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Investigation on Fish Assemblages around Cooling Water System Outlet in the Coastal Water of Bontang City, East Kalimantan

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I. Introduction

Bontang City geographically stretches between 117°23' and 117°38' E and 0°01' and 0°12' N, and lies between Mahakam Delta and Sangkulirang Bay, East Kalimantan (Figure 1). Defined as a centre for petrochemical industries receiving raw gas materials by piping from oil and gas exploitation in the Mahakam Delta, the coastal zone of Bontang City continuously transforms with new constructions such as industrial plants, reclamation, ports, and channel dredging. Newell (1998) reported that dredging and land reclamation disturb benthic communities, and as much as 30% of total fisheries yield to man is derived from benthic resources including demersal fishes. The development of ports and fisheries harbours also involve dredging and disposal activities to maintain the required depths for navigation (Kudale 2010, Commision 2007 and Commission, 2009). Some coastal water areas in Bontang City accomodate waste hot water released from cooling water system outlets of some chemical companies. This heated water carrying much thermal energy may greatly affect on physical, chemical and biological characteristics of water. Hot water flowing from the outlets is already subject to the rising of sea water temperature in Bontang City and able to harm fishes. Since very limited information is available on fish living around the areas, fish species and their asssemblages are urged to investigate.

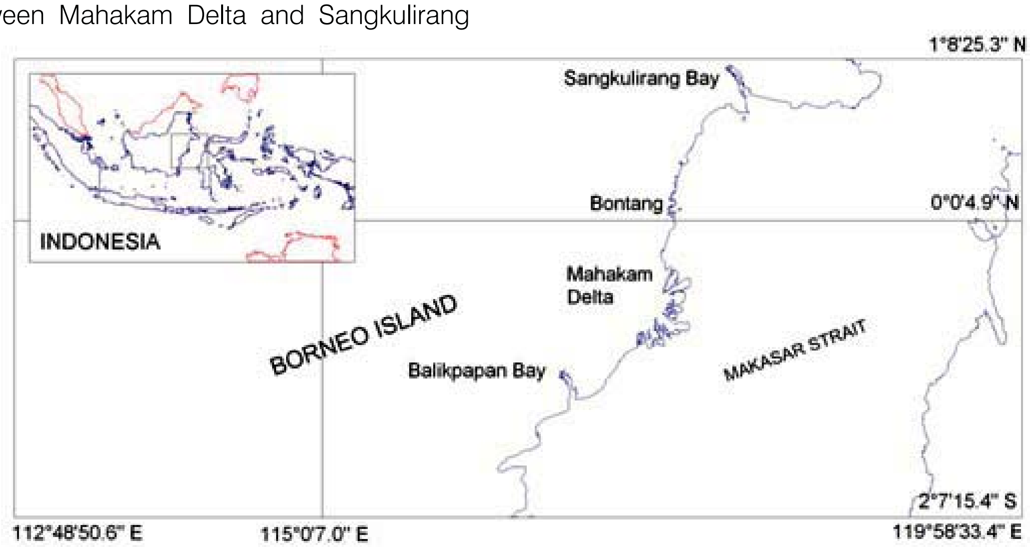

Figure 1 : Map showing location for the investigation of fish species and their assemblages in Bontang City, East Kalimantan

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The investigation aimed at identifying fish species and studying fish community structure and their assemblages in waters around the outlets. Further, fishes sampled from the mouth of outlet and inlet were also observed.

II. Materials and Methods

The investigation was undertaken in January and February 2013. Fishes samples were collected from water around the outlet of a methanol industry (PT Kaltim Methanol Industri) in Bontang City. The water is a dredged channel with approximately 400 m width and 10 m depth. In January 13th a bottom minitrawler sizing 11 m x 1.25 m equipped with a net of 12 m long having mesh size of 1.25 inches at front and 1.5 m long as cod end having mesh size of 1.0 inch at end was used to perform fish sampling in spring tide. Another fish sampling was conducted in neap tide in the following month on February 5th. Limited towing time 15 to 20 minutes was decided to avoid net damage due to sharp hard substrate. Samplings were done between 150 m going west and 200 m going east from the outlet. Geographic positions of net setting and hauling were recorded by GPS Garmin 60 CSx. Fish samples were also taken at the mouth of outlet and water intake by angling using hook #7 and nylon line 0.33 mm. Live bait 3 to 4 cm of small shrimps *Metapenaeus* sp was used. To obtain the data of sea surface tempetaure and salinity in sampling area, three 500 m line transects having eight to 11 observed points each were constructed with certain angle from the outlet. The interval distance between observed point was 50 m. Sea surface temperature and salinity were measured using water checker Horiba U-50 series.

