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Diversity and Distribution of Fishes in Tropical Estuary Kuantan, Pahang, Malaysia

[1]K.C.A. Jalal, [1]B.Y. Kamaruzzaman, [2]A. Arshad, [2]R. Ara and [3]M.F. Rahman
[1]Department of Biotechnology, Kulliyyah of Science, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia
[2]Department of Aquaculture, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[3]Department of Fisheries, Matshya Bhaban, Ramna, Dhaka, 1000, Bangladesh

Abstract: A study on diversity and distribution of fish communities and water qualities were carried out from January 2009 to December 2010 to cover monsoon and non-monsoon at Kuantan estuary, Pahang, Malaysia. A total of 19 species of primary marine fish belong to 12 families were recorded. Out of 311 individuals the fish fauna was dominated by Ariidae followed by Lutjanidae and Lactaridae. As such Ariidae contributes 50% of the fish caught in the study area and its diversity index (H') was 0.97. A The Ariidae family consist of four (4) species; *Arius maculatus*, *Arius sumatranus*, *Arius tenuispinis* and *Arius thalassinus*. The Ariidae family can be found in all stations as they are euryhaline (highly tolerant to salinity) and this fish family are known to be a hardy estuarine catfish. Among all species in family Ariidae, *Arius thalassinus* was the most dominant (23%) among all species. As such collected species showed highest species diversity (0.34) followed by *Arius tenuispinis* (0.25) compared to other species. *Arius tenuispinis* alone contributed 11.90% among the samples caught from all stations. The fishes were caught and recorded highest in September-December. *Pseudorhombus quinque ocellatus*, *Nibea soldado*, *Sardinella fimbriata*, *Toxotes jaculatrix*, *Dasyatis ushiei*, *Setipinna taty* were the least dominant in the Kuantan estuary with 9.33% of total abundance. Physico-temperatures, such as temperature (22.03-30°C), Conductivity (10.342.43 mS cm^{-1}), TDS (0.06-26.34 mg L^{-1}), salinity (0.05-29.09 ppt), DO (6.37-8.38 mg L^{-1}), pH (4.97-8.03), Chl a (0.01-1.33 μg L^{-1}), nitrite (0.01-0.08 mg L^{-1}), nitrate (0.60-0.88 mg L^{-1}), phosphate (0.24-0.40 mg L^{-1}). Nevertheless, the study envisages that the water quality and fish diversity are still conducive in the Kuantan estuary. The fish diversity of Pahang estuary was high monsoon compared to non-monsoons. The station 4 (LKIM fishing boat jetty and adjacent Hospital Kuantan) is the most polluted area due to the presence of several outskirts could be alarming for the sustainable development of fish and other aquatic organisms in Kuantan estuary in the long run.

Key words: Fish communities, water quality, diversity, conductivity, Kuantan estuary

INTRODUCTION

In the tropics, rivers contribute greatly to wetland ecosystems in the form of flood plains, ox bow lakes, freshwater swamps and estuaries. The estuary is composed of interwoven ecosystem structures including water column, scrub-shrub, forested wetland, emergent marsh, mud/sand flat, shallow slope and deep tidal channel. These habitats contribute to maintaining biodiversity and making available wetland bioresources such as fisheries to the local people. However, wetlands are generally fragile and easily disturbed (Mitsch and Gosselink, 1989). For example, in Malaysia various human interventions on estuarine ecosystems such as dam construction, industrial, housing land use activities, have resulted in the reduction of fish diversity over a period of time (Ali *et al*., 1996).

