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Fish Distribution and Abundance in the Sungai Sepang Besar Estuary, Selangor: Influence of Water Physicochemical Parameters

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ABSTRACT

This study reports on the abundance and distribution of seven fish species (*Toxotes jaculatrix*, *Toxotes chatareus*, *Thryssa dussumieri*, *Plotosus lineatus*, *Photopectoralis bindus*, *Arius sagor* and *Stolephorus indicus*) in relation to water physicochemical parameters (pH, dissolved oxygen, turbidity, salinity, temperature, ammonia, nitrogen and phosphate) of Sungai Sepang Besar (SSB) estuary. Fishes were sampled from April 2014 to February 2015 by utilizing gill nets of various mesh sizes (1.25, 2.25, 2.50, 2.75, 3, and 4.5 inches) and long lines at nine stations (S1-S9) divided into three reaches (lower, middle and upper). Dissolved oxygen (DO), salinity, pH, and ammonia were significantly different from sampling stations ($p<0.05$). Fish distribution in SSB was influenced by salinity, pH, DO, turbidity, phosphate, ammonia, and nitrate. Fish distribution at the lower reaches was strongly influenced by DO, salinity, turbidity, and pH; ammonia and phosphate at the upper reaches; and nitrate at the middle reaches. The findings of this study will be helpful in the management of SSB and its estuary, as well as how land use activities may impact its aquatic environment.

Keywords: *Estuarine fish, fish ecology, mangrove, physio-chemical*

INTRODUCTION

Malaysia is a mega-diverse country for its flora and fauna, with 2243 species of fish recorded from the aquatic environment [1], of which 1636 are marine species, 413 freshwater species, 116 species are migratory that move from marine to freshwater, while 78 species reside in both brackish and freshwater environments. The sustainability of aquatic biota requires good water quality [1], while pollution threatens organisms and their environment [2].

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Water chemistry, physical habitat, land use activities [3], food source, and nutrient availability [4] affect the diversity and abundance of fish. Many marine and coastal fishes use estuaries for spawning and growth during their early developmental stages [5]. However, the spatial location of a river or a stream is important for freshwater fish [6]. Past studies on Sungai Sepang Besar have been on heavy metals, fatty alcohols in sediments, effluents of shrimp and animal farms, surface runoff, agriculture herbicides, sewage, ecotourism, and power plant activities [7 - 10], while ecological studies were on fiddler crab distribution [11] and fish length-weight relationship [12]. Noting the need for more information on the ecological aspects of fish, this paper reports on the relationship of fish abundance and distribution in the SSB *viz a viz* water physicochemical parameters.

EXPERIMENTAL

Site Description

This study was conducted in Sungai Sepang Besar (SSB), Selangor (N2°35'30", E101°43'1") on the west coast of Peninsular Malaysia. SSB faces the Straits of Malacca and is lined by the Sepang Mangrove Reserve. The river runs through the Sepang and Sungai Pelek towns before reaching the Straits of Malacca.

Sampling Procedure

Nine sampling stations (S1-S9) along the SSB were selected and divided into three reaches (lower, S1-S3; middle, S4-S6; upper, S7-S9) (Figure 1). Fish samples were collected from April 2014 to February 2015 using gill nets (mesh sizes of 1.25, 1.5, 2.25, 2.50, 2.75, and 3.0 inches, with dimensions of 92 m X 2.6 m) and long lines during both spring and neap tides. The nets and long lines were employed during the daytime for 5 to 6 hours before hauling. Sampled fishes were identified by taxonomic keys [1, 13]. *In-situ* water physicochemical parameters recorded included temperature (°C), pH, dissolved oxygen (DO) (mg/l), turbidity (NTU), and salinity (parts per thousand - ppt) which were measured using a Multiparameter Water Quality Hydrolab (Model Quanta). At the same time, ammonia, nitrate, and phosphate determination are outlined in [14].