During investigation, hydrographic aspects such as tide and water depth including water current were surveyed using tidal scale pole, echosounder GPSmap 2108 Garmin and Braystoke BFM001 current meter respectively. Tide and tidal water current were observed every 30 minutes in spring tide (Januari 12th and 14th to 15th) and in neap tide (February 4th to 6th). Sounding water depth was conducted on January 12th. Data of sea surface temperature and salinity were analyzed by descriptive statistics using SPSS version 15. Software of PAlaeontological STatistics PAST version 3 was also used to describe fish community structure through index of diversity including dominancy and Margalef richness. Catch per unit effort CPUE was used to obtain fish density (Can *et al.*, 2005). Fish species were identified according to Anam and Mostarda (2012), Peristiwady (2006), Allen (2000), and Masuda et al. (1975), while fish sample photographs were documented using digital camera of Nikon Coolpix AW100.

III. Results and Discussion

a) *Environmental Factors*

Since physical, chemical dan hydrographic conditions in waters may influence a distribution pattern of fish (Hsieh, 2012), some environmental factors measured during investigation in the water around outlet are described in Table 1.

Table 1 : Sea surface water temperature and salinity measured in water around the outlet of a methanol industry in Bontang City, East Kalimantan

	Temperature (°C)			Salinity (‰)		
	Spring tide		Neap tide	Spring tide		Neap tide
	HWL	LWL		HWL	LWL	
Numer of data (n)	29	29	29	29	29	29
Distribution	32 to 40	31 to 41	32 to 40	32 to 35	31 to 34	28 to 31
Frequency	36 (12)	35 (10)	34 (9)	34 (20)	32 (15)	30 (18)
Range	8	10	8	3	3	3
Mean	35.76	34.69	34.66	33.86	32.31	30.14
Variance	3.19	4.29	2.73	0.98	0.51	0.48
Standard Deviation	1.79	2.07	1.65	0.99	0.71	0.69

Notes : HWL= high water level, LWL= low water level. Number in parenthesis shows the frequency.

Sea surface water temperature in spring tide both at HWL and LWL tended to be fluctuated as shown in the above table. The most frequency of sea water temperature during the investigation occurred at 35 to 36°C. However, the water in the investigation area in general exhibited marked extreme water temperature exceeding 5°C of normal limit, while in neap tide it appeared approximately 34°C. The rise and fall of sea surface monitored for about 73.5 hours during spring tide and 50 hours during neap tide showed a difference pattern (Figure 2). During neap tide, the HWL and LWL were occurring almost at similar level in several days. This tide enabled sea water to mix more with the water from the outlet and lead to sea water temperature degradation. Theoritically, young fish can survive in water 2°C warmer than the maximum temperature adults can tolerate (Moyle and Cech, 2000). While Steady et al. (2011) suggests the maximum allowable temperature uplift is between +2°C and +3°C.

