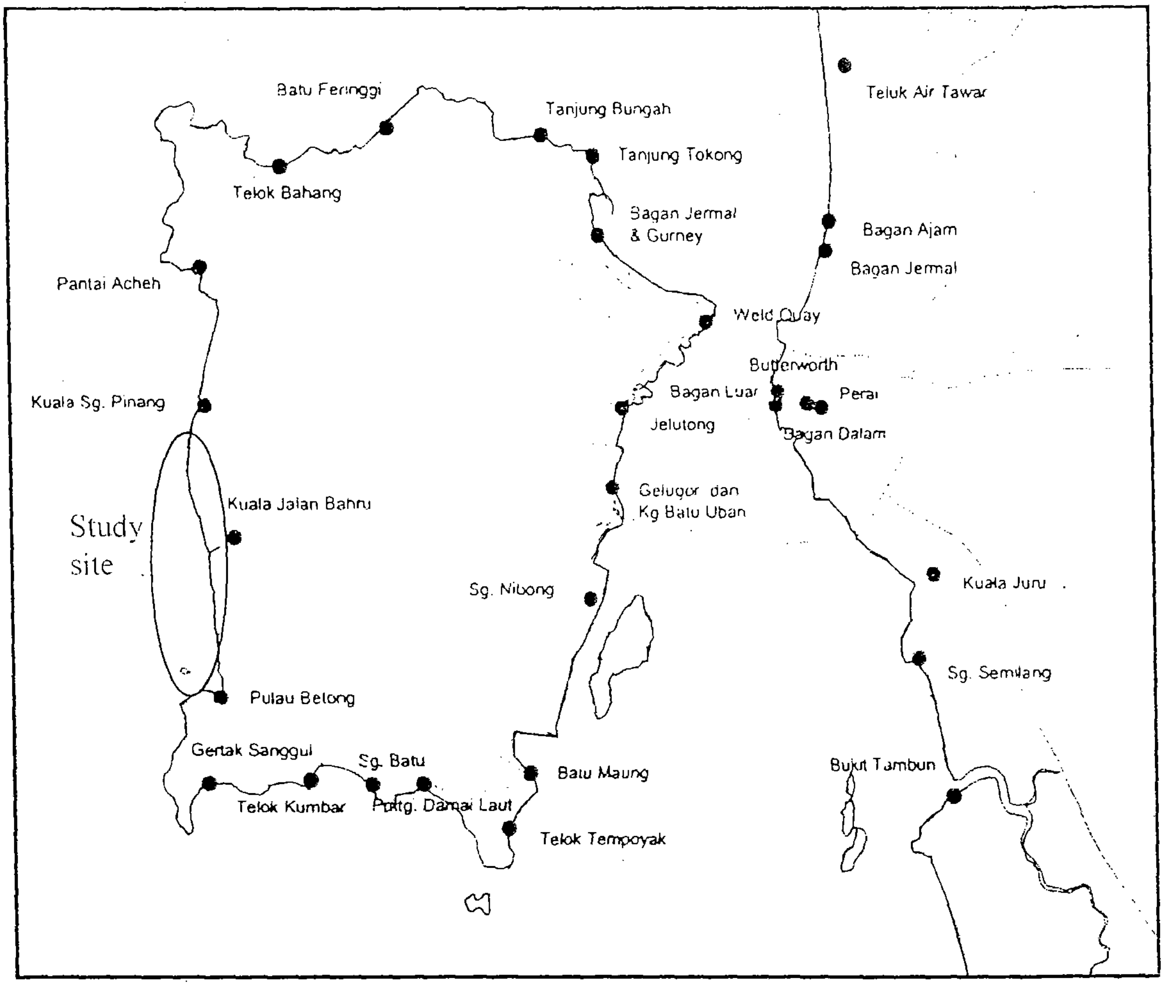


Fig. 1 Map showing location of study site.