Data Analysis

Diversity was determined via the Shannon-Wiener Index (H'= $-\sum$pilnpi) [15], evenness via the Pielou's Index (J=H'/H_{max}) [16], and richness via the Margalef's Index [D=(S-1)/lnN] [17]. Catch Per Unit Effort (CPUE) is a development indicator of sustainable fisheries resource utilization and was calculated as biomass [gill net = total weight fish (g)/net area (m^2)/hour; longline= total weight fish (g) /hour] and density [gill net = number of fish (no)/net area (m^2)/hour; longlines = number of fish (no)/hour].

One-way ANOVA was used to test for significant differences in fish catch per unit effort (CPUE) between fishing gears, sampling reaches, and sampling stations. Fish distribution in relation to environmental variables (pH, salinity, dissolved oxygen, turbidity, ammonia, nitrate, and phosphate) was analysed using canonical correspondence analysis (CCA) [18]. To reduce the effect of rare species and

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clutter, only seven abundant species (where n>30) were considered in the CCA and reported in this paper. The CCA was performed via XLSTAT add-in for Microsoft Excel (Microsoft Corporation) [19].

STATION	LATITUDE	LONGITUDE
Station 1 (S1)	2°35'49.01"N	101°42'49.00"E
Station 2 (S2)	2°36'01.00"N	101°42'39.00"E
Station 3 (S3)	2°36'09.07"N	101°42'22.00"E
Station 4 (S4)	2°36'59.06"N	101°42'49.04"E
Station 5 (S5)	2°37'09.79"N	101°43'09.09"E
Station 6 (S6)	2°37'14.00"N	101°43'25.89"E
Station 7 (S7)	2°37'15.00"N	101°43'49.00"E
Station 8 (S8)	2°37'31.43"N	101°43'47.44"E
Station 9 (S9)	2°37'53.11"N	101°43'43.00"E

Figure 1: Map of the study area and location of each sampling station

RESULTS AND DISCUSSION

Fish Species Diversity and Abundance

A total of 832 fish from 32 families comprising 50 species were sampled from SSB. *Toxotes jaculatrix* (n=288; 34.6%) was most abundant followed by *Toxotes chatareus* (n=186; 22.4%) (Toxotidae), *Thryssa dussumieri* (n=48; 5.8%) (Engraulidae), *Plotosus lineatus* (n=40; 4.8%) (Plotosidae), *Photopectoralis bindus* (n=38; 4.6%) (Leiognathidae), *Arius sagor* (n=37; 4.5%) (Ariidae) and *Stolephorus indicus* (n=30; 3.7%) (Engraulidae), while other fish species collectively recorded low abundance (< 3%). The complete list of the fish species from SSB is reported in [14]. *Toxotes jaculatrix* was abundant at the lower reaches, *A. sagor* at the middle, and *P. bindus* at the upper reaches. The Shannon-Weiner (H') was 2.37, Evennes (J) was 0.21, and Margalef's (D) was 7.29. The middle reaches recorded higher values for H' (2.92), J (0.6), and D (5.96) as compared to other reaches.

SCIENCE LETTERS
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The number of fish sampled in the SSB ranged from 161 to 538 individuals, with the highest abundance recorded at the lower reaches (518), followed by the upper reaches (161), and the lowest at the middle reaches (153). The lower and upper reaches recorded similar fish species richness (27 species), while the middle reaches recorded 30 species. The lower reaches recorded the highest fish biomass (5.90 ±31.10 g/m^2/hr) and density (0.08 ± 0.40 no/m^2/hr) from gillnets while fish biomass (208.10 ± 216.90 g/hr) and density (0.48 ± 0.41 no/hr) from longlines was highest at the middle reaches (Table 1). Station 1 recorded the highest biomass (16.00 ± 54.00 g/m^2/hr) and highest fish density from gillnets (0.21 ± 0.69 no/m^2/hr) and lowest biomass (6.93 ± 15.50 g/hr) and fish density (0.04 ± 0.09 no/hr) from longlines while station 4 recorded highest biomass (277 ± 352.00 g/hr) and density (0.52 ± 0.57 no/hr) for longlines (Table 2). The density and biomass were not significantly different between sampling reaches ($p<0.05$) and sampling stations ($p>0.05$) for both gillnets and longlines.

