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Demersal fishes and their distribution in estuarine waters of Mahakam Delta, East Kalimantan

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ABSTRACT

Suyatna I, Bratawinata AA, Sidik AS, Ruchaemi A (2011) Demersal fishes and their distribution in estuarine waters of Mahakam Delta, East Kalimantan. Biodiversitas 12: 204-210. The study aimed (i) to identify of the demersal fishes, (ii) to analyze the diversity and (iii) to determine their distribution. Surveys were carried out between August 2009 and January 2010 in Mahakam Delta, East Kalimantan. Data were analyzed using several indices of Shannon Weaver, Simpson, Margalef species richness, and Bray Curtis distance. The canonical correspondence analysis (CCA) was also used to correlate between fish species and their environmental factors and to show the fish distribution. Sixty samplings were done using bottom-trawl at various water depths from one to forty two meters to collect the data. Taxonomically, during the study, 10 orders, 61 families, 87 genera and 131 species of fish with 43340 individuals were identified. Among the families, Leiognathidae was the most important group of fish, they distributed throughout the depths. Meanwhile CCA showed that Leiognathidae and Sciaenidae were observed to be rich in the shallow water. Generally, index of Shannon Weaver, Simpson and Margalef species richness ranged between; 0.52 and 2.48; 0.11 and 0.82; 2.24 and 18.61 respectively. Bray Curtis distance indicated the significant difference of individual number of demersal fishes between shallow and deep waters.

Key words: Mahakam delta, water depth, trawl, demersal fish, canonical correspondence analysis.

INTRODUCTION

The Mahakam Delta is located on the East of Kalimantan between S $0^o21'$ and $1^o10'$, and E $117^o15'$ and $117^o40'$ (Sandjatmiko 2006). Due to its 1500 km^2 of mangroves and channels, the Mahakam Delta is a place that is not easy to reach (Dutrieux 2001), then Madeo (2001) stated that starting from $1990's$ the development of aquaculture has changed the environment up to 76% as a global human impact. Mangrove area conversion into shrimp pond *tambak* is the major factor. The thickness of the green belt was only ranging from 30 to 193 m (Suyatna et al. 2010). Kamal (2006) estimated Mangrove destruction 30% of 6273.5 ha caused a decrease of fish catch of about 975.0 tons $year^{-1}$. While ongoing mangrove degradation, the Mahakam Delta has also been significantly pertubed by trawl fishing in the past 25 years because the Presidential Decree no 39 year 1980 acts to forbid the operation of trawls in Indonesia, the trawls are still operated in the delta up to present. According to Remesan and Ramahandran (2005) mini trawls were usually operated in the sea by the artisanal fishermen and based on the target group, three types of trawls are in operation namely fish, shrimp and crab trawl. Can (2006) identified that the trawls are not very selective and catches are composed of a highly diversified mix of fish. While Firdaus (2010) described the catch between trawls and trap nets is significantly different, the first could fished 16.10 kg/h and others only 1.67 kg/h. Budiman et al. (2006) had reported that an overfishing of the demersal fish was occurred in Kendal waters of Kendal district. Results of the above study were among the reasons why the study related to biological aspects in Mahakam Delta is needed to be performed. The study aimed (i) to identify of the demersal fishes, (ii) to analyze the diversity and (iii) to determine their distribution.

MATERIALS AND METHODS

The study was carried out between August 2009 and January 2010 in Mahakam Delta, East Kalimantan. Sampling areas were divided into three strata on the basis of depth: Stratum I or shallow: 1 to <10 m; Stratum II or intermediate: <10 to <20 m and Stratum III or deep: 20 to 42 m. A total of 60 bottom trawl hauls consisting of 20 hauls for each stratum (shallow, intermediate and deep) were performed using a motorized boat sizing 12m x 2m x 1.5m and equipped with a net size of 10 m length. The hauls were considered as sampling sites (observations). Double machines were used at the intermediate and deep sampling areas to increase the power of the boat. Towing time varied from 15 to 25 minutes. Garmin *GPSMap* 60CSx recorded the geographic position of all sites. Fish identification referred to the field guide book of Peristiwady (2006), Allen (2000), and Masuda et al. (1975). The physico-chemical properties of waters were measured *in situ* at the sea surface using water checker Horiba, except water transparency. All data of fish

