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Fish community structure in high water temperature around Bontang Industrial Estate, East Kalimantan, Indonesia

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Abstract. *Suyatna I, Sidik AS, Almadi FA, Rizal S, Sukarti K. 2016. Fish community structure in high water temperature around Bontang Industrial Estate, East Kalimantan, Indonesia. Biodiversitas 17: 558-564.* We have conducted studies on fish community and their physical and chemical properties of coastal waters in the work area of the industrial estate from 2012 to 2014. At least four industries are known to use the coastal waters in cooling their processing equipments, the hot wastewater is then discharged back into the coastal environment. The current study reports the result of a survey undertaken around the work area of PT Blackbear Resources Indonesia. The result showed that high water temperature and tidal fluctuation are affecting the fish community in the area. By sampling results, during HWL of the spring tide at the maximum of water temperature of 35,9^{o}C, fish were the most populated and found 5999 ind. or 72,4% of the total number of 8291 fish. During LWL of the same tide type fish were observed 1931 ind (23.3%) and during the neap tide 361 ind (4.3%) at the maximum of water temperature of approximately 40^{o}C, this ambient showed that the fish population drastically change in number and the environment became undesirable.

Keywords: Bontang, industry, fish community, high water temperature, leiognathids

INTRODUCTION

Geographically, Bontang City stretches between 117^{o}23' and 117^{o}38' E and 0^{o}01' and 0^{o}12' N, and is located between the ecosystems of Mahakam Delta and Sangkulirang Bay of East Kalimantan, Indonesia. Defined as a centre for petrochemical industries, raw materials for such industries are transported through pipes from Oil and Gas exploitation companies in the Mahakam Delta and Balikpapan. The coastal zone of Bontang City is continuously transformed with new constructions such as industrial plants, land reclamation, ports, and channel dredging (Suyatna and Sidik 2013). In the process of petrochemical production, the industry uses sea water to cool their processing machines and utilities in a cooling water system, and discharges the hot waste water to the sea environment. Cooling water system applied in the industrial processes in Bontang is in two forms i.e. once through system or blowdown cooling system. Once through system usually discharge huge volume of 'still hot' wastewater to the environment around or not far from the outlet, sea water temperature was recorded high. Blowdown cooling system, different from once through system, discharges only small volume of waste water, since the sea water used in the system is reused by recirculation. A higher water temperature accelerates both biological and chemical processes in the sea, and reduces the solubility of dissolved oxygen in the water (Boyd 1995). This can affect the physiological life of fish such as growth, reproduction and distribution. However, the environmental factors change according to photoperiod, tidal cycle and climatic change (Lam et al. 2005). Hot water flowing from the outlet of industries has already been recorded to be responsible for the rising of sea water temperature around an industrial estate and may harm fish in Bontang.

A study to explain the actual fish composition structure of a community is required, since the mentioned industries are not only responsible for the increase in sea water temperature but also had potential of causing chemical pollution, thereby, altering the population and species of the fish community.

The study was carried out to understand (i) the community of fish species, (ii) the most fish population and (iii) the physical and chemical properties of sea water around the work area of PT Blackbear Resources Indonesia (PT BBRI).

MATERIALS AND METHODS

The study was undertaken in August 2013 and May to June 2014 in Guntung village, Bontang Utara Subdistrict, Bontang City, East Kalimantan, Indonesia around the work area of PT BBRI (Figure 1). Even the cooling water system of PT BBRI is blowdown cooling system; the sea water area surrounding this industry is also influenced by wastewater from other outlets from once through system of the neighboring industries.

Hydrographic parameters such as tide, water depth and current velocity were surveyed using tidal pole, echo-sounder GPSmap 2108 Garmin and Braystoke BFM001 Current Flow Meter, Valeport Marine Scientific Ltd made in UK 1985. Tide was observed manually in every 30 minutes. Physical and chemical factors such as temperature,