RESULTS

Fish larvae from 25 different taxons were caught in this study (Table 1). Individuals from the family Engraulidae had the highest abundance on the whole with 48.7 % from the total catch. The species that was caught from this family were *Thryssa* sp. (43.26 %) and *Stolephorus* sp. (5.41 %). This was followed by *Secutor* sp., a Leiognathid (10.15 %), *Valamugil* sp. a Mugilid (7.89 %), *Sardinella* sp. a Clupeid (6.56%), *Apogon* spp. (3.29 %), *Ambassis* spp. (3.10 %)) and Athermid spp. (2.85 %). Larvae of *Chirocentrus dorab, Anodontostoma chacunda*, *Lutjanus* spp, *Megalopsis cyprinoides*, *Sillago* spp, *Therapon jarbus*, *Periopthalmus* spp, *Leiognathus* spp, *Siganus* spp. and *Otolithes* spp. each made up 2.40 % to 0.25 % from the whole catch.

Four of the 10 most common fish larvae, Thryssa sp., *Secutor* sp. , *Stolephorus* sp. and *Dussumieria* sp. were caught at all three zones sampled and al all times. Showing a very widespread distribution with coastal waters. Others such as Valamugil sp. and *Sardinella* sp. were only sampled within zones A and B.

Fish larvae abundance was highest in Zone A (936 individuals per 1000 m^3) followed by Zone B (487 individuals per 1000 m^3) and lowest was in Zone C (117 individuals per 1000 m^3) (Fig. 2). There was a very significant difference ($p < 0.001$) in fish larval abundance for Zones A (200 meters from shore), B (200 to 400 meters from shore) and C (400 to 800 from shore). LSD tests showed that sample means for Zone C was significantly lower compared to Zone B and the population means for Zones C and B were significantly lower than the population mean of Zone A.

The density of fish larvae was significantly higher at night with a density of 625 individual per 1000 m3 as compared with 402 individuals per 1000 m^3 during the day (Fig. 3).

The density of fish larvae was highest during high spring tide with a density of 839 individuals per 1000 m^3 as compared with 389 individuals per 1000 m^3 during low spring tide and 313 individuals per 1000 m^3at neap tide (Fig. 4). Statistical analyses showed that were significant differences in the mean density of fish larvae for each of the various tides.

Table 1. Species composition of the whole catch

Species	% individuals
Thryssa sp.	43.26
Secutor sp.	10.15
Valamugil sp.	7.89
Sardinella sp.	6.56
Stolephorus sp.	5.41
Dussumieria sp.	4.64
Apogonidae spp.	3.29
Ambassis spp.	3.10
Athermidae spp.	2.85
Chirocentrus dorab	2.45
Anodontostoma *chacunda*	2.02
Lutjanus spp,	1.67
Megalopsis cyprinoides	1.36
Therapon jarbus,	1.00
Sillago spp.	0.97
Periopthalmus spp,	0.72
Siganus spp.	0.53
Leiognathus spp,	0.25
Otolithes spp	0.25
Fistu	0.29
Lates calcarifer	0.26
Fish sp. A	0.25
Fish sp. B	0.25
Fish sp. C	0.25
Fish sp. D	0.25
Fish sp. F	0.25

Table 2. Composition of the fish larvae by Zones

Taxon	Overall	Zone A	Zone B	Zone C
Thryssa sp.	222	368	234	64
Secutor sp.	52	92	61	4
Valamugil sp.	41	97	25	0
Sardinella sp.	34	74	27	0
Stolephorus sp.	28	39	36	8
Dussumieria sp.	24	34	34	4
Apogonidae spp.	17	40	11	0
Ambassis spp.	16	44	4	0
Athermidae spp.	15	33	11	0
Chirocentrus dorab	13	29	8	0
Anodontostoma chacunda	10	13	18	0
Lutjanus spp,	9	26	0	0
Megalopsis cyprinoides	7	13	8	0
Therapon sp.	5	12	3	0
Sillago spp.	5	0	3	12
Periopthalmus spp,	4	11	0	0
Siganus spp.	3	0	0	8
Leiognathus spp,	2	0	0	5
Otolithes spp	1	4	0	0
Fistu	1	0	0	4
Lates calcarifer	1	0	0	4
Fish sp. A	1	0	4	0
Fish sp. B	1	4	0	0
Fish sp. C	1	4	0	0
Fish sp. D	1	0	0	3
Fish sp. F	1	4	0	0