including environmental factors were analyzed using statistical software. Index of Shannon-Weaver, Simpson, Margalef species richness (using *log*) and the canonical correspondence analysis (CCA) except the Bray Curtis distance were made by statistical program of the Brodgar version 2.6.5. The Bray Curtis distance was analyzed by using software of the PAlaeontological STatistics, PAST version 2.0. Graphs of the CCA was realized by the Brodgar, map of Mahakam Delta by MapINFO 8.5 while others were made by hand.

RESULTS AND DISCUSSION

The general conditions of the study area (south, center and north part) related to the distribution of geographic position of the sampling sites, the distance of each sampling site from the coastline, and the bathimetry are presented in the Figure 1. Taxonomically, our study identified the main fish orders as presented in the Table 1. The measurement result of the physico-chemical properties and the environmental factors are summarized as shown in the Table 2. Table 1 shows that only the concentration of turbidity did not follow general condition. The turbidity should be less as more away from the coast, but it is possible to accept this condition as being valid because the turbid water of the big River of Mahakam highly affected the sea. Such environmental factors were studied in order to observe their effects on the demersal fish distribution as Moyle and Cech (2000) stated that the distribution and abundance of fish found out in estuaries are determined primarily by physical and chemical factors and only secondarily by biological factors.

Fish community structure

During the study, 10 orders, 61 families, 87 genera and 131 species of fish with 43340 individuals were identified and listed in the table below. From those data, the structure of fish community in the Mahakam Delta was revealed as presented in the Table 3.

Navarro et al. (2010) only could collect 64 demersal fishes from 36 fish families in the eastern coast of the mouth of the gulf of California during eight surveys aboard a commercial shrimp trawling boat that operated at the depth of 10 to 60 m during the 2005/06 and 2006/07 shrimp fishing seasons. Budiman et al. (2006) in their study on the distribution analysis of demersal fishes in Kendal found out 44 families and the most number of the species belonged to Apogonidae. Related to the fish community structure, our study showed that 87% of 60 observations the fish diversity index varied between 1 and 2.09 belonging to the intermediate level, and the index of less than one and more than three belongs to the category *Low* and *High*. Ridho and Suman (2003) studied the relationship between fish community structure and biomass of demersal fishes in various water depths. They found out that the fish diversity was much more stable in water depth of ≤ 30 m and showing the higher the fish diversity index the greater the fish biomass. We found out the similar result with that finding. Individual number of fish of our study showed that the shallow water was higher than deep waters as well as the fish diversity (Figure 2 and 3). Budiman et al. (2006) found out less fish population at depth ≥ 10 m, and the same finding was also observed in the Mahakam Delta. Higher Simpson index (C) was identified in the shallow water and this means that there was one or more species extremely high in population (dominant), where the index closes to one means that there was dominant species, the criterion index is $0 \leq C < 0.5$ low dominance, $0.5 \leq C < 0.75$ intermediate dominance and $0.75 \leq C < 1.0$ high dominance. Ponyfish or Pepetek belonging to the family Leiognathidae (its member presented in Table 5) were the most populated with total number of 15860 individuals (36.59%). While other dominance demersal fish species was represented by Croakers or Gulamah (*Johnius amblycephalus*, Bleeker 1855 and *Atrobucca brevis* Sasaki and Kailola 1988) belonging to the family Sciaenidae and Longfin Anchovy or Bulu Ayam/Bilis (*Setipinna tenuifilis*, Valenciennes 1848 and *Thryssa mystax* Bloch and Schneider 1801) belonging to the family Engraulidae with their individual number were 7310.0 (16.86%) and 7520.0 (17.35%) respectively. Totally, individual numbers of fish of each stratum from shallow to deep were 24216, 7250 and 11874 individuals respectively. The diversity index in our study (Table 3) was higher compared to the index reported by Genisa (2006) who studied in the Mahakam Delta that ranged from 0.53 to 1.55. However Margalef species richness was much lower compared to 13.18 to 23.70. This might prompt a drop in abundance in the Mahakam Delta at present like that occurred in the Gulf of Thailand. In the Gulf the abundance of *Leiognathus* had dropped from 27.4% to 7.6% in ten years caused of the heavy trawl fishing (Longhurst and Pauly 1987).