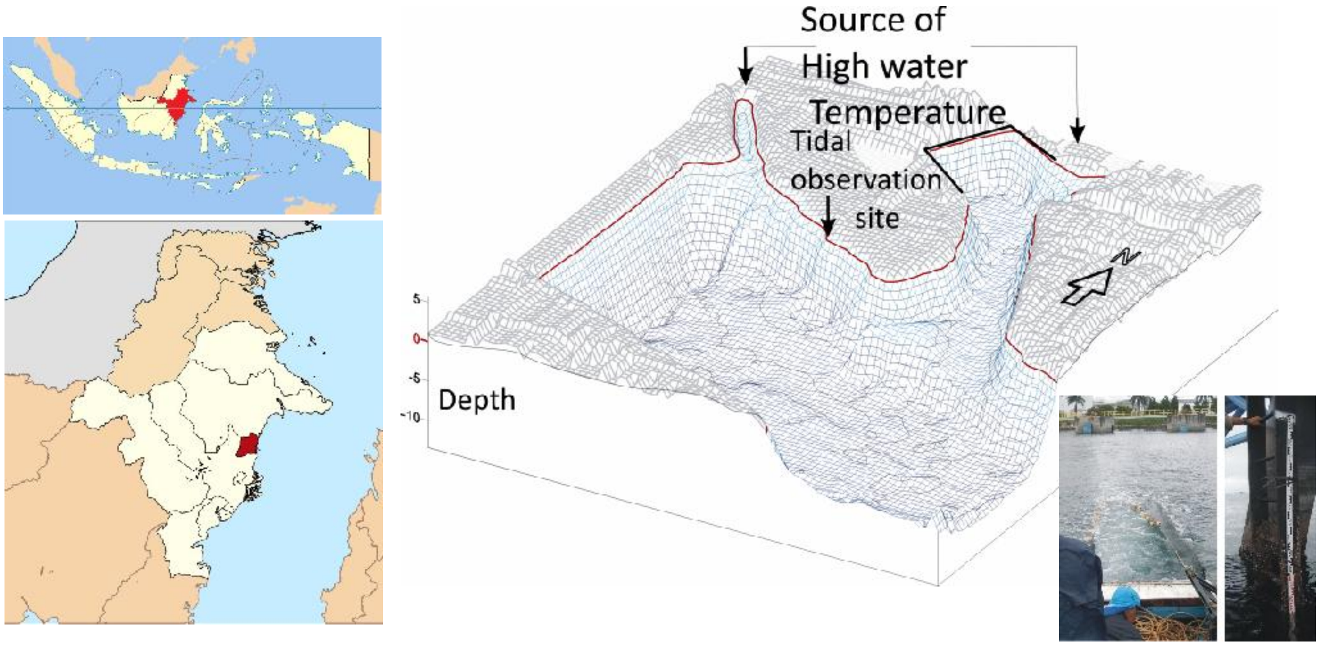

Figure 1. Study site in Guntung village, North Bontang Subdistrict, Bontang City, East Kalimantan, Indonesia and partly bottom profile, fish sampling gear and tide pole.

salinity, pH and dissolved oxygen (DO) was taken approximately every 25 m interval using Water Checker Horiba U-50 series starting from the outlet extending 250 m (three directions) with angle of 37.5^o. Fish were sampled during high water level (HWL) and low water level (LWL) in spring tide as well as during neap tide three times each, using a trawl net with size of 10 m length and performed by a motorized boat to tow the net. Trawl net was towed approximately 30 minutes to avoid torn net due to hard substrate (area of reefs dredged). Small fish were weighed with a digital precision balance ACS AD-300i (capacity: 300 g x 0.01 g). Fish identification was referred to to the field manual according to Anam and Mostarda (2012), Matsunuma et al. (2011), Allen (2000), Peristiwady (2006), and Masuda et al. (1975), Chakrabarty et al. (2008), Chakrabarty et al. (2010a), Chakrabarty and Sparks (2008), Seah et al. (2009) and Chakrabarty et al. (2010b). The swept area was applied to find fish density (Can et al. 2005): a = *D.h.X*, where h is the length of the head-rope, D is the cover of distance. X is the fraction of the head-rope length. The value of X varies from 0.4 to 0.66 (commonly used 0.5). Garmin GPSMap 60CSx was used to record the geographic position of sampling sites and to determine the distance. Diversity index (Shannon Winner_H', Dominancy and Margalef richness) of fish was analyzed using software of the PAlaentological Statistics 'PAST' version 3.05 (Hammer 2015).

RESULTS AND DISCUSSION

Physical and chemical properties

The physical, chemical and hydrographic conditions of waters influencing fish in their habitats were studied by Kane et al. (2010), Madeira et al. (2012) and Hsieh (2012) and therefore some properties of water in the study area were measured. After measuring water depth and corrected by water level position that resulted from tide observation during 164.5 hours or seven days (Table 1), of the 3476 data recorded, sounding depth showed the maximum water depth of -16.39m (actual depth) and -13.78m (chart depth) and bottom profile. The bottom profile lying in long, narrow and deep waters is shown in Figure 1.

Regular changes of water level were known as two low tides and two high tides in 24 hours and tidal cycle duration at the location was recognized to occur between 5.5 and 8.0 hours and this type of tide according to Hicks (2006) is classified as mixed semidiurnal. As tide, local current velocities were monitored to describe water dynamics. Currents in the coastal area can have various origins such as tides and temperatures (Santema 1964). As seawater is heated molecular activity increases and thermal expansion occurs, reducing the density, different density of water causes water current. The velocities are commonly in km, m or cm per second (Harris 1978). In general, the result of the current velocity measurement is presented in Table 2. Suyatna et al. (2012) monitored current velocities 24 hours continuously in estuarine waters (at surface, middle and the bottom) during spring tide using the same current meter, and the current velocities ranged from 0.117 to 0.765 m/sec in day time and from 0.704 to 1.467 m/sec at night. Compared to this result, the current velocities around the study area were very weak.