The Shannon-Weiner (H'=2.37), Eveness (J=0.21), and Margalef's (D=7.29) from the present study recorded lower values as compared to other estuaries in Peninsular Malaysia (Table 3). The lower J was related to the large number of *T. jaculatrix* and *T. chatareus* sampled. Diversity measures the relationship between the number of species and their numbers [20], and dominance by a few species tends to suppress the index. A lower D value reflects low species richness [21] (as with SSB) than other estuaries. Differences in fish diversity and species richness between the present and other studies in Peninsular Malaysia may be attributed to differences in habitat characteristics, season, tidal phase (spring/neap & flood/ebb), day-night patterns, gear type used and sampling intensity [22, 23].

Table 1: CPUE (biomass and density) of sampling gears at each sampling reach of Sungai Sepang Besar

CPUE	Mean Biomass (g/m^2/hr)				Mean Density (no/m^2/hr)			
Gear Type	LR	MR	UR	Total Biomass	LR	MR	UR	Total Density
GN	5.900 ± 31.130	0.752 ± 1.079	0.643 ± 0.994	2.430 ± 17.990	0.084 ± 0.400	0.018 ± 0.027	0.020 ± 0.036	0.041 ± 0.232
CPUE	**Mean Biomass (g/hr)**				**Mean Density (no/hr)**			
Gear Type	LR	MR	UR	Total Biomass	LR	MR	UR	Total Density
LL	2.31 ± 8.95^{c*}	208.10 ± 216.90^{b*}	167.70 ± 311.80^{a*}	126.1 ± 232.4	0.01 ± 0.05^{c*}	0.48 ± 0.41^{b*}	0.37 ± 0.59^{a*}	0.29 ± 0.46

Note: UR, Upper Reaches; MR, Middle Reaches; UR, Upper Reaches; GN, Gillnets; LL, longlines; *$p<0.05$

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Table 2: CPUE of sampling gears (gillnets and longlines) at each sampling station of Sungai Sepang Besar

Sampling reaches	Sampling Stations	GN Mean Biomass ($g/m^2/hr$)	GN Mean Density ($no/m^2/hr$)	LL Mean Biomass (g/hr)	LL Mean Density (no/hr)
Lower reaches	S1	16.00 ± 54	0.21 ± 0.69	6.93 ± 15.50	0.04 ± 0.09
	S2	1.21 ± 1.62	0.02 ± 0.03	0.00	0.00
	S3	0.48 ± 1.01	0.01 ± 0.03	0.00	0.00
Middle reaches	S4	0.71 ± 0.67	0.02 ± 0.03	277 ± 352.00	0.52 ± 0.57
	S5	1.26 ± 1.58	0.03 ± 0.04	185 ± 141.60	0.48 ± 0.40
	S6	0.28 ± 0.42	0.00 ± 0.01	161 ± 105.90	0.45 ± 0.33
Upper reaches	S7	0.25 ± 0.35	0.01 ± 0.02	217 ± 458.00	0.36 ± 0.69
	S8	0.82 ± 1.03	0.02 ± 0.03	149 ± 211.80	0.40 ± 0.53
	S9	0.86 ± 1.31	0.03 ± 0.05	137 ± 284.00	0.37 ± 0.69

Note: S, Station; GN, Gillnets; LL, longlines; hr, hour

Table 3: Comparison of Diversity Indices from Estuaries in Peninsular Malaysia

Location	Species Richness	H’	J	D	Source
Present study	50	2.37	0.21	7.29	
Klang, Selangor	119	2.59	0.55	11.82	[24]
Sg Dinding, Perak	49	2.87	0.74	-	[25]
Sg. Pulai, Johor	105	2.86	0.63	14.09	[26]
Sg. Johor, Johor	130	3.50	0.72	15.59	[26]
Pahang Estuary	24	2.09	-	-	[27]
Matang, Perak	89	3.66	0.81	7.58	[28]