Margalef species richness in shallow waters of the Mahakam Delta was higher compared to the intermediate and deep waters as well (Figure 3) but not significantly different. More detail of explanation related to the individual and fish species number difference among the strata, statistically it could be seen in the Tabel 4. According to the analysis of Bray Curtis distance, the individual number of fish in the shallow compared to the intermediate and deep waters showed significantly different but not between the intermediate and the deep waters. However, the fish species number was almost all similar. The value of the Bray Curtis distance closes to one means that the two objects are more similar.

Table 1. Orders of the demersal fish species identified during the study within the Mahakam Delta.

Order	No of family	No of genus	No of species
Perciformes	37	54	95
Tetraodontiformes	4	8	8
Scorpaeniformes	4	3	6
Clupeiformes	3	9	9
Pleuronectiformes	3	3	3
Rajiformes	3	3	3
Syngnathiformes	2	2	2
Siluriformes	2	2	2
Anguilliformes	1	1	1
Aulopiformes	1	1	1
	61	87	131

Tabel 2. The summarized measurement result of the environmental factors related to the condition of the study area during the study in the Mahakam Delta.

Sampling areas	Distance (km)	Depth (m)	Salinity (g/L)	Turbidity (mg/L)	Transp. (m)	DO (mg/L)
Shallow	0.03-9.60	1.00-9.10	3.10-31.00	1.00-173.00	0,40-2.30	3.40-7.20
Intermediate	0.07-18.0	10.0-18.0	2.10-34.80	3.00-198.00	1.00-7.00	4.00-6.00
Deep	4.60-16.90	22.5-42.0	25.40-34.60	1.00-336.00	1.00-8.70	3.00-6.80

Table 3. The diversity indices of the fish community structure based on the water depth strata during the study in the Mahakam Delta.

Diversity	Water depth strata			Index category
	Shallow	Intermediate	Deep	
Shannon Weaver *Hln*	0.13 to 2.09	0.26 to 2.08	0.30 to 1.98	1 and >3
Simpson *C*	0.18 to 0.96	0.14 to 0.91	0.17 to 0.89	0 and1
Margalef *R*	4.46 to 17.58	2.24 to 16.68	3.48 to 15.71	-
Range no of individual	71.00 to 6242.00	16.00 to 1452.00	88.00 to 3042.00	= 43340 ind
Range no of species	5.00 to 18.00	3.00 to 18.00	5.00 to 17.00	= 131 species