The result of the physical and chemical properties measured during the study is shown in Table 3. The table shows that the highest temperature (39.6^{o}C) and salinity (35 ‰) were recorded around the outlet, and they indicate a gradual decrease according to the distance from the source of high water temperature. Temperature, along with salinity affects almost every physical property of seawater (Canadian Council of Ministers of the Environment, 2007) including pH, DO and solubility of gases (FGDC 2012). The CTMax from all estuarine and coastal fish species is reported between 36.4^{o}C and 37.9^{o}C (Murchie et al. 2011), 27.4^{o}C and 38^{o}C and the elevation of 2^{o}C may cause stress of fish (Madeira et al. 2012). Contamination resulting to fish mortality has not been recorded in this area in past two decades. However, the non-toxic algal bloom was observed many times along the coast of Bontang, this can be either a natural phenomenon (Anderson 2005) or link to excessive pollution inputs such as nutrients (Anderson et al. 2002) and change of sea temperature (Silk 2015).

The salinity measured in the study area ranged from 28 to 35 ‰, and this range belongs to offshore waters when referring to Nordlie and Haney (1999) who classify coastal waters salinities to be between 16 and 32 ‰ and offshore waters 25 to 35 ‰. The pH values from all observations in the area were most similarly, ranging from 7.71 to 8.19. The growth of fish is greatly affected by pH (Majeed et al. 2015), and the ideal water pH for biological productivity is from 7.0 to 8.5 (Kane et al. 2010). Furthermore, the measured DO ranges from 4.89 to 5.00 mg/L and shows that the farther the distance from the outlet, the higher the concentration. Most species of fish are distressed when DO falls to 2 to 4 mg/L (Francis-Floyd 2014) and the minimum DO requirement for tropical marine fish is 5 mg/L, or 75% saturation (Mallya 2007).

Table 1. The result of tide observation in the study area

Date	Duration (hour)	Water level observed First (m)	Last (m)	Lowest (m)	Highest (m)	Tide range (m)	Tide type
2 to 4 August 2013	52.0	2.32	2.52	1.96	3.31	1.35	Spring tide
22 to 24 May 2014	47.5	1.30	1.75	1.07	1.87	0.80	Neap tide
1 to 4 June 2014	65.0	1.28	1.05	0.70	2.53	1.83	Spring tide
7 days	164.5					2.61	

Table 2. The result of current velocity measurement in the study area

Date	Duration (hour)	'n' data	Current velocity (m/sec) Surface water (0.0m)	(cm/sec)	Tide type and Measurement time
2 to 4 August 2013					Neap tide
11.00 am to 23.00 pm	12.5	26	0.033-0.036	3.3-3.6	Every 30'
00.00 am to 23.30 pm	24.0	48	0.033-0.038	3.3-3.8	Every 30'
00.00 am to 15.30 pm	15.5	31	0.033-0.039	3.3-3.9	Every 30'
1 to 4 June 2014					Spring tide
15.00 pm to 03.00 am					
Station A	12	13	0.036-0.115 at 0.0m	3.6-11.5	Hourly
		13	0.038- 0.163 at -4.0m	3.8-16.3	Hourly
		13	0.038-0.117 at -9.0m	3.8-11.7	Hourly
Station B	12	13	0.157-0.333 at 0.0m	15.7-33.3	Hourly
		13	0.053-0.291 at -0.5m	5.3-29.1	Hourly
		13	0.053-0.269 at -1.0m	5.3-26.9	Hourly

Table 3. The mean concentration of some surface water quality parameters measured at the spring tide (high and low) and the neap tide during the study period.

Distance from outlet (m)	Temperature (^{o}C) Spring	Neap	Salinity (‰) Spring	Neap	pH Spring	Neap	DO (mg/L) Spring	Neap
25	35.9	39.6	30	35	8.01	8.07	4.90	5.49
50	34.2	35.0	31	35	7.98	8.06	5.04	5.47
75	33.9	34.4	31	35	7.98	8.13	4.91	5.59
100	33.8	35.6	30	35	8.01	8.09	4.89	5.55
125	33.8	34.4	30	35	8.02	8.17	5.06	5.47
150	34.0	35.6	30	35	7.97	8.09	5.26	5.61
175	34.1	34.6	30	35	7,82	8.19	5.28	5.56
200	34.5	36.3	31	35	7.71	8.10	5.37	5.63
225	35.3	36.4	28	33	7.91	8.09	4.98	5.65
250	35.2	37.0	29	33	7.95	8.15	5.22	5.61

Fish composition, diversity and density

Fifty-three (53) species belonging to 7 orders, 22 families, 32 genera from 8291 fish caught were identified, and fishes were dominated by the members of order Perciformes (Figure 2 and Table 4). The overall difference in the size distribution of fish was not significant, and based on fish species most of them were categorized as young fish as shown in Table 5.