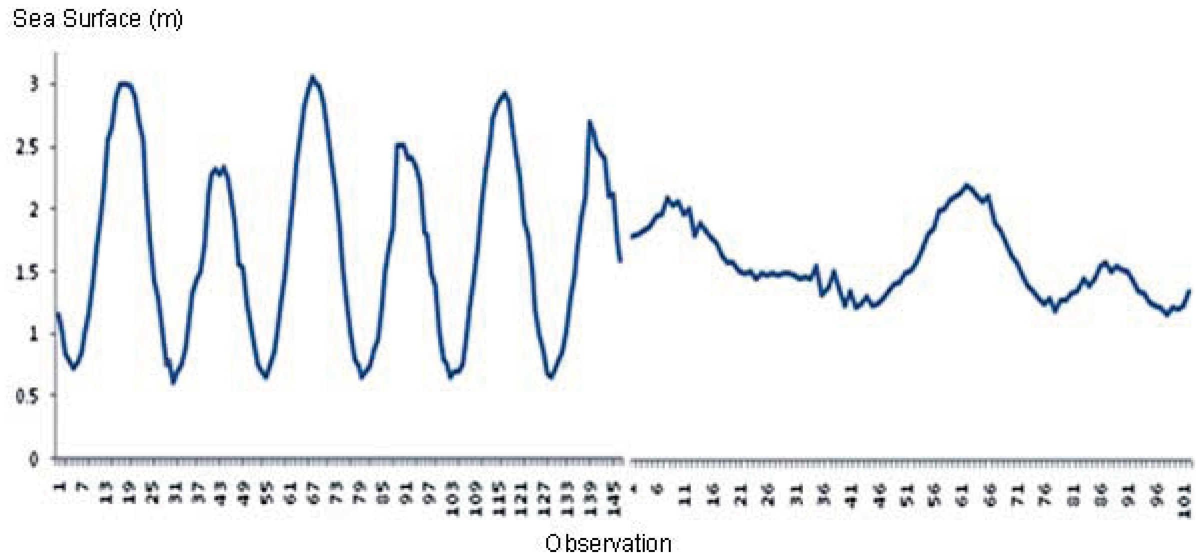

Figure 2 : The rise and fall of sea surface at the investigation site during spring and neap tide (left and right) in Bontang City, East Kalimantan

Salinity distribution in spring and neap tide ranged from 31 to 35^0/oo and 28 to 31^0/oo respectively. The salinity of 34^0/oo was the most concentration showing within the normal limit. The salinity concentration in neap tide was much more less than in spring tide. During the investigation, the area was rained twice and predicted to have affected to salinity. Hydrographic surveying without measuring tides directly is one of many uses (Federation Internationale Geometre, 2013). For the fish species investigation purpose, the survey was carried out with directly measuring tides. It obtained 1,158 water depth points and the deepest water depth measured was 13.7 m. Using the tidal range as a correction factor, the water depth for three levels based on tidal cycles is presented in the following table.

Table 2 : Water depths at the investigation site measured during hydrographic survey based on tidal cycles

	Tidal Cycle		
Vertical Surface (m)	Spring Tide	Neap Tide	Δd
Range of tidal level	-2.05	-1.03	-1.02
High Water Level	-14.28	-13.06	-1.22
Low Water Level	-12.03	-12.03	0.00
Mean Water Level	-13.05	-12.55	-0.50

As it is very important to fish and related to fish distribution, water current was observed at three water columns accordingly. The result of measurement is presented in Table 3 below.

Table 3 : Ranges of water currents (m s^{-1}) measured at three water columns in investigation site

	Surface Water (0.2d)	Mid Water (0.6d)	Bottom Water (0.8d)
Observation Hour	Spring Tide (Jan 12 and 15, 2013)		
10 am to 18.30 pm	0.031 to 0.086 (n=18)	0.031 to 0.149 (n=18)	0.038 to 0.101 (n=18)
00 am to 08.30 am	0.031 to 0.081 (n=17)	0.028 to 0.101 (n=17)	0.031 to 0.081 (n=17)
	Neap Tide (Feb 04 and 05, 2013)		
9.30 am to 18.30 pm	0.041 to 0.101 (n=18)	0.033 to 0.081 (n=18)	0.036 to 0.068 (n=18)
00.00 am to 16.00 pm	0.033 to o.081 (n=33)	o.036 to 0.091 (n=33)	0.033 to 0.058 (n=33)

A recent investigation on hydrographic aspects of fish trap "Julu" fisheries using a tidal water current, the maximum during spring and neap tide was observed 1.48 and 0.78 m s^{-1} respectively (Suyatna, et al., 2012). Sepa (2006) identified that tidal current of 0.70 m s^{-1} belongs to a strong current. Thus the water currents measured at investigation site were categorized as weak currents. It was probably because the site physically includes as a semi-closed water.

b) Number of Species, Composition and Fish Densities

During investigation, a total of 5670 fishes was caught from the water around the outlet of a methanol industry. Of all fishes, 5164 individuals resulted from bottom minitrawl sampling consisted of 40 different fish species and 19 families. The other 560 individuals caught with angling covering 37 different species belonging to 12 families (Table 4 and 5).