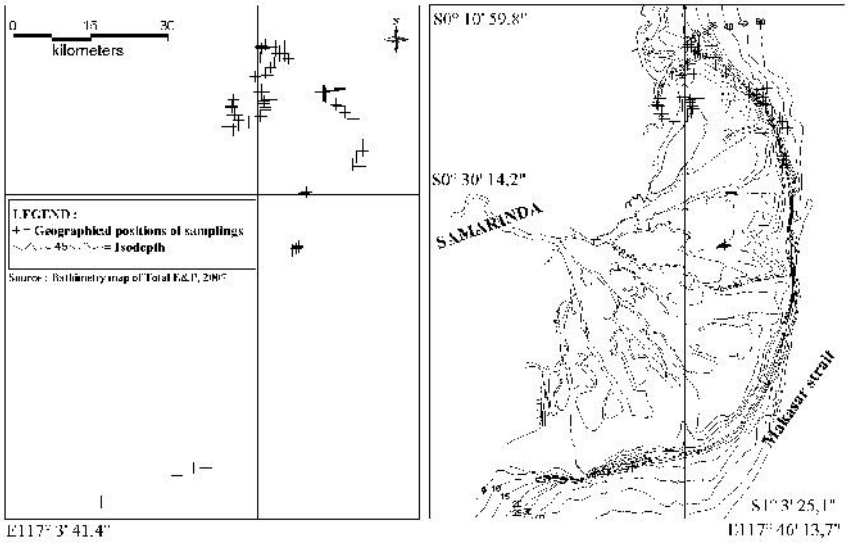

Figure 1. Map showing the distribution of sampling sites (left) and overlapped with the bathimetry and the deltaic plain (right) of the Mahakam Delta of East Kalimantan.

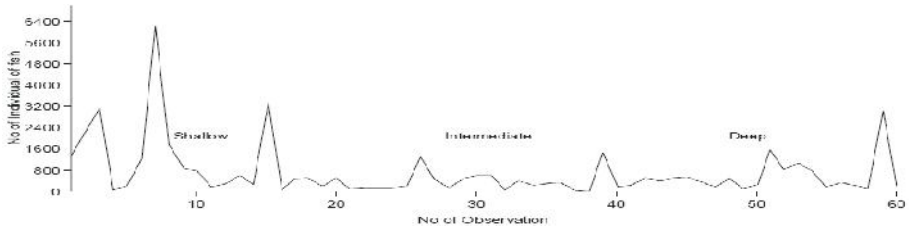

Figure 2. Individual number of fish of the three strata (shallow, intermediate and deep waters) during the study in the Mahakam Delta.

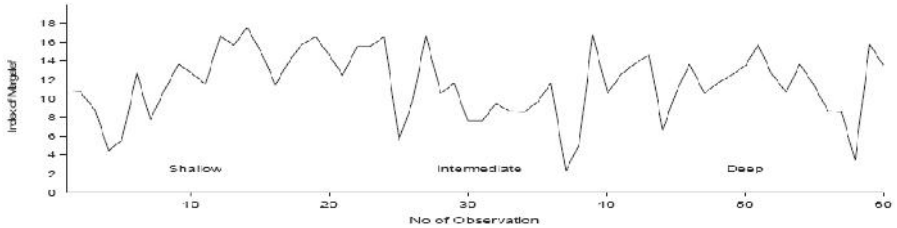

Figure 3. The index of *Margalef* species richness of the three strata during the study in the Mahakam Delta.

In the Table 5, we presented four families which comprising the most number of species in their groups identified in the Mahakam Delta in order to show the comparison of the body size between permanently and non permanently demersal fish from part of our samples.

The majority of ponyfish were observed living throughout the observed sites, very small body size and much smaller compared to other groups. Only *L. equulus* the length and weight could reach more than 20 cm and 100 g Several members of those fishes of our samples can be seen below (Figure 4).

In Irian Jaya, Genisa (2001) found out that the most important and populated estuarine demersal fish were family Haemulidae. In 2003 he continued to study on the distribution and fish community structure in the same place, but he just found out four species of ponyfish *L. splendens*, *L. brevirostris*, *L. fasciatus* and *S. ruconius* (Genisa 2003). Only *L. brevirostris* Valenciennes 1835 was not identified. A study of ponyfishes composition in West Sumatra found out 10 species of *Leiognathus* and one species each from the genera of *Secutor* and *Gazza* (Wedjatmiko 2007). . In the Mahakam Delta, the fishes were identified 11 species, almost half of the total number of species living in the Indonesian Waters. Therefore, up to this point we conclude that the Mahakam Delta is rich in fish species because not only homed many its own fish species but also nurses varied fish species from other environments. Although in small number and relatively small size compared to their real size, we found out many species from outside of the Mahakam Delta as presented in the Table 5. This has a relation with the statement of Svedang (2003) that the inshore demersal fish communities were dominated by immature fish that disappear when they grow older and most likely migrate offshore.