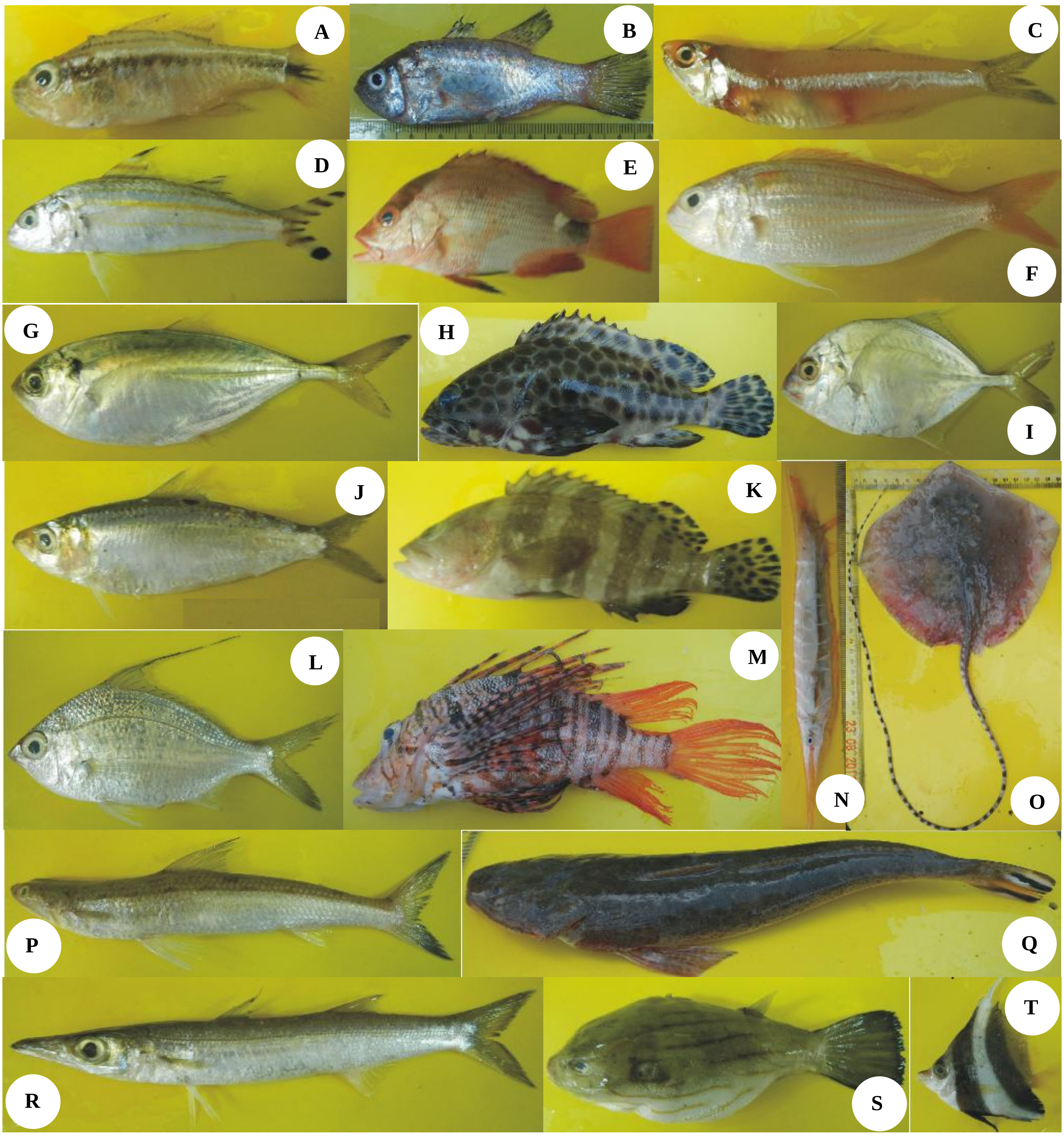

Figure 2. Some fish species other than leiognathids caught during the study. A. *Apogon kiensis*, B. *A. poecilopterus*, C. *Stolephorus indicus*, D. *Upeneus vittatus*, E. *Lutjanus erythropterus*, F. *Nemipterus hexodon*, G. *Megalaspis cordyla*, H. *Epinephelus megachir*, I. *Ulua mentalis*, J. *Sardinella fimbriata*, K. *E. sexfasciatus*, L. *Gerres filamentosus*, M. *Pterois russelli*, N. *Centriscus scutatus*, O. *Himantura gerrardi*, P. *Saurida tumbil*, Q. *Platycephalus endrachtensis*, R. *Sphyraena obtusa*, S. *Arothron manillensis*, T. *Heniochus diphreutes*.