Human activity has altered fish habitats by filling or dredging these areas, constructing solid piers, diverting and increasing runoff, decreasing base flow and changing drainage patterns in watersheds, releasing contaminants into the air and water, increasing nutrient loading and releasing chemical pollutants. Unfortunately, many species are increasingly threatened because of declining conditions in natural aquatic ecosystems in Kuantan estuary. The greatest threats to these fish fauna arise from environmental perturbations resulting from dredging and sand mining which induced suspensions could be

Corresponding Author: K.C.A. Jalal, Department of Biotechnology, Kulliyyah of Science, International Islamic University, Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia

potential to change and impact local biota. These includes: habitat loss and fragmentation; degraded water quality; declining indigenous species. Land use practices can lead to non-point source pollution affecting fish in estuaries. Improper land use management practices can result in increased sediment, nutrient, organic-chemical and heavy-metal loadings to streams while creating abnormal flow rates. All have negative effects on aquatic communities by destroying habitat, increasing turbidity, lowering dissolved oxygen levels, disrupting food webs, decreasing diversity, raising stream temperatures, altering stream flow and increasing the abundance of undesirable species. Urbanization and industrialization of the lower reaches of many estuaries and tributaries have resulted in extensive filling of wetlands and reduce shallow water and riparian habitat (Lowe-McConnell, 1990, 1995; Whitfield, 1996). A continuation of the environmental degradation in the water quality of the rivers and estuary would result in an increase in the economic costs to be borne by the state due to loss or revenue from fisheries sectors (Ali *et al*., 1996; Mazlan *et al*., 2006). Fishing is also an important traditional activity for coastal peoples. With pressure from an increasing number of fishermen with more efficient technology and competition for use of estuary for incompatible purposes, the estuarine fisheries are an important management issue.

Kuantan estuary is receiving increasing pressure as people continue to utilize the coastal zone for housing, recreation and industrial purposes. It was found that, although the fishes of Malaysia had been studied in the past, a considerable amount of the information on fresh fishes was from small rivers, lakes, reservoirs and coastal waters in Malaysia (Bishop, 1973; Mohsin and Ambak, 1996; Ambak and Jalal, 1998, 2006; Kamaruzzaman *et al*., 2002). In fact, the Kuantan estuary, have never been seriously considered as a complete study. As scientists, conservationists and policy-makers wrestle with how to balance development with maintaining biodiversity, it's important to understand what controls patterns of biodiversity and how the biodiversity of a system will respond to different environmental scenarios.

River and estuarine ecology and management activities in most countries suffer from an inadequate knowledge to the constituent biota, especially in large poorly investigated tropical river systems. Fisheries assessments are one of the best tools for fisheries management to understand the populations of fish in a given area. We must seek to protect undisturbed habitat, maintain functioning habitat and, if possible, improve or create habitat beneficial to both game and non-game species (Magurran, 1988; Jalal *et al*., 2009). Thus, it is an urgent need to establish a long term monitoring study to determine the ecological distribution of various fish species in Kuantan estuary. Based on this context, this study is focused on spatial and temporal distribution and species diversity of commercial fishes in Pahang estuary.

Spatial diversity by the species present in an environment has long been recognized as a frequent occurrence. In terrestrial systems, anthropogenic habitat loss and fragmentation has altered the spatial distribution of organisms and change competitive and predator-prey interactions (Debinski and Holt, 2000; Haila, 2002). Furthermore, some evidence showing that human-mediated effects can alter space use by fishes with cascading effects on lower trophic levels (Olin *et al*., 2002). Demonstrations of spatial partitioning in fish communities vary considerably, from purely qualitative descriptions of the different habitats to be used proportionally of each category of habitat of each species. An understanding of fish-habitat relations in aquatic habitat is a major concern for both fisheries biologists and ecologists. Knowledge of fish-habitat relations can be used to protect in stream flows enhance aquatic habitats and mitigate effects of channelization (FAO, 2000).

MATERIALS AND METHODS

Study area: The sampling was carried out in Kuantan Estuary (Fig. 1) from January 2009 to December 2010 to cover monsoon and non-monsoon seasons. The non-monsoon season sampling was scheduled from January to August. While it was monsoon from September to December Kuantan estuary runs from the river Lembing through Kuantan City before flowing out to South China Sea. It has a diverse ecosystem and also rich with natural resources like prawn, shell fish and some mangrove species. However, this estuary is now threaten by the several kinds of pollution as this river situated near the fisherman villages and the development of this area is currently in rapid progress adjacent to the shore areas.