Table 4. Similarity of individual and species number between two strata based on the Bray Curtis distance during the study in the Mahakam Delta.

Based on the individual number				Based on the species number			
Strata	**Shallow**	**Intermed.**	**Deep**	**Strata**	**Shallow**	**Intermed.**	**Deep**
Shallow	1	0,46081	0,65802	Shallow	1	0,93249	0,97778
Intermed.	0,46081	1	0,75821	Intermed.	0,93249	1	0,95464
Deep	0,65802	0,75821	1	Deep	0,97778	0,95464	1

Table 5. The demersal fish species and their size distribution identified during the study within the Mahakam Delta.

Estuary	Lenght weight distribution				
	Sample	Lenght (cm)		Weight (g)	
	Size	Min	Max	Min	Max
Ponyfishes (*Leiognathidae*)					
Leiognathus equulus (Forsskal 1775)	3453	3.5	20.5	0.81	120
L. fasciatus (Lacepede 1803)	1	13	13.5	42.3	43
L. splendens (Cuvier 1829)	3278	2.5	17	0.35	74
L. leuciscus (Gunther 1840)	560	5	12	0.9	27.14
L. bindus (Valenciennes 1835)	1909	3.5	11.6	0.62	23.5
L. nuchalis (Temminc and Sckege l845)	24	7.5	10	5.6	14.2
L. elongatus (Gunther 1874)	62	10.2	14.2	16.9	41.6
Gazza minuta (Bloch 1797)	1484	4	13	0,51	27
G. achlamys (Jordan and starks 1917)	2592	8.3	14	9.2	42
Secutor ruconius (Hamilton 1822)	2492	3.5	11	0.7	17
S. indicius (Monkolprasit 1973)	5	8	10.8	5	16.3
Marine					
Trevallies (*Carangidae*)					
Caranx sexfasciatus (Quoy and Gaimard 1825)	15	9	24	9.43	160
Carangoides dinema (Bleeker 1851)	16	13.5	25	33	260
C. talamparoides (Bleeker 1852)	19	9.5	20	11.5	129
C. ferdau (Forsskal 1775)	8	10.5	16	15.11	58.14
C. uii (Wakiya 1924)	13	10.5	14	17.06	38.9
C. hedlamdensis (Whitely 1934)	16	14.5	25	34.5	240
C. chrysophrys (Cuvier 1833)	3	25	25	260	260
Psenopsis humerosa (Munro 1958)	2	10	12.5	19	33
Gnathanodon speciosus (Forsskal 1775)	4	6,5	14	4	38
Ulua mentalis (Cuvier 1833)	37	6	24	5	240
Alectis ciliaris (Bloch 1788)	3	4	25	2.2	240
A. indicus (Ruppell 1828)	7	6	29	3.4	390
Groupers (*Serranidae*)					
Epinephelus merra (Bloch 1793)	2	20	20	100	162.38
E. coioides (Hamilton 1822)	7	11	40	15.65	1000
E. amblycephalus (Bleeker 1857)	9	15	26	20	240
E. sexfasciatus (Valenciennes 1828)	2	9	16	9	215
E. ongus (Bloch 1790)	1	18	-	83	-
Cephalopholis microprion (Bleeker 1852)	1	17	-	80	-
C. formosa (Shaw and Nodder 1812)	1	16	-	134	-
Snappers (*Lutjanidae*)					
Lutjanus erythropterus (Bloch 1790)	2	9	29	12,15	360
L. johnii (Bloch 1792)	30	7	75	4.64	5300
L. russelli (Bleeker 1849)	31	7	19,5	12.5	280
L. quinquelineatus (Bloch 1790)	1	13.5	-	15	-
L. vitta (Quoy and Gaimard 1824)	1	14	-	28.4	-
L. lutjanus (Bloch 1790)	90	8	15,5	5.5	45
L. malabaricus (Bloch and Schneider 1801)	15	12.5	35	27.9	740

To give an idea the demersal fish species came from the marine environment from among of our samples, please refer to Figure 5, 6 and 7.