Table 4 : List of fishes caught from all bottom minitrawl samplings during spring and neap tide

Common name	Species name	Samp size	Spec num	Length (cm) Min	Length (cm) Max	Weight (g) Min	Weight (g) Max
Snappers (Lutjanidae)	: *Lutjanus* sp	5	4	4	11.2	1.1	21.9
Groupers (Serranidae)	: *Epinephelus* sp	3	3	10.5	29	16.3	306.6
	: *Cephalopholis* sp	7	2	4	18.5	2	76.3
Rabbitfish (Siganidae)	: -						
Surgeonfish (Acunthuridae)	: -						
Spotted Scats (Scatophagidae)	: -						
Sea Breams (Nemipteridae)	: *Nemipterus* sp	64	1	6.9	20.5	3.6	139.5
	:*Pentapodus* sp	2	2	7		12	
Emperors (Lethridae)	: -						
Damselfish (Pomacentridae)	: -						
Trevallies (Carangidae)	: *Carangoides* sp	1	1	7		5.4	
	: *Alectes* sp	2	1	2.5	6	0.6	4.1
Queenfish (Carangidae)	: *Scomberoides* sp	2	1	4.9	10	0.4	6.7
Herring (Elopidae)	:-						
Fusilier (Caesionidae)	: -						
Silver Biddy (Gerreidae)	: *Gerres* sp	105	3	6	19.4	1.5	54.1
Ponyfishes (Leiognathidae)	:	4752					
	: *Leiognathus* sp	1409	3	3,0	14.3	0.2	35.7
	: *Gazza* sp	3170	2	4	8	0.9	8.9
	: *Secutor* sp	173	2	6.2	10	2.8	11.1
Goatfishes (Mullidae)	: *Upeneus* sp	121	2	5.4	13	0.9	13.9
Lizardfish (Harpodontidae)	: *Saurida* sp	28	1	6.5	25.6	1,0	134.9
Flathead (Platycephalidae)	: *Platycephalus* sp	14	1	8	31	2.1	200.3
Perchlet (Chandidae)	: *Ambassis* sp	2	1	5	6	0.9	1.8
Pufferfish (Tetraodontidae)	: *Arothron* sp	7	1	4.5	18.5	1.6	122.2
Cardinalfish (Apogonidae)	: *Apogon* sp	16	1	5.5	9	1.6	5.5
Cutlassfish (Trichiuridae)	: *Trichiurus* sp	4	1	15.7	81,0	10,0	516.8
Flounder (Bothidae)	: *Pseudorhombus* sp	19	1	5.2	6.5	0.5	5.9
Anchovy (Engraulidae)	: *Stolephorus* sp	1	1	8		3	
Razorfish (Centriscidae)	: *Centriscus* sp	1	1	6.5		0.3	
Northern Pilchard (Clupeidae)	: *Amblygaster* sp	5	2	8.1	10	7.1	10.8
Ray (Dasyatidae)	: *Dasyatis* sp	2	1	10	51	9.1	516.4
Scorpionfish (Scorphaenidae)	: *Pterois* sp	1	1	11.5		14.9	
		5164	40				

Table 4 shows in majority the size distribution of fish indicated juvenile stage and larvae such as trevallies (*Carangoides* sp, *Alectis* sp), groupers (*Epinephelus* sp, *Cephalopholis* sp) and snappers (*Lutjanidae* sp). These fishes nursed and fed in the water around the outlet of investigation site. Blaber (2000) stated that estuaries and shallow waters throughout the world play a major role as nursery areas for a wide variety of organisms. *Leiognathus* sp, *Secutor* sp and *Gazza* sp belonging to the family Leiognathidae were recorded as the most abundant species (Figure 3), followed by Goatfish *Upeneus* sp (Mullidae), Silver biddy *Gerres* sp (Gerreidae) and Sea breams *Nemipterus* sp (Nemipteridae). These fishes were categorized as demersal fishes and having wide distribution on the basis of depth (Suyatna et al, 2010). According to the diversity index, dominance species occured at LWL of spring tide. While Shannon index showed various fish species appeared at HWL of both spring and neap tide. Species richness Margalef increased at HWL of spring and neap tide (Table 6).

Table 5 : List of fish groups caught by angling from mouth of the outlet and intake water of methanol industry