Table 4. Length-weight size distribution and mean individual number of fishes caught

No	Common name	Family	Genus	Size distribution		Total number
				Length (cm)	Weight (g)	
HWL in spring tide, four samplings						
1	Ponyfish	Leiognathidae	a. *Leiognathus* (3)	3.0-14.3	0.2-35.7	1997
			b. *Secutor* (1)	3.0-14.3	0.2-35.7	3433
			c. *Gazza* (2)	3.7-8.0	0.8-8.9	262
2	Silver biddy	Gerreidae	*Gerres* (2)	5.0-9.1	1.7-11.9	75
3	Goatfish	Mullidae	*Upeneus* (2)	5.4-8.8	2.2-22.5	112
4	Lizardfish	Harpodontidae	*Saurida* (1)	7.5-24.0	3.0-104.0	15
5	Threadfin beam	Nemipteridae	*Nemipterus* (3)	6.9-20.5	3.6-139.5	34
6	Cardinalfish	Apogonidae	*Apogon* (3)	5.7-9.0	1.6-4.6	13
7	Flathead	Platycephalidae	*Platycephalus* (2)	9.5-16..5	2.1-28.7	10
8	Flounder	Bothidae	*Pseudorhombus* (2)	5.2-6.5	1.0-2.1	9
9	Stingray	Dasyatidae	*Dasyatis* (1)	33	77.7	4
10	Grouper	Serranidae	*Cephalopholis* (1)	10.5-22.5	15.8-137.0	3
11	Grouper	Serranidae	*Epinephelus* (3)	13.5-26.5	16.9-147.0	3
12	Puffer	Tetraodontidae	*Arothron* (2)	4.5-16.0	1.6-122.2	6
13	Hairtail	Trichiuridae	*Trichiurus* (1)	15.7	1	3
14	Sardinella	Clupeidae	*Amblygaster* (2)	8.1-10.0	7.1-9.1	5
15	Queenfish	Carangidae	*Scomberoides* (1)	10	6.7	3
16	Snapper	Carangidae	*Lutjanus* (4)	6.0-8	2.0-4.9	6
17	Trevally	Carangidae	*Alectis* (1)	18.5	72	6
				Total individuals:		5999
LWL in spring tide, three samplings						
1	Ponyfish	Leiognathidae	a. *Leiognathus* (3)	2.7-13.0	0.3-23.2	181
			b. *Secutor* (1)	4.5-13.0	0.4-23.2	1517
			c. *Gazza* (2)	2.7-6.4	0.3-4.5	143
2	Silver biddy	Gerreidae	*Gerres* (1)	5.5-8.5	1.0-8.6	26
3	Goatfish	Mullidae	*Upeneus* (2)	5.4-10.0	1.6-13.9	24
4	Lizardfish	Harpodontidae	*Saurida* (1)	7.0-25.6	1.0-134.9	7
5	Threadfin beam	Nemipteridae	*Nemipterus* (2)	9.3-19.0	1.3-89.7	10
6	Cardinalfish	Apogonidae	*Apogon* (2)	7.7-8.2	4.2-5.4	4
7	Flathead	Bothidae	*Pseudorhombus* (2)	5.9	5.9	4
8	Stingray	Dasyatidae	*Dasyatis* (1)	51	516.4	2
9	Grouper	Serranidae	*Cephalopholis* (1)	6.2-16.8	2.0-69.9	4
10	Snapper	Lutjanidae	*Lutjanus* (3)	11.2	17.2	2
11	Hairtail	Trichiuridae	*Trichiurus* (1)	25.1-81	8.4-516.8	3
12	Trevally	Carangidae	*Scomberoides* (1)	4.9	0.4	2
13	Lion fish	Scorpaenidae	*Pterois* (1)	11.5	14.9	2
				Total individuals:		1931
Neap tide, three samplings						
1	Ponyfish	Leiognathidae	a. *Leiognathus* (3)	3.5-10	0.3-16.2	135
			b. *Secutor* (1)	3.5-10	0.5-16.2	15
			c. *Gazza* (2)	4.0-5,5	0.3-2.5	130
2	Silver biddy	Gerreidae	*Gerres* (2)	4.5-10	0.9-11.1	15
3	Lizardfish	Harpodontidae	*Saurida* (1)	3.4-18.0	2.3-49.2	11
4	Threadfin beam	Nemipteridae	1) *Nemipterus* (1)	9.0-29.0	4.2-138.9	5
			2) *Pentapodus* (1)	7.0-20.0	3.2-116.9	4
5	Cardinalfish	Apogonidae	*Apogon* (1)	5.5-7.0	2.4-5.5	4
6	Glass perchlet	Channidae	*Ambassis* (1)	5.0-6.0	0.9-1.8	3
7	Flathead	Platycephalidae	*Platycephalus* (2)	8.0-31.0	10.8-200.3	7
8	Flathead	Bothidae	*Pseudorhombus* (1)	6.5	1.2	2
9	Grouper	Serranidae	*Cephalopholis* (1)	4.0-29.0	0.5-306.6	6
10	Snapper	Lutjanidae	*Lutjanus* (2)	4.0-7.0	1.1-6.6	3
11	Puffer	Tetraodontidae	*Arothron* (2)	18.5-19.0	48.3-150.0	7
12	Hairtail	Trichiuridae	*Trichiurus* (1)	53	116	2
13	Trevally	Carangidae	*Alectis* (1)	2.5-6.0	0.6-5.4	4
14	Anchovy	Engraulidae	*Stolephorus* (1)	8	0.3	2
15	Sardinella	Clupeidae	*Amblygaster* (1)	10	10.8	3
16	Razorfish	Centriscidae	*Aeoliscus* (1)	10	10.8	3
				Total individuals:		361