Fig. 2. Abundance of Fish Larvae by Zones

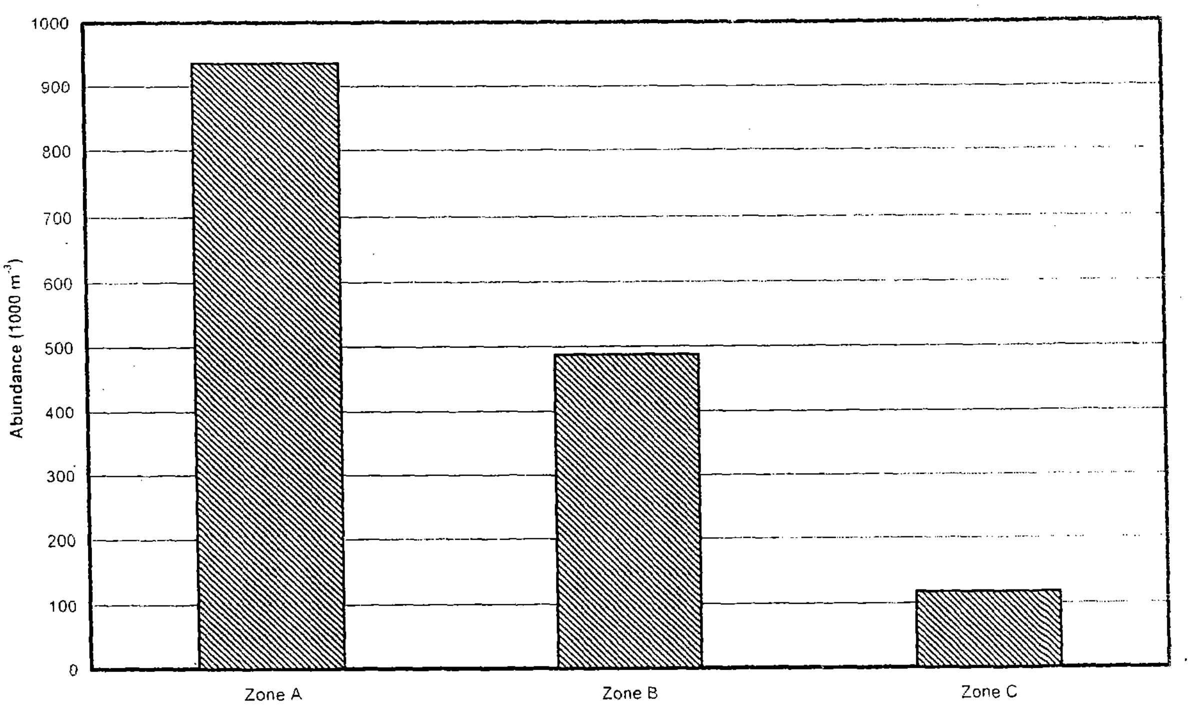


Fig. 3. Abundance of