Fish group		Sample	Species	Length weight distribution			
		size	number	Length		Weight	
Common name	Species name			Min	Max	Min	Max
Snappers (Lutjanidae)	: Lutjanus sp	252	12	9.2	28	13.5	207
Groupers (Serranidae)	: Epinephelus sp	1	1	14	-	39.5	-
	Cephalopolis sp	7	2	12.1	20	26.2	141
Rabbitfish (Siganidae)	: Siganus sp	3	3	21.5	-	179.5	-
Surgeonfish (Acanthuridae)	: Acunthurus sp	2	1	31	-	589.8	-
Spotted scat (Scatophagidae)	: Scatophagus sp	1	1	16.5	-	159	-
Sea Breams (Nemipteridae)	: Nemipterus sp	9	1	12.5	19.6	27.4	115
	Scolopsis sp	26	2	9	18	11	46
	Pentapodus sp	28	3	6	18.5	2.6	18
Emperors (Lethrinidae)	: Lethrinus sp	26	2	8.7	21.5	12.5	162
Damselfish (Pomacentridae)	: Abudefduf sp	4	1	13.5	16.5	47.3	100
Trevalies (Carangidae)	: Carangoides sp	83	4	15	26.6	48.5	321.3
	Caranx sp	53	1	14	25	41.6	197.6
Herring (Elopidae)	: Megalops sp	2	1	20	41	231.8	590.8
Fusilier (Caesionidae)	: Caesio sp	12	1	16.2	23	53.8	10
Silver biddy (Gerreidae)	: Gerres sp	2	1	15	-	56.6	-
		510	37				

Table 6 : Indices of diversity, dominance and margalef richness of fish sampled during spring and neap tide in water around the outlet

	Spring tide						Neap tide		
	Sampling at HWL			Sampling at LWL			Sampling		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Taxa	22	16	13	10	16	11	15	18	12
Individuals	1108	130	2749	364	530	284	30	101	112
Shannon	1.101	2.14	0.9354	0.5371	0.6871	0.8282	2.478	1.569	1.623
Dominance	0.5915	0.1651	0.4577	0.8039	0.7557	0.6552	0.1022	0.3387	0.2709
Margalef	2.996	3.082	1.515	1.526	2.391	1.77	4.116	3.684	2.331

Angling at mouth of the outlet and water intake yielded the number of different fish species as mentionned in the Table 5. Five of 12 families consisting of Siganidae, Acanthuridae, Scatophagidae, Elopidae and Caesionidae were not observed from all samples taken by minitrawl. Acanthuridae as herbivorous fishes

(Navaro and Vivien, 1981) resembles the deeper bodied siganids in general shape and often occur together. Members of Scatophagidae are the euryhaline fishes commonly found in estuaries and harbours. Elopidae and Caesionidae commonly distributed in coastal waters, members of Elopidae are sometimes travelling in schools in open water (Matsunuma, 2011). The most common fish species caught at water intake was the member of Lutjanidae, *Lutjanus* sp composed of 12 species and family Carangidae i.e *Carangoides sp* and *Caranx sp* (Figure 4 and 5). Meanwhile, members of Nemepteridae such as *Pentapodus* sp were easy to fish at mouth of hot water outlet (± 40°C) very close to the outlet (Figure 4). These species are common inhabitants of sand-rubble bottoms near coral and rocky reefs (Allen and Erdmann, 2009).

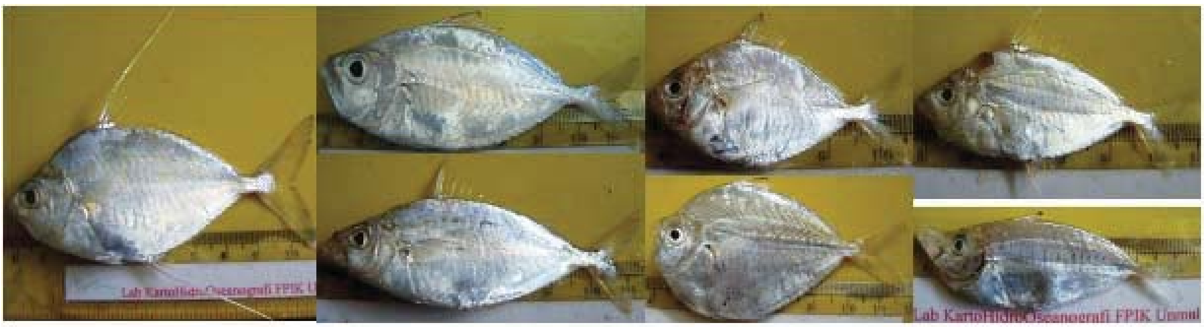

Figure 3 : Members of family Leiognathidae observed during investigation. At left *Leiognathus fasciatus,* First row from left *Gazza minuta, L. splendens, L. nuchalis*. Second row from left *G. minuta, Secutor ruconius, S. indicus* (All photos were taken at site)