Sampling and data analysis: Sampling was done by separating the study area into 5 different stations. The distance between each station was 500 m. Those stations were selected based on different locations of ecosystem. Station 1 is the area that near to the open sea. Station 2 near the fishing village occupied with fishing activity. Station 3 which situated near the mangrove swamp. Station 4 is the most disturbed area because all the pollutants from non point sources enter into this area. Station 5 is the last station which can be considered as undisturbed area and it is near the fresh water zone. The sampling stations were lies in-between N03°47.706'E103°

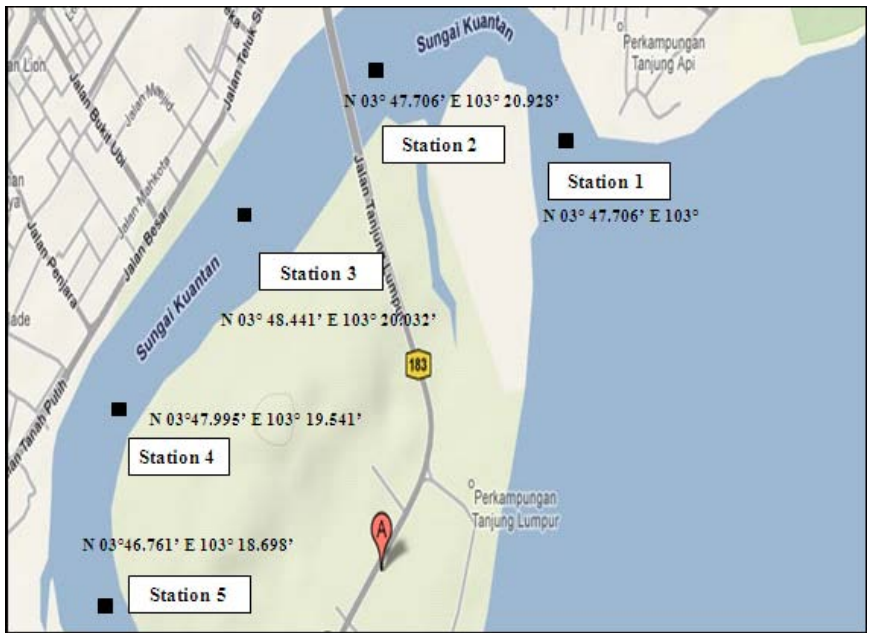

Fig. 1: Kuantan Estuary and its sampling areas, Google-Map data (c) 2009 and, Map IT, Europa

to N03°46.761'E103°18.698'. Fish samples were collected using Random Stratified Sampling Method from five zones of the sampling stations.

Physico-chemical parameters: The physicochemical parameters such as temperature, conductivity, salinity, DO and pH of the water was done along the Kuantan River which covers 5 different stations by using Hydrolab Data Sonde 4a, USA'. All the data were measured by Hydro lab Datasonde 4a, USA'. All the data were recorded in situ and then analyzed in the laboratory. Standard method APHA 4500-NO_3-B, 1995 was used to evaluate was used to evaluate Nitrogen -Nitrate (NO_3^-B) at wavelength (λ) of 507 nm. HACH programme 2515 (detection range 0-0.50 mg L^{-1}) was used to measure nitrate in the sample. Standard Method APHA 450-P-D, 1995 was used to evaluate phosphorous value at wavelength (λ) of 420 nm. HACH programme 541 (detection range: 0.00-33.00 mg L^{-1}) was used to measure phosphate level in the water column (Parsons *et al*., 1992). Differences in physic-chemical parameters among the different stations were calculated using student t-test analysis. The $p<0.05$ was considered to be statistically significant (Jalal *et al*., 2008). Fish sampling was done from different locations to investigate the fish diversity in different environments. The sampling was conducted from 1st January 2009 to 31st December 2010 in both monsoon and non monsoon seasons. Studies on fish in different tropical and temperate lakes and rivers appear to have chiefly on nets (Lowe-McConnell, 1990, 1995; Welber *et al*., 2003). The fishing gear were consisted of gill nets (1, 2 and 3 inch mesh size, 100 m long and 3 m depth), drift nets and fish trap to catch all sizes of fish. The gill nets were set perpendicular to the shore and vertically from the surface to the deeper part of the river so that the spatial distribution of the fishes could be easily analyzed. The fish specimens were fixed in 10% formalin solution and preserved in 70% alcohol at the laboratory of the Faculty of Science, International Islamic University of Malaysia Kuantan campus. All fishes were identified using available taxonomic keys (Mohsin and Ambak, 1996; FAO, 1974). The species diversity of fishes in Pahang Estuary was calculated by using Shannon-Weiner index (Shannon and Weaver, 1963; Jalal *et al*., 2008).