fish larvae by Tide

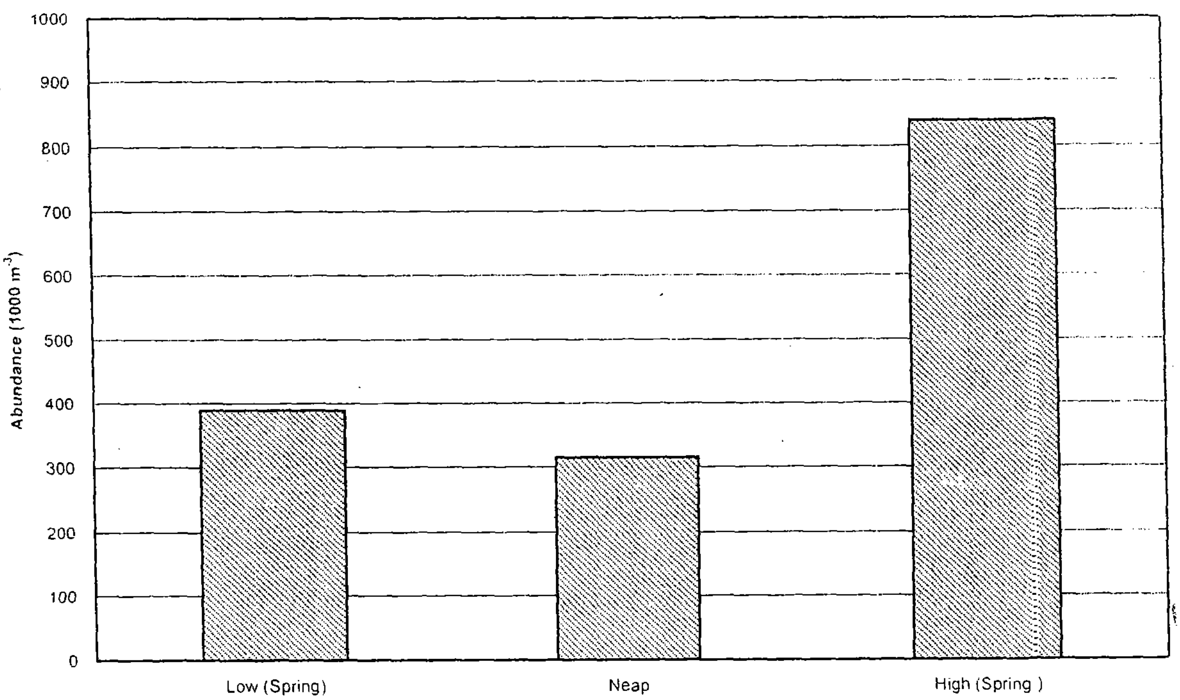
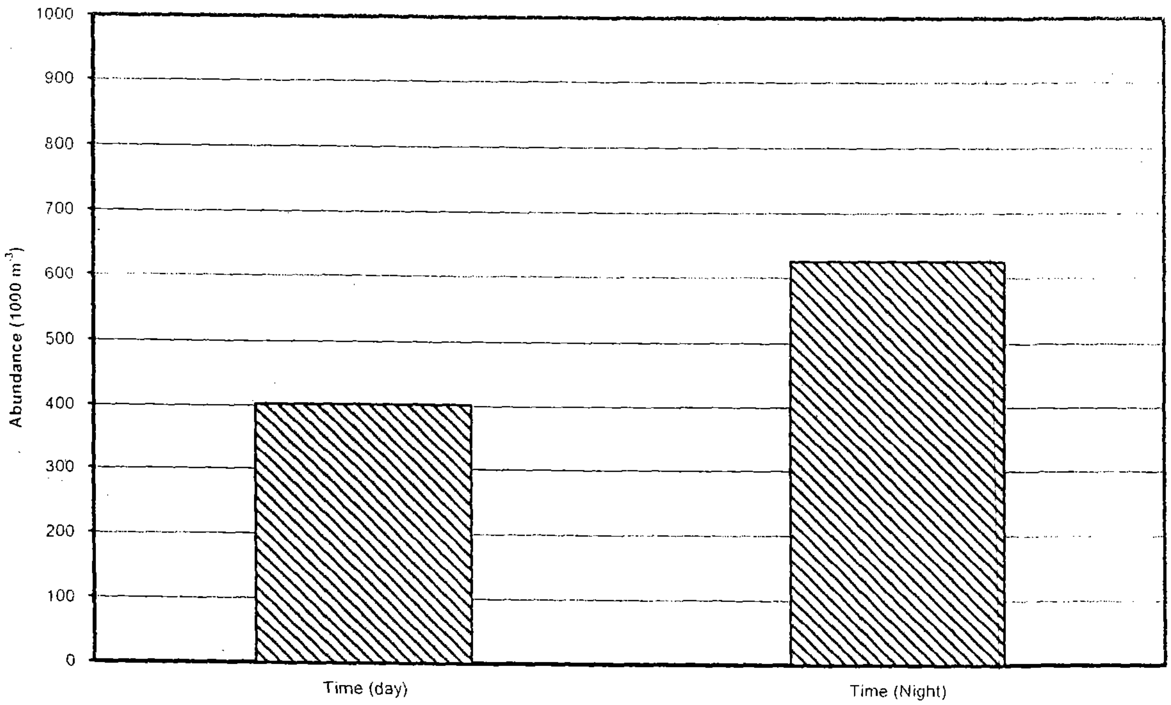