Fish distribution

English et al. (1994) suggested that to study fish distribution, observe the correlation between fish species and the environmental factors, and this would be helpful. In relation to this, the study used the CCA that could analyze the combination of three variables (species, environmental factor and site) and show the correlation. Many authors used this tool such as Sanchez and Serrano (2003) and Byron and Link (2010). From the correlations, the distribution pattern of fish could be viewed easily. The result of the CCA of our study showed that the environmental factors (bold lines) except the dissolved oxygen (DO), namely transparency, salinity, depth, distance and turbidity denoted by Trans, Sali, Depth, Dist and Turb had highly correlation between each other (Figure 11).

On the figure, salinity and depth were sticked together, H42 is showing a site with depth of 42 m. Again, through viewing on the triplot and biplot of the CCA, we can simply interpret the major distribution of demersal fishes. The CCA shows that Cardinalfish or Gelageh (such as *Apogon kiensis* Jordan and Snyder 1901 and *A. poecilopterus* Cuvier 1828) denoted by (Gelg) belonging to Apogonidae, Herrings or Selangat (*Anodontostoma chacunda* Hamilton 1822 and *Hilsa kelee* Cuvier 1829) denoted by (Slngt), Puput or Ditchelee (*Pellona ditchela* Valenciennes 1847) denoted by (Pupt) belonging to Clupeidae, Croakers or Gulamah (*Johnius amblycephalus* and *Atrobucca brevis*) denoted by (Gul) belonging to Sciaenidae, Longfin Anchovy or Bulu Ayam (*Setipinna tenuifilis* and Anchovy or Bilis (*Thryssa mystax*) denoted by (BulA) and (Bils) belonging to Engraulidae, Sailfin Perchlet or

Table 6. Distribution of species on the basis of fish group and water depth in the Mahakam Delta.

Common name	Local name	No of species	Water depth			Species category
			Shallow	Inter-mediate	Deep	
Ponyfishes	Pepetek	10	√	√	√	Demersal fish
Goatfishes	Niko	2	√	√	√	Demersal fish
Sylver biddies	Kapas-kapas	4	√	√	√	Demersal fish
Snappers	Kakap	7	√	√	√	Demersal fish
Trevallies	Ikan Putih	12	√	√	√	Demersal fish
Groupers	Kerapu	8	√	√	√	Demersal fish
Kingfish	Baji-baji	1			√	Demersal fish
Black kingfish	Gabus laut	1			√	Demersal fish
Moonfish	Terang bulan	1			√	Demersal fish
Flutemouth	Ikan terompet	1			√	Demersal fish
Bigeye	Mata besar	1			√	Demersal fish
		48				

Beseng (*Ambasis interruptus* Bleeker 1852) denoted by (Bsng) belonging to Channidae; all those species negatively correlated with the environmental factors including sites (water depth). The Croakers and Anchovy, according to Moyle and Cech (2000), are often found as inhabitants of turbid estuaries, bays and rivers, and the distribution and the abundance of fish found in estuaries are mainly determined by physical and chemical factors. We might conclude that the

Figure 4. Members of the Family Leiognathidae (From left *L. equulus, L. splendens, L. nuchalis, G minuta* and *S ruconius* (Source: Original photos taken from the samples).

Figure 5. Members of the Family Lutjanidae (From left *Lutjanus decussatus, L. malabaricus, L. russelli, L. quinquelineatus* and *L. erythropterus*. (Source: Original photos taken from the samples).