RESULTS

The results of the physicochemical parameters found in this study are presented in Table 1. The temperature of this study showed that no significant differences among the stations with $p>0.05$. The spatial distribution of temperature among five stations showed that there were no significant differences between the stations at $p>0.05$ level of significance. The highest temperature was 28.7 °C observed in June at St. 2 whilst the lowest 22.03°C in November at St.5. The conductivity also showed that there were no significant differences between the stations

Table 1: Physicochemical parameters (Jan-Dec, 2010) in Kuantan Estuary

Physicochemical parameters	St. 1	St. 2	St. 3	St. 4	St. 5
Temperature (°C)	28.71±0.73^{a}	28.39±0.89^{a}	26.73±0.28^{a}	26.78±0.25^{a}	25.08±1.37^{a}
Conductivity	40.95±1.27^{a}	31.56±0.95^{b}	28.97±2.38^{bc}	24.11±2.01^{c}	15.02±3.86^{d}
TDS (mg L^{-1})	25.85±1.30^{a}	20.52±1.41^{a}	22.89±1.09^{b}	19.27±6.76^{bc}	13.43±1.62^{d}
Salinity (ppt)	25.54±1.52^{a}	22.92±0.99^{a}	23.13±0.85^{a}	4.45±0.73^{b}	0.54±0.37^{c}
DO (mg L^{-1})	8.00±0.27^{a}	8.04±0.27^{a}	7.33±0.25^{a}	6.83±0.32^{a}	7.75±0.53^{a}
pH	7.60±0.20^{a}	7.38±0.23^{a}	6.90±0.27^{a}	6.58±0.35^{a}	6.32±0.55^{a}
Chlorophyll α (μg L^{-1})	0.03±0.01^{a}	0.70±0.19^{b}	0.79±0.29^{b}	1.11±0.20^{bc}	0.91±0.22^{bcd}

Values with different superscripts in same row are significantly different at $p<0.05$

Table 2: Abundance and diversity of fishes in Kuantan Estuary (Jan-Dec, 2009)

Species name	Family	Local name	English name	Abundance (%)	Diversity
Apogon hyalosoma	Apogonidae	Ikan seriding	Cardinal fish	3.86	0.13
Arius maculatus	Ariidae	Duri tompok	Spotted cat fish	9.00	0.22
Arius sumatranus	Ariidae	Blotan	Goat cat fish	5.47	0.16
Arius tenuispiuis	Ariidae	Mayong	Thin spine sea cat fish	11.90	0.25
Arius thalassinus	Ariidae	Duri/jahan	Giant cat fish	23.15	0.34
Lutjanus russelli	Lutjanidae	Merah tanda	Russels snapper	4.50	0.14
Lutjanus argeutimaculatus	Lutjanidae	Ikan merah bakau	Mangrove red snapper	4.18	0.13
Lactarius lactarius	Lactariidae	Ikan lelamah	Big jawed jumper	7.71	0.20
Lates calcarifer	Lactariidae	Siakap putih	Baramundi	4.18	0.13
Nibea soldado	Nettastomatidae	Ikan gelama/gigi jarang	Mangrove red snapper	1.93	0.08
Pseudorhombus quinque ocellatus	Psettodidae	Ikan sebelah	Five spot flounder	1.61	0.07
Sardinella fimbriata	Rhynchobatidae	Ikan tamban	Fringe scale sardinella	1.29	0.06
Toxotes jaculatrix	Torpedinidae	Ikan sumpit	Banded archer fish	1.61	0.07
Eleutheronema tetradactylum	Polynemidae	Ikan kurau	Four finger thread fish	2.25	0.09
Dasyatis ushiei	Dasyatidae	Ikan pari lembu	Cow sting ray	0.96	0.04
Epinephelus coioides	Serranidae	Ikan kerapu bunga	Orange spotted grouper	4.50	0.14
Paranibea semiluctuosa	Sciaenidae	Ikan gelama kelam	Half mourning croaker	6.11	0.17
Pennahia macrophthalmus	Sciaenidae	Gelama cerua	Big head pennah croaker	2.25	0.08
Setipinna taty	Engraulidae	Kasai janggut	Scaly hairfin anchovy	1.93	0.09