Fig. 4. Abundance of fish larvae by Time



DISCUSSION

A total of 26 larval fish species from 16 families were hauled on coast fringing mangroves on the West Coast of Penang Island. On coasts, there are fish species that survive in mangroves for their lifetime and also breed in here. Besides that, migrating species move into mangroves to breed and exist in the mangroves every now and then. Janekarn and Boonruang (1986) stated that the species abundance and composition depend on the breeding behaviour of species as well as the changes in salinity and temperature. With respect to their behaviour, they distinguished four types of mangrove fish: 1) True residents, that complete their life cycle in mangrove areas, 2) partial residents, which are associated with mangrove areas during larval and juvenile stages or during their adult life such as clupeids, anchovy, grey mullets and flatfish, 3) tidal visitors , such as sillagnids, carangids and sciaenids and 4) seasonal visitors which use the mangrove areas for spawning or nursing grounds, such as anguillids.

When the species composition were analyzed, it was discovered that the more dominant species found were nearer the shores of this site compared to other species. Juvenile anchovies, *Stolephorus* sp. and *Thryssa* sp. were found in large numbers especially in Zone A that was fringed by mangroves. Both species are Engraulids that are pelagic and planktivorous that use mangroves as breeding grounds during rainy seasons (Janekarn and Boonruang, 1986). Robertson and Duke (1987) also recorded 90% of their larval haul in the mangroves of Australia as anchovies and stated that the presence of these larvae were similar to the presence of larvae in many other mangroves in the tropics. According to them, anchovies migrate from mangroves to other areas in large groups. Neira *et al.* (1992) also stated Engraulid larvae prefer coastal areas especially near mangroves as their nursery ground.

Mugilid larvae are the second highest in abundance and only were present in Zones A and B. This was probably caused by the recruitment of larvae to the shore and also the utilisation of the mangroves as breeding grounds by adults and larvae complete their life cycle growing by the shore (Janekarn and Bonruang, 1986). In this study, we found *Valamugil* sp larvae in high abundance only in zones A and B.

Larvae from the Clupeid family are also dominant in the near shore area. *Sardinella* spp. from this family are fish that use the mangroves only at one stage of their lives and show behavioural preference for mangroves. Tzeng and Wang(1992) conducted studies on composition and structure of larval distribution in a mangrove estuarine area in Taiwan and found *Sardinella* spp. to be the most abundant. Leiognathid larvae are dominant and this is because they inhabit the coastal waters even as young adults.

Ambassis spp. from the family Ambassidae was also dominant in this catch. This fish larvae was highest in abundance in Zone A and normally found in brackish water and form the migratory group.

Gobiids were found in the plankton hauls and this species also live in the mud flats as adults. The other larvae found such as *Lutjanus* spp. and *Otolithes* spp. have high commercial value and are major contributors to the coastal fishing industry.

Fish larval abundance in the sampling area portrays the nature of the fishing industry in the area. This correlates with the high catch of eilaeus merguiensis and Acetes spp. in the West

Coast of Penang Island. Chong *et al.* (1990) also stated that the waters near mangroves in Malaysia are rich with adult Penaeus merguiensis. Vance *et al.* (1990) also explained the abundance of Penaeus merguiensis larvae in their catch. This being the fact that Penaues merguiensis is important as commercial catch in the West-indo Pacific. In an estuary, the production of Penaeus mergueinsis all year is an important link for fisheries in the estuaries and near shore for fish species besides contributing to the fishing of Penaeus merguiensis in deep waters.