Note: Number in paranthesis: species number.

Table 5. Composition of community member of fish species caught from the study area

Orders	Families	Genera	Species	Environment origin (commonly found)
Perciformes	14	19	38	Demersal, pelagic, muddy, sandy, coral substrate
Scorpaeniformes	2	3	3	Demersal, muddy and sandy substrate
Clupeiformes	2	3	4	Pelagic, coastal and estuarine water
Tetraodontiformes	1	3	4	Demersal, coastal and estuarine water
Syngnathiformes	1	1	1	Demersal, seagrass meadow
Myliobatiformes	1	2	2	Demersal, muddy and estuarine water
Aulopiformes	1	1	1	Demersal, muddy and estuarine water
	22	32	53	

Table 6. The diversity indices of fishes caught around the waters of industrial estate

Diversity	Taxon	No of ind.	Dominance_D	Shannon_H’	Margalef_R
HWL (spring tide)	23	5999	0.441	1.075	1.954
LWL (spring tide)	19	1931	0.632	0.841	1.850
Neap tide	22	361	0.276	1.765	2.887

Table 7. Diversity of fishes caught around the waters of industrial estate

Tide	*Leiognathus* sp	*Secutor* sp	*Gazza* sp	Total Number	Density (ind/km^2)
HWL spring tide	1997	3433	262	5682	476,741
LWL spring tide	181	1517	143	1841	154,195
Neap tide	135	15	130	280	23,452

Leiognathids from one family were caught 7813 fish (95.1%) and the remaining from 21 families only 406 fish (4.9%). Leiognathids of three genera (*Leiognathus*, *Gazza* and *Secutor*) were composed of seven species: *Leiognathus nuchalis*, *L. splendens*, *L. fasciatus*, *Gazza achlamys*, *G. minuta*, *Secutor ruconius* and *S. indicius*. In the previous study all these leiognathids were also observed at the same place (Suyatna and Sidik 2013).

Wantiez and Kulbicki (1995) found leiognathids of soft bottom communities were the major species in density and biomass like *L. rivulatus* and *S. ruconius.* In India, pugnose ponyfish (*Secutor* sp) is one of the major by-catch composition (Muddula 2015) from the country leiognathids were known 16 species (Abraham et al. 2011), in Sri Lanka 13 species (Chakrabarty et al. 2008), in Malaysia 22 species (Seah et al. 2011) that were identified from eight or nine genera (Seah et al. 2012), at certain location of Malaysia such as the coastal waters of Pulau Sibu-Tinggi nine species (Mazlan et al. 2006), and in Thailand found in intertidal mudflats seven species (Sichum and Tantichodok 2013). In Indonesia, these fishes from various places were reported 11 species (Suyatna et al. 2010), 10 species (Wedjatmiko 2007), 20 species (Pauly 1977). The Table 6 showing a result analysis of the diversity indices of the total diversity of fishes and estimated the density of leiognathids. The value of dominance, Shannon (H’) and richness is almost similar at the high and low tide of the spring tide, but higher at the neap tide, except the dominance. This indicated no extreme difference of fish population size at the neap tide (Table 4).

The highest density of leiognathids species observed at HWL in the spring tide (Table 7) could be as a result of passive migration aiming at finding new area for feeding, at the same time water temperature that decreases at site due to dilution by sea water coming from outside (the sea) made the environment more comfortable for living. Juliani and Suyatna (2014) reported stock potency of leiognathids in waters of East Kutai district but did not mention the density.