at $p>0.05$ level of significance. The highest conductivity showed in 40.95±1.27 at St. 1 and lowest in 15.02±3.86 at St. 5. Due to urbanization and industrial development lot of human activities present at Station 1-4. In fact the amount of total dissolved solids might be higher in those stations which were higher compared to Station 5 due to the overloading of nutrients and urban and rural runoff. Station 5 is considered as most undisturbed area. There were no human activities adjacent to the shore line areas. Thus, the amounts of total dissolved solids seemed to be lower at Station 5 (Table 1).

In this study, Conductivity, TDS, Salinity and Chl a showed significant differences between all the five stations with $p<0.05$ (Table 1). The temperature was higher at St. 1 (28.71) and lower at St. 5 (25.08). Conductivity was higher at St. 1. (40.95 mS cm^{-1}) and lower at St. 5 (15.02 T mS cm^{-1}). The study shows the fluctuation of salinity in estuarine water which was higher at St. 1 (25.54 ppt.) near the open water gradually reduced towards the upstream at St. 5 (0.54). DO content lowest at the St. 4 (6.83) and the highest at St. (8.04) at station 2. The maximum pH value was recorded at St. 1 (7.60) at St.1, whilst minimum pH value was (6.32) at St. 5. Generally, during north-east monsoon the pH value slightly decreased may be due to dilution effect. This may also be demonstrated by the increase in pH value during non-monsoon season (February-July). Excessive nutrients and plant growth can in turn decrease DO levels and increase turbidity. In this study, the chlorophyll a was measured in μg L^{-1}. The range of chlorophyll a in all stations is between 0.03 and 1.141 μg L^{-1}. When refer to Table 1, it clearly shows that the amount of chlorophyll a in the surface water of Station 4 is relatively higher (1.14 μg L^{-1}) compared to other stations. Station 4 is located near the Hospital Tengku Ampuan Afzan (HTAA), where rapid growth of urban development exists and the presence of obnoxious algal mat due to the several outskirts from the hospital and jetty areas.

Fish diversity and distribution: A total of 19 species of primary marine fish belong to 13 families were recorded from Kuantan Estuary, throughout the sampling period (January-December, 2009-2010) (Table 2). The fish fauna was dominated by Ariidae followed by Lutjanidae and Lactaridae. Out of 19 species of fishes caught in Kuantan Estuary, 4 species from family Ariidae were dominant and they contribute 50% of the fish caught in the study area with the diversity index (H') of 0.97. The Ariidae family consist of four (4) species which is; *Arius maculatus*, *Arius sumatranus*, *Arius tenuispinis* and *Arius thalassinus*. The Ariidae family can be found in all stations as they are euryhaline (highly tolerant to salinity) and able to stay with narrow range of dissolved oxygen and fluctuation of pH. Among all species in family