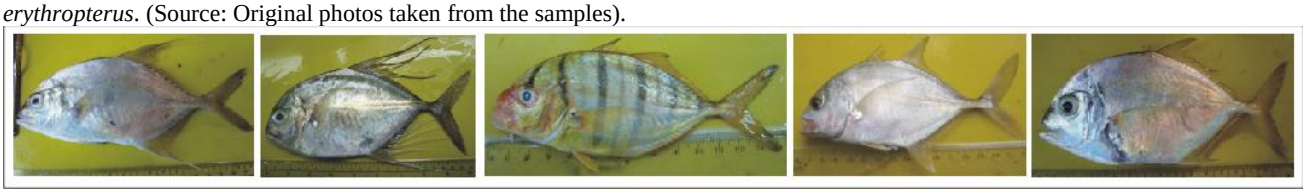

Figure 6. Members of the Family Carangidae (From left *Carangoides dinema, C. hedlamdensis, Gnathanodon specious, C. talamparoids, Ulua mentalis*. (Source: Original photos taken from the samples).

Figure 7. Members of the Family Serranidae (From left *Epinephelus coioides, E sexfasciatus, E merra, E ongus* and *Cephalopholis* (Source: Original photos taken from the samples).

Figure 9. Members of the Family Sciaenidae and Engraulidae (From left *Atrobucca brevis* Sasaki and Kailola 1988, *Johnius amblycephalus* Bleeker 1855, *Thryssa mystax* Bloch and Schneider 1801 and *Setipinna tenuifilis* Valenciennes 1848.

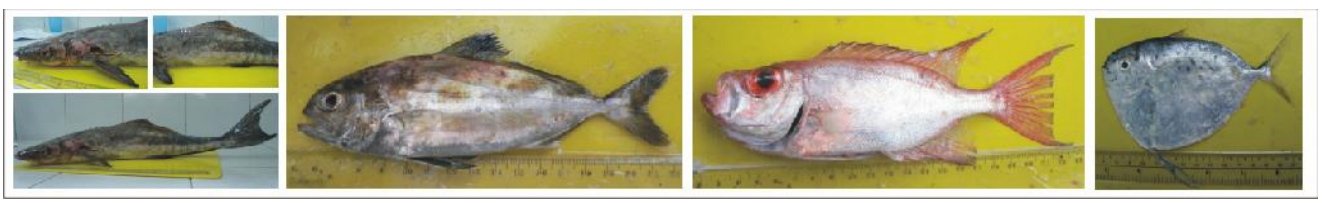

Figure 10. Members of the Family Rachycentridae, Carangidae, Priacanthidae and Manidae (From left *Rachycentron canadum* Linnaeus 1766, *Seriola fasciata* Bloch 1793, *Priacanthus tayenus* Richardson 1846 and *Mene maculata* Bloch and Schneider 1801.