To conclude, in high water temperature, 53 species of various fish were found. Leiognathids were the most abundance and different based on the tidal range level (spring and neap tide), from seven species belonging to three genera identified, *Secutor* sp was the largest. Around the outlet, physical and chemical water properties were in tolerable limit except water temperature.

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REFERENCES

Abraham KJ, Joshi KK, Murty VS R. 2011. Taxonomy of the fishes of the family Leiognathidae (Pisces, Teleostei) from the West coast of India. Zootaxa 2886: 1-18.

Anam R, Mostarda E. 2012. Field identification guide to the living marine resources of Kenya. Food and Agriculture organization of the United Nations, Rome.

Anderson DM. 2005. The ecology and oceanography of harmful algal blooms, multidisciplinary approaches to research and management. Intergovernmental Oceanographic Commission, Paris.

Anderson1 DM, Glibert PM, Burkholder JM. 2002. Harmful Algal Blooms and Eutrophication: Nutrient Sources, Composition, and Consequences. Estuaries 25 (4b): 704-726.

Booth D, Edgar G, Figueira W, Jenkins G, Kingsford M, Lenanton R, Thresher R. 2009. Temperate Coastal and Demersal Fish and Climate Change. In: Poloczanska ES, Hobday AJ, Richardson AJ. (eds), A Marine Climate Change Impacts and Adaptation Report Card for Australia 2009. NCCARF Publication, Broadway NWS, Australia.

Boyd CE. 1995. Bottom Soils, Sediments, and Pond Aquaculture. Chapman & Hall, New York.

Canadian Council of Ministers of the Environment. 2007. A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life. Canadian Water Quality Guidelines for the Protection of Aquatic Life, Ottawa.

Can MF, Mazlum Y, Demirci A, Aktas M. 2005. The Catch composition and catch per Unit of Swept Area (CPUE) of penaeid shrimps in the bottom trawls from Skenderun Bay, Turkey. Turkish J Fish Aquat Sci 4: 87-91.

Chakrabarty P, Amarasinghe T, Sparks JS. 2008. Rediscription of Ponyfishes (Teleostei: Leiognathidae) of Sri Lanka and the status of *Aurigequula* Fowler 1918. Cey J Sci (Bio Sci) 37 (2): 143-161.

Chakrabarty P, Chu J, Nahar L, Sparks JS. 2010a. Geometric morphometrics uncovers a new species of ponyfish (Teleostei: Leiognathidae: Equulites), with comments on the taxonomic status of *Equula berbis* Valenciennes. Zootaxa 2427:15-24.

Chakrabarty P, Sparks JS, Ho HC. 2010b. Taxonomic review of the ponyfishes (Perciformes: Leiognathidae) of Taiwan. Mar Biodiv 107-121. DOI 10.1007/s12526-010-0037-0.

Chakrabarty P, Sparks JS. 2008. Diagnoses for *Leiognathus* Lacepede 1802, *Equula* Cuvier 1815, *Equulites* Fowler 1904, *Eubleekeria* Fowler 1904, and a New Ponyfish Genus (Teleostei: Leiognathidae). American Museum Novitates. Number 3623, Washington DC.

Francis-Floyd R. 2014. Dissolved Oxygen for Fish Production. Series of Fisheries and Aquatic Sciences Department, UF/IFAS Extension, Washington DC.

FGDC [Federal Geographic Data Committee]. 2012. Coastal and marine ecological classification standard. Federal Geographic Data Committee, Washington DC.

Hammer Q; DAT Harper, PD Ryan. 2015. PAST. Palaentological Statistic Software Package for Education and Data Analysis. Palaentologia Electronica 4 (1):1-9.

Harris TFW. 1978. Review of coastal currents in southern african waters. South African National Scientific Progrmmes Report no 30. South Africa, Pretoria.

Hicks SD. 2006. Understanding tides. U.S. Department of Commerce National Oceanic and Atmospheric Administration National Ocean Service. Washington DC.

Hsieh HY, Lo WT, Wu LJ. 2012. Community Structure of Larval Fishes from the Southeastern Taiwan Strait: Linked to Seasonal Monsoon-driven Currents. Zool Stud 51 (5): 679-691.

Juliani, Suyatna I. 2014. The stock potency of demersal fish resources at the coastal zone, East Kutai District in East Kalimantan. Intl J Sci Eng 6 (2): .135-143.

Kane S, Qarri F, Lazo P, Bekteshi L. 2010. The effect of physico-chemical parameters and nutrients on fish growth in Narta lagoon, Albania. J Hygienic Engin Design UDC 639.32(496.5): 62-68.

Lam K, Tsui T, Nakano K, Randa DJ. 2005. Physiological adaptation of fishes to tropical intertidal environments. Physiol Trop Fish 21: 501-581.