Ariidae, *Arius thalassinus* was the most dominant (23%) among all species. As such collected species showed highest species diversity (0.34) followed by *Arius tenuispinis* (0.25) compared to other species. *Arius tenuispinis* alone contribute 11.90% among the samples caught from all stations. The fishes were caught were recorded highest in September 50 individuals followed by 42 individuals in October with the total catch of 311 individuals. The Ariidae family occurs in all tropical and subtropical seas and there are numerous freshwater and estuarine dwellers as well (Jalal *et al*., 2008). The eastern Pacific species are largely coastal fishes which frequent sand and mud bottoms of bays, harbours and brackish river mouths; a few species range into deeper water and are seen in trawler catches. Freshly captured specimens should be handled with care as the sharp spines in front of the dorsal and pectoral fins are venomous. Family Lactariidae was the second highest family caught in the study area, this family contribute 11.89% of all fish caught with the diversity index (H') of 0.33 during sampling period. The family of Lactariidae from sampling area was comprised of two species *Lactarius lactarius* and *Lates calcarifer*. There were no significant variations of these two fishes throughout the sampling period. The distributions of fishes were consistent among the months. The diversity index (H') of two species from this family were *Lactarius lactarius* 0.20 and *Lates calcarifer* 0.13. In the study area these species was caught mostly in stations 3-4 which adjacent to mangrove area. Sciaenidae family was the third highest 8.36% comprises *Paranibea semiluctuosa* (6.11%) and *Pennahia macrophthalmus* (2.25%). The diversity index of these two species was 0.25. Sciaenids are generally bottom dwellers that inhabit sandy or muddy areas, frequently off beaches or in sheltered bays, estuaries and river mouths. During this study, this species was mostly caught in St.1-St.2 which are the high saline zones in the study area. The family of Engraulidae contributes 1.93% of the collected sample with diversity index (H') 0.08, was represented by *Setipinna taty*. They are generally very accepting of a wide range of temperatures and salinity. Large schools can be found in shallow, brackish areas with muddy bottoms, as in estuaries and bays. Some species from this family enter or live in freshwater. The anchovy is a significant food source for almost every predatory fish in its environment. This small pelagic fish is also important for human consumption in indo-pacific region and they are also important live bait used by pole and line tuna fisheries.

Eleutheronema tetradactylum from family Polynemidae, contributed 2.25% of the total catch with diversity index (H') value of 0.09. They were locally known as Thread fish and Ikan Kurau found at St. 1 during sampling period. Juveniles are found in estuaries as they are protected from predators. They usually form loose schools, although larger fish are more often observed in pairs or singly. This is a commercial fish and has a high value in the market, usually they entered mangrove area to feed. One of the first parameters to be affected by poor water quality is the reduction of fish species which ultimately. Fish species might not become extinct and there will still be some species that can tolerate extremely adverse water quality condition such as *Arius* sp. However, these species were not harvested because of their very low market values. Arius sp. are species with catholic food habits, feeding on materials ranging from domestic wastes to rotting carcasses. However, other species preferring good quality water will disappear from the population. Those species to disappear first would usually be the estuarine sp. that prefers clear, cool and fast flowing water with high DO concentrations. During the sampling activities several individuals of commercially important species such as Siakap (Sea Bass) and Gelama (Red Snapper) were caught. Although the number fishes were not significant but the fact that these transient species still moved into Pahang estuary bodies for their spawning purposes. We believe that if the water quality of the river can be improved further, species such as these commercially valuable species would return to Pahang estuary. The disappearance of most of expensive marine commercial species Kerapu (Grouper) in estuarine ecosystem indicates that the water quality has changed enough to result in the disappearance of these more environmentally sensitive species. During our survey, none of these species were observed in the middle and lower river sections where environmental degradation is the highest. Our definition of commercially important species has changed over the years due to changes in dietary patterns. Species that were considered as "rough fish" 15 years ago are now highly prized. It is fortunate that these commercially valuable species are also one of the hardiest groups fresh water species. As such Sciaenidae and Engraulidae none of these species are adversely affected in the Kuantan estuary. However, as hardy as these species may be, it will still be stressing for them to live in a continuously degraded environment. For example, although they can tolerate low DO level due to their air breathing capability, prolonged exposure to anoxic condition can result in stunted growth. Furthermore these species can also "leave" their original habitat to search for better ones if the degraded condition continues. Thus it is better in the long term to improve the aquatic environment so that these species can reproduce and grow and contribute to the local fisheries.