In the West Coast of Penang Island, fishing is concentrated to the use of gill nets and anchovies besides other commercial fishes. The larvae found have high implications towards the fishing industry because the disturbing of nurseries can affect the fishing industry as well.

Differences were studied between the intertidal (zone A), subtidal mudflats (Zone B) and open sea conditions (Zone C). Overall, the study showed larval abundance and species composition diversity was highest in Zone A followed by Zones B and C. Conclusively the distance from shore reduces the number and diversity of larvae. The abundance in zones fringing mangroves is similar as to what was discovered by Vance *et al.* (1990). Robertson and Duke (1987, 1990b) and Janekarn and Boonruang (1986).

Three factors have been cited as important determinants of the inshore distribution patterns of juvenile fish patterns : 1) differences in physical factors between habitats, 2) differences in structural heterogeneity and thus the intensity of predation and 3) differences in productivity and food availability between habitats (Robertson and Duke, 1987).

There is an evident difference in productivity and ample food supply between the three zones especially Zone C as compared to zones A and B. Two important functions often studied in mangroves in the tropics are the ability of the mangroves to export nutrients and detritus to the shore besides the imminent importance as a nursery. By comparing the catches of fish and shrimp, scientists have concluded that mangroves are important as nurseries in South East Asia (Chong *et al.*, 1990).

Robertson and Duke (1990) proved the importance mangroves as nurseries for fish and commercial crustaceans in Australia. Their study showed the mangrove habitat has foremost importance as a nursery for juvenile Penaeus merguiensis besides showing that postlarvae and juveniles are limited to mangroves. A high positive correlation was found between the shore lined by mangroves and the mean yearly catch of Penaeus merguiensis (Staples et al, 1985).

Primary productivity in mangroves is high and due to the lack of feeding, productivity is vital to the shore ecosystem. Export of carbon dioxide with the direct flow of debris of mangroves is in abundance. Dead leaves, stick, flowers and roots are digested by macrofauna or continuously disintegrated by microbes. These two factors are the basis for the detritus food chain. Detritus feeds the higher trophic level organisms either directly or through other organisms (Chong *et al.*, 1990). Hence, the mangroves provide abundant food supply food for fish and shrimp larvae. These active exchanges are important for the management of near shore fishing activities. Besides that, mangroves have the ability to absorb organic components from the flow of freshwater for photosynthesis and thus is a primary producer.

The concentration of zooplankton is highest in mangroves (Janekarn and Boonruang, 1986) and because larvae occupies the same niche as other microzooplankton feeders , larval abundance is highest in areas with high zooplankton abundance. Besides that structural heterogeneity contributes to the availability of protection and shelter for larvae forms the patterns of larval distribution. Dorf and Powell (1997) researched Rhode Island and Louise *et al.* (1995) who studied the mangroves in the French West Indies showed that larvae prefer habitats that offer protection in the form of vegetation from potential predators. The lack of vegetation will cause migration from that area as the risk of predation would be higher.

Robertson and Duke (1987) proved the preference of fish and crustacean larvae for mangroves. The ability to ensure protection through the availability of complex structural roots, support roots and broken twigs and branches as well as pnumatophores were cited as the reason for this preference.

Vance *et al.* (1990) also stated although Penaeus merguiensis use the mangroves as a place to hunt for food, the more important contributing factor is the availability of protection. They found high concentrations of larvae in murky waters as an effort to escape predation. Penaeus merguiensis is apparently the vital diet component of many fish, hence the protection offered by mangroves is essential. Murky water provides a better base for protection as proven by many scientists (Robertson and Duke, 1990a, Vance *et al.*, 1990).

CONCLUSION

This study revealed that this area has a high nursery value and relevant steps need to be taken to ensure that the coastal fishing industry can be sustained through conserving this area. The zone fringed by mangroves which was the intertidal zone had the highest larval abundance. Larval abundance was reduced as the distance from shore increases. The high abundance of fish larvae in the near-shore area was due to abundant supply of food as well as the level of protection provided. Tidal patterns had a significant effect on fish larvae distribution. Significantly more fish larvae were caught during high spring tide.