Madeira D, Narciso L, Cabral H N, Vinagre C. 2012. Thermal tolerance and potential impacts of climate change on coastal and estuarine organisms. J Sea Res 70: 32-41.

Mallya YJ. 2007. The effects of dissolved oxygen on fish growth in aquaculture. Kingolwira National Fish Farming Centre, Fisheries Division Ministry of Natural Resources and Tourism Tanzania. Reykjavik, Iceland.

Majeed A, Mandokhail BM, Masood Z, Rehman H-UR, Ullah A, Gul N. 2015. Assessment Study About The Water Quality Criteria and Heavy Metals Concentrations in Different Fish Ponds of Four Districts of Balochistan Province, Pakistan. Global Vet 14 (3): 351-357.

Masuda H, Araga C, Yoshiro T (1975) Coastal fishes of southern Japan. Tokai Univ. Press. Japan.

Matsunuma M, Motomura H, Matsuura K, Shazili NAM, Ambak MA. 2011. Fishes of Terengganu, East Coast of Malay Peninsula, Malaysia. National Museum of Nature and Science, Tokyo, Universiti Malaysia Terengganu, Terengganu, and Kagoshima University Museum, Kagoshima.

Mazlan AG, Seah GY. 2006. Meristic and length-weight relationship of ponyfihes (Leioganthidae) in the coastal swater of Pulau Sibu-Tinggi, Johor, Malaysia. Malays. Appl Biol 35 (1): 27-35.

Muddula KN, Govinda RV, Joseph U, Ranjan T, Siva KV, Ramesh BK. 2015. Length-weight relationship of pugnose ponyfish *Secutor insidiator* (Bloch, 1787) (Family: Leiognathidae) from the Visakhapatnam Coastal Waters, North East Coast of India. Res J Anim Vet Fish Sci 3 (5): 1-4.

Murchie KJ, Cooke SJ, Danylchuk AJ, Danylchuk SE, Goldberg TL, Suski CD, , Philipp DP. 2011. Thermal biology of bonefish (Albula vulpes) in Bahamian coastal waters and tidal creeks: An integrated laboratory and field study. J Thermal Biol 36: 38-48.

Nordlie FG, Haney DC. 1999. Adaptations in salt marsh teleosts to life in waters of varying salinity. Italy J Zool 65 (Suppl.): 405-409.

Peristiwadi T. 2006. Important fish species in Indonesia. Identification guidance. LIPI Press. Jakarta [Indonesia].

Santema P. 1964. The effect of tides, coastal currents, waves and stormsurges on the natural conditions prevailing in deltas. Symposium on Scientific Problems of the Humid Tropical Zone Deltas and their Implications. Dacca (East Pakistan), 24 February - 2 March 1961.

Seah GY, Abdullah S, Zaidi CC, Mazlan AG. 2009. Systematic Accounts and Some Aspects of Feeding and Reproductive Biology of Ponyfishes (Perciformes: Leiognathidae). Sains Malaysiana 38 (1): 47–56.

Seah GY, Mazlan AG, Simon KD, Arshad A, Mohamed CAR, Usup G. 2011. Overview of the leiognathid species in Malaysia. AACL Bioflux 4 (4): 505-510.

Seah GY, Usup G, Mohamed RCA, Arshad AB, Ghaffar MA. 2012. Phylogeny and morphological delineation of leiognathids in the waters of Peninsular Malayasia. Coastal Mar Sci 35 (1): 91-95.

Sichum S, Tantichodok P. 2013. Diversity and assemblage patterns of juvenile and small sized fishes in the seashore habitats of the Gulf of Thailand. Raffles Bull Zool 62 (2): 795-809.

Silk J. 2015. Short-term HAB forecasting in a changing environment. Harmful Algal Blooms and Climate Change Scientific Symposium, Göteborg, Sweden.

Suyatna I, Rafii A, Abdunnur, Widiarso D. 2012. Hydrooceanographic aspect of fishing ground Julu in waters of Mahakam Delta, Kutai Kartanegara. Aquarine 2 (2): 72-77. [Indonesia].

Suyatna I, Sidik AS. 2013. Investigation on fish assemblages around cooling water system outlet in the coastal water of Bontang city, East Kalimantan. Global J Sci Front Res Biol Sci 13 (5): 9-16.

Suyatna I, Bratawinata AA, Sidik AS, Ruchaemi A. 2010. Demersal fishes and their distribution in estuarine waters of Mahakam Delta, East Kalimantan. Biodiversitas 11 (4): 204-210

Wantiez L, Kulbicki M. 1995. Main fish populations and their relation to the benthos in a silted bay of New Caledonia, as determined by visual censuses. Cybium 19 (3): 223-240.

Wedjatmiko. 2007. Composition of Ponyfsh (Leiognathidae) in West Sumatera Waters. Iktiologi Indonesia 7: 1-8 [Indonesia].