Spatial Variation of Physicochemical Parameters

The physicochemical parameters of SSB are given in Table 4. The temperature did not vary between sampling stations, while pH ranged from 6.60 (S9 – upper reaches) to 8.45 (S1 – lower reaches) and was significantly different between sampling stations ($p<0.05$). Salinity ranged from 25.8 ppt at S8 (upper reaches) to 29.04 ppt at S1 (lower reaches) and was significantly different between sampling stations ($p<0.05$). The decrease in salinity from the lower reaches at S1 towards the upper reaches at S9 was due to greater freshwater mixing due to river flow at the latter. DO ranged from 2.89 mg/L at S7 (upper reaches)) to 4.05 mg/L at S3 (lower reaches) and was significantly different between sampling stations ($p<0.05$).

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Turbidity ranged from 44.9 NTU at S3 (lower reaches) to 76.3 NTU at S4 (middle reaches) and was not significantly different between sampling stations (p>0.05). Ammonia ranged from 0.12 mg/L at S2 & S4 (lower & middle reaches, respectively) to 0.45 mg/L at S9 (upper reaches) and was significantly different between sampling stations (p<0.05). Nitrate ranged from 1.9 mg/L at S6 (middle reaches) to 3.18 mg/L at S9 (upper reaches) but was not significantly different between sampling stations (p<0.05). Phosphate ranged from 0.22 mg/L at S2 (lower reaches) to 0.32 mg/L at S8 & S9 (upper reaches) and was significantly different between sampling stations (p>0.05).

Table 4: Water Physicochemical Parameters and Nutrient Levels of Sampling Stations of Sungai Sepang Besar.

Stations	Temp (°C)	DO (mg/L)	pH	Salinity (ppt)	Turbidity (NTU)	Nitrate (mg/L)	Phosphate (mg/L)	Ammonia (mg/L)
1	29.6 ± 0.95	3.63 ± 1.15	8.45 ± 0.72	29.04 ± 3.28	58.73 ± 58.26	2.31 ± 1.30	0.26 ± 0.18	0.17 ± 0.24
2	29.68 ± 0.89	3.99 ± 0.75	8.17 ± 0.64	27.97 ± 4.00	67.6 ± 80.10	2.18 ± 1.28	0.22 ± 0.17	0.12 ± 0.11
3	29.65 ± 0.96	4.05 ± 0.66	7.76 ± 0.75	27.71 ± 4.25	44.91 ± 46.07	2.46 ± 1.72	0.23 ± 0.19	0.18 ± 0.28
4	29.76 ± 0.93	3.13 ± 0.95	7.10 ± 0.41	26.78 ± 4.31	76.3 ± 107.6	3.02 ± 2.67	0.23 ± 0.20	0.12 ± 0.15
5	29.63 ± 1.56	3.43 ± 1.14	7.05 ± 0.37	26.82 ± 3.82	70.2 ± 126	2.51 ± 1.34	0.23 ± 0.15	0.20 ± 0.18
6	29.83 ± 0.89	3.36 ± 1.37	6.96 ± 0.40	25.63 ± 5.02	70.3 ± 115.3	1.9 ± 0.54	0.28 ± 0.20	0.16 ± 0.15
7	29.72 ± 0.76	2.89 ± 1.12	6.77 ± 0.31	26.06 ± 3.92	47.02 ± 38.43	2.42 ± 1.16	0.26 ± 0.20	0.28 ± 0.20
8	29.63 ± 0.86	3.10 ± 1.22	6.70 ± 0.41	25.81 ± 4.27	67.1 ± 118.20	2.51 ± 0.93	0.32 ± 0.24	0.36 ± 0.32
9	29.66 ± 0.78	2.98 ± 1.22	6.60 ± 0.41	25.84 ± 4.26	52.68 ± 31.11	3.18 ± 1.64	0.32 ± 0.16	0.45 ± 0.53
Overall Mean	29.68 ± 0.97	3.40 ± 1.15	7.29 ± 0.82	26.85 ± 4.26	61.66 ± 87.44	2.50 ± 1.51	0.26 ± 0.19	0.23 ± 0.28