REFERENCES

Arvin, P. 1977. Introduction to the common marine zooplankton of Peninsular Malaysia. Penerbit Universiti Pertanian Malaysia, Serdang. 42 p.

Berry, A. J. 1964. The natural history of the shore fauna of North Penang. Malay. Nat. J., 18; 81 - 103

Boesch, D.F, and Turner, R.E. 1984. Dependence of Fishery Species on Salt Marshes: The role of food and refuge. Estuaries, 7; 460-468.

Chong, V. C., Sasekumar, A., Leh, M.U.C., and D'Cruz, R., 1990. The fish and prawn Communities of a Malaysia coastal mangrove system, with comparison to adjacent mud flats and inshore waters. Estuarine, Coastal and Shelf Science, 31; 702-722

Delsman, H.C. 1972. Fish eggs and larva from the Java Sea ???

Dorf, B.A. and Powell, J.C. 1997. Distribution, abundance and habitat characteristics of juvenile Tautog (*Tautog onitis*, Family Labridae) in Narragansett Bay, Rhode Island, 188-1992. Estuaries, 22; 589-600.

Janekarn, V. and Boonruang, P. 1986. Composition and occurrence of fish larva in mangrove areas along the East Coast of Phuket Island, West Peninsular Thailand. Phuket Marine Biological Station, Research Bulletin No. 44.

Leis, J.M. and Rennis, D.S. 1983. The larva of Indo-Pacific coral reef fishes. New South Wales University Press,

Louis, M., Bouchan, C. and Bouchan-Navaro, Y., 1995. Spatial and temporal variation of mangrove fish assemblages in Martinique (French West Indies). Hydrobiologia, 295; 275-284

Neira, F.J., Potter, I.C. and Bradley, J.S., 1992. Seasonal and spatial changes in the larval fish fauna within a lartge temperate Australian estuary. Marine Biology, 112; 1-16.

Robertson, A.I. and Duke, N. C., 1987. Mangroves as nursery sites: Comparisons of the abundance and species composition of fish and crustaceans in mangroves and other nearshore habitats in tropical Australia. Marine Biology, 965; 193-205

Robertson, A.I. and Duke, N.C., 1990a. Mangrove fish communities in tropical Queensland, Australia: Spatial and temporal patterns in densities, biomass and community structure. Marine Biology, 104; 369-379.

Robertson,A.I. and Duke, N.C., 1990b. Recruitment, growth and residence time of fishes in a tropical Australian mangrove system. Estuarine, Coastal and Shelf Science, 31; 723-743.

Staples, D.J., and Vance, D.J., 1985. Short term and long term influences on the immigration of postlarval banana prawns, *Penaeus merguiensis*, into a mangrove estuary of the Gulf of Carpentaria, Australia. Marine Ecology Progress Series, 23; 15-29.

Thayer. G.W, Colby, D. R. and Hettler, W.F., 1987 Utilization of the red mangrove prop root habitat by fishes in South Florida. Marine ecology progress series. 35; 25-38.

Tzeng, W.N. and Wang, Y.T., 1992. Structure, composition and seasonal dynamics of the larval and juvenile fish community in the mangrove estuary of Tanshui River, Taiwan. Marine Biology, 113; 481-490.

Vance, D.J., Haywood, M.D.E. and Staples, D.J., 1990.Uses of a mangrove estuary as a nursery by postlarval and juvenile banana prawns, *Penaeus merguiensis* de Man, in Northern Australia. Estuarine, Coastal and Shelf Science, 31; 689-701.

Vatanachai, S. 1979 The identification of fish eggs and larvae obtained from the survey cruises in the South China Sea. Symposium on coastal and high seas pelagic resources. Proceedings of the Indo Pacific Fisheries Council, 15th Session Section 3. pp. 111-130. 1974.

Young, P.C., 1978. Moreton Bay, Queenland: A nursery area for juvenile penaeid prawns. Australian Journal of Marine and Freshwater Research, 29; 55-75.