Figure 4 : Nine of twelve members of family Lutjanidae observed during investigation. First row from left *Lutjanus decussatus, L. johnii, L. fulvus,* Second row from left *L. lineolatus, L. ruselli, L. spilurus,* Third row *L. vitta, L. fulviflamma, L. rufolineatus* (All photos were taken at site)

Figure 5 : Members of family Nemipteridae observed at mouth of the outlet. From left *Pentapodus setosus, Scolopsis ciliatus, P bifasciatus* (All photos were taken at site)

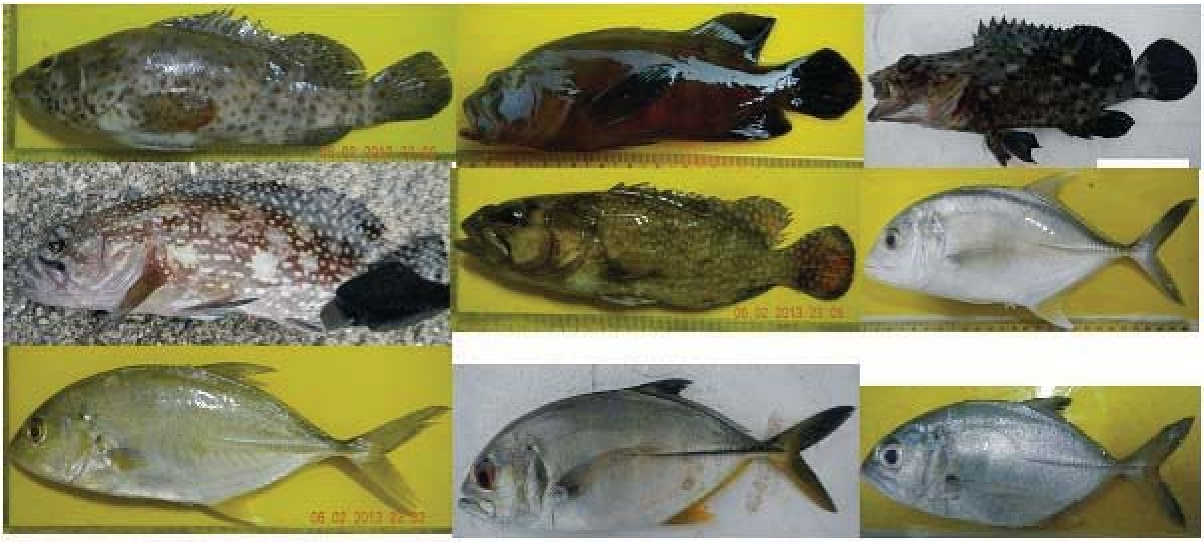

Figure 6 : Members of family Serranidae and Carangidae observed at water intake. First row from left *Epinephelus coioides, Cephalopholis polycentron, E. Rivulatus*. Second row from left *C. sonnerati, E. corallicola, Carangoides ferdau*. Third row *Carangoides bajad, Caranx sexfasciatus, Carangoides coeruleopinnatus* (All photos were taken at site)

Acoording to the analysis of CPUE, the significant fish density was dominated by four families in which members of family Leiognathidae showing the most populated fish (Table 6). Suyatna et al (2000) found out that Leiognathidae was the most important group of fish in Mahakam Delta.

Table 6 : Significant fish density (ind/km^2) in water around the outlet based on family and tidal cycle

	Spring tide		Neap tide
	HWL	LWL	
Leiognatidae	328356	99200	16534
Mullidae	9067	1688	0
Gerreidae	6756	1689	889
Nemipteridae	4356	622	711
Apogonidae	978	178	267

As seen in the above table, fish density was greatly affected by tidal cycle, and fishes tended to enter the water around the outlet together with sea rise. At low tide and neap tide fish density decreased.

IV. Conclusion

The assemblage of fish species in water around the outlet, at mouth and inlet differed. During the investigation, 57 different species were identified from 5670 fishes. Members of family Leiognathidae were the most common fish species observed in water around the outlet. While members of family Lutjanidae were assemblaged at water intake and certain species of Nemipteridae seemed to withstand temperature pressure. Fishes assemblage was greatly influenced by tidal cycle. Highest shannon and margalef index occurred in neap tide, while highest dominance index was observed at LWL in spring tide. The water condition around the outlet was included as relatively good indicated by the number and species of fish caught.

V. Acknowledgement

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