Fish Distribution in Relation to Water Physicochemical Parameters

Among the physicochemical parameters, pH, salinity, turbidity, and DO contributed most to the distribution of *Toxotes jaculatrix* and *T. chatareus* at S1 and S2 (river mouth - lower reaches) (Figure 2). *Thryssa dussumieri, A. sagor*, and *S. indicus* distribution were correlated with higher nitrate concentrations at S3, S4, S6 (middle reaches) & S7 (upper reaches). *Plotosus lineatus* and *P. bindus* distribution was correlated

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with higher phosphate and ammonia concentrations at S8 & S9 (upper reaches). The CCA indicated that the physicochemical parameters significantly affected the distribution patterns of the abundant fishes in SSB, *albeit* with differences in correlation strength.

The effect of water physicochemical parameters on fish assemblage and distribution within estuarine and coastal waters is known [27, 29, 30, 31, 32], and this was also shown for SSB. *Toxotes jaculatrix* and *T. chatareus* were mostly sampled from the lower reaches (S1 & S2) as reflected by the density and biomass where DO, turbidity, salinity, and pH were higher. Fish abundance varies with salinity fluctuations [33], and higher salinity at river mouths leads to the migration of *Toxotes* spp. into estuarine waters as a strategy for predator avoidance and food [34], reproduction [35], and survival of fish larvae and juveniles [36]. pH can be a major determinant of fish distribution and abundance because species vary widely in their tolerance to acidity [37, 38], and high values result in osmoregulation, respiration, and blood acid-base balance problems [39]. Water turbidity is important as it protects juvenile fish from predators [32, 31], reduces visibility in the water column, and minimizes the visual perception among predatory fish [40]. *P. lineatus* and *P. bindus* were associated with higher phosphate and ammonia concentrations but with lower DO, pH, salinity, and turbidity in the upper reaches of SSB (S8 & S9). At the same time, *T. dussumieri, A. sagor*, and *S. indicus* were mainly sampled in higher nitrogen levels (S3, S4, S6 & S7). The influence of nitrate, phosphate, and ammonia was less critical on fish distribution based on the length of the vectors of the CCA.

Nitrate input into the SSB may result from human activities along the river. The Sungai Pelek town, situated at the upper reaches and farming along SSB, is a vital nutrient input source. The runoff from land-based activities that flows into aquatic environments adds significant organic material and nutrients to enrich these environments [41] besides domestic input. A positive correlation has been shown to affect *P. lineatus* abundance and nitrate in seagrass beds at Ban Pak Klong, Thailand [42], while [43] stated that the Ohta River, Japan received a discharge from farmland and forest, which was enriched with large amounts of nutrients such as particulate nitrogen and phosphorus. The presence of marine fishes such as *P. bindus*, *P. lineatus*, and *T. dussumieri*, *S. indicus*, and *A. sagor* in the middle and upper reaches of SSB where the salinity is lower was perhaps related to the fishes utilising these areas as nursery and feeding grounds. Fish dependence on habitats or specific habitat regions is species-specific and site-specific [44 - 47], which may also be related to their life history characteristics.

Most fish species sampled in SSB are commonly found in rivers, estuaries, and coastal waters in Peninsular Malaysia [1]. Some fishes sampled are commercially important, such as *A. sagor*, *S. indicus*, *T. dussumieri*, and *P. lineatus* [48]. Some fish species sampled from the SSB are euryhaline [27] and were recorded from all sampling stations [14].

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