DISCUSSION

Based on the results obtained, the highest temperature was 28.7°C observed in June at St. 2 whilst the lowest 25.08°C in November at St.5. A general increase in the water temperature recorded on June can be attributed to the general increase in atmospheric temperature and lack of intensive rain (Sekar *et al*., 2009). Whereas, the low temperature found in December and month might be due to the heavy rain falls during monsoon the surface runoff started from September to January in the tropical ecosystem (Law and Jong, 2006). According to Bong and Lee (2008), the average surface seawater temperature for typical tropical waters ranged from 28.6-30.0°C. Estuarine fish are mainly euryhaline forms that are able to exist in unstable surroundings surviving variable salinities, currents and food supplies (Koutrakis *et al*., 2000). The salinity of water which has a significant influence on the species composition of the resident biota, fluctuated within the estuary with ebb and flow of tides and with changes in freshwater run-off. Besides, salinity in an estuary also varies according to the location in the estuary, the daily tides and the volume of freshwater flowing into the estuary (http://www.noaa.gov/ocean.html). High salinity found on the month of April in the estuary was due to deficit river discharge associated with the low rainfall, as the general effect of the monsoon season.

The fish diversity was quite high even though the estuary is quite small and continuous disturbing by fishing boats. Most of the fishes were caught near the mangrove area (St. 3) during monsoon seasons (September-December) which probably due to the breeding season of estuarine fishes. From this study the Ariidae family was dominant among other family in the study area, they contribute 50% of the fish caught in the study area with the diversity index (H') of 0.97. Similar finding was observed in the Pahang estuary where Ariidae species occupied 50% of the fish caught (Jalal *et al*., 2008). The Ariidae family occurs in all tropical and subtropical seas and there are numerous freshwater and estuarine dwellers as well. The eastern Pacific species are largely coastal fishes which frequent sand and mud bottoms of bays, harbours and brackish river mouths; a few species range into deeper water and are seen in trawler catches. Freshly captured specimens should be handled with care as the sharp spines in front of the dorsal and pectoral fins are venomous. Fishermen often snap these off before untangling the fish from their nets (Ahmad Azfar, 2010). Family Lactariidae was the second highest family caught in the study area, this family contribute 11.89% of all fish caught with the diversity index (H' 0.33) during sampling period. The family of Lactariidae from sampling area were comprises two species *Lactarius lactarius* and *Lates calcarifer*. The species is widely distributed in the tropical and subtropical areas of the western Pacific and Indian Ocean. Its range of distribution includes the areas from Australia, Southeast Asia, the Philippines and countries bordering the Arabian Sea.

Eleutheronema tetradactylum from family Polynemidae, was also found in the study area, during this study. They contribute to 2.25% of the total catch with diversity index (H') value of 0.09. They were known as Thread fish and Ikan Kurau in Malay. They were found in St. 1 during sampling period. Juveniles are found in estuaries as they are protected from predators. They usually form loose schools, although larger fish are more often observed in pairs or singly. This is a commercial fish and has a high value in the market, usually they entered mangrove area to feed. One of the first parameters to be affected by poor water quality is the reduction of fish species which ultimately. Fish species might not become extinct and there will still be some species that can tolerate extremely adverse water quality condition such as *Arius* species. Although, the number fishes were not significant but the fact that these transient species still moved into Kuantan estuary bodies for their spawning purposes. It can be concluded that if the water quality of the river can be improved further, species such as these commercially valuable species would return to Kuantan estuary. The disappearance of most of expensive marine commercial species Kerapu (Grouper) in estuarine ecosystem indicates that the water quality has changed enough to result in the disappearance of these more environmentally sensitive species.

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