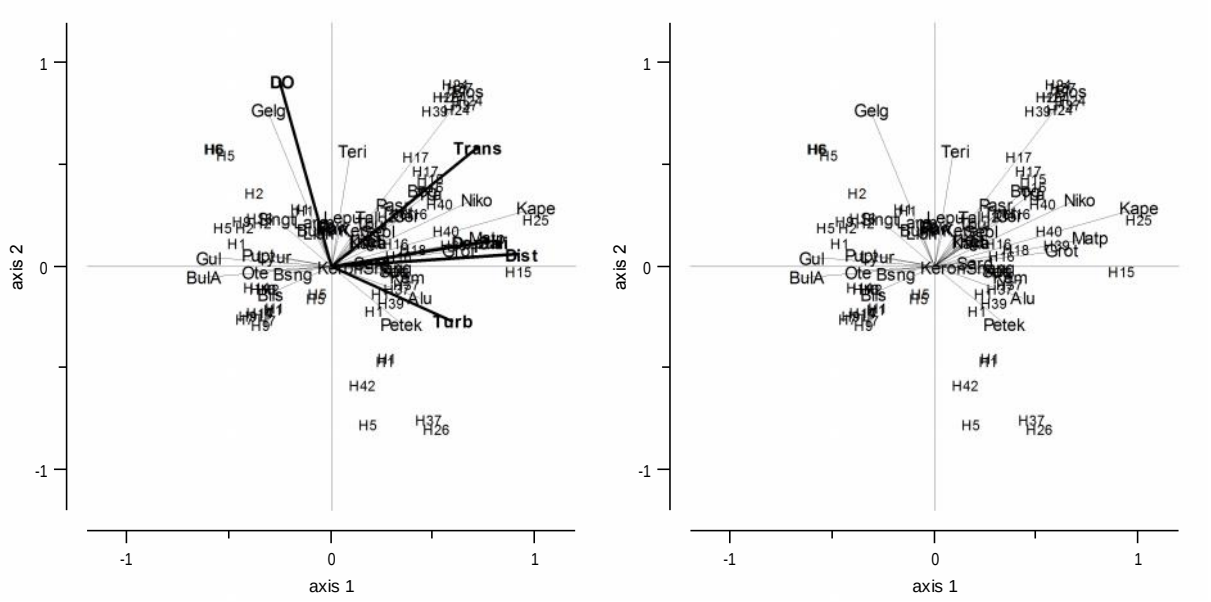

Figure 11. Triplot (left) and biplot (right) of the CCA showing correlation among species, environmental factors and sites (denoted by H) and between species and sites.

mentioned fish groups were strictly living in shallow water near the coastline from 30 m up to 9600 m and their distribution was limited mainly by the environmental factors of salinity and water depth. Ecologically, Pepetek or ponyfish members of the family Leiognathidae such as *L. equulus*, *L. splendens*, *G. minuta*, *S. ruconius* and others denoted by (Petek) mainly inhabit the same environment but because some of these species distributed up to the sea (deeper, denoted by H and the number beside the letter showing water depth), thus they (Petek) separated from (Gelg), (BulA), (Bils) and (Gul). Navarro et al. (2010) surveyed at depth 10 to 60 m, the family with the most species was Sciaenidae. Several of our samples related to those fishes are shown in the Figure 9 above.

Other species such as Mata Besar or Bigeye *Priacanthus* sp., Baji-baji or Kingfish *Seriola* sp., Gabus Laut or Cobia *Rachycentron* sp., Terang Bulan or Moonfish *Mene* sp. (please refer to Figure 10 for the complete species names and their authors), ikan Terompet or Flutemouth *Fistularia petimba* Lacepede 1803 denoted by (Matp), ikan Niko or Goatfishes *Upeneus* sp. denoted by (Niko) and Kape-kape or Sylver biddies *Gerres* sp. denoted by (Kape) positively correlated with the environmental factors. In other words, they prefer to inhabit very saline and transparent water away from the coastline up to more than 16000 m. These fish groups were strictly living in deeper water and their distribution are limited at least by the environmental factors of salinity, water turbidity, water depth and DO concentration. In connection with the demersal fish distribution, probably other environmental factors might also play an important role as Parry et al. (1995) in their study on the distribution, abundance and diets of demersal fish at depth 07 m (shallow waters), 12 to 17 m (intermediate waters) and 22 m (deep waters). The demersal fish distribution is linked to the spread of foods and preys and sedimentary types as well.

From a total of 131 species, 43 species formed six groups and to exhibit a wide range of distribution within the study area, and five species were restricted to the deep water (Table 6).

CONCLUSION

During the study, in the bottom trawls, 131 demersal fish species belonging to 87 genera, 61 families and 10 orders were identified. The most abundant fish was Pepetek or Ponyfishes (15860 individuals, 36.59%) and they distributed throughout the observed sites from shallow to deep as well as from brackish to salt waters, Bulu Ayam or Longfin Anchovy (7520.0 individuals, 17.35%) and Gulamah or Croakers (7310.0 individuals, 16.86%). Based on the CCA, Herrings, Croaker, Longfin anchovy, Anchovy, Ditchelee, Cardinalfish and Sailfin perchlet had strongly negative correlation with salinity, distance, water depth, turbidity and transparency. Meanwhile Black Kingfish (Cobia), Bigeye, Goatfish, Threadfin bream, Sylver biddy, Flutemouth and Moonfish were strongly and positively correlated with the environmental factors. Thus, members of the first family groups were distributed approaching the coastline, while the second ones tended to be away from the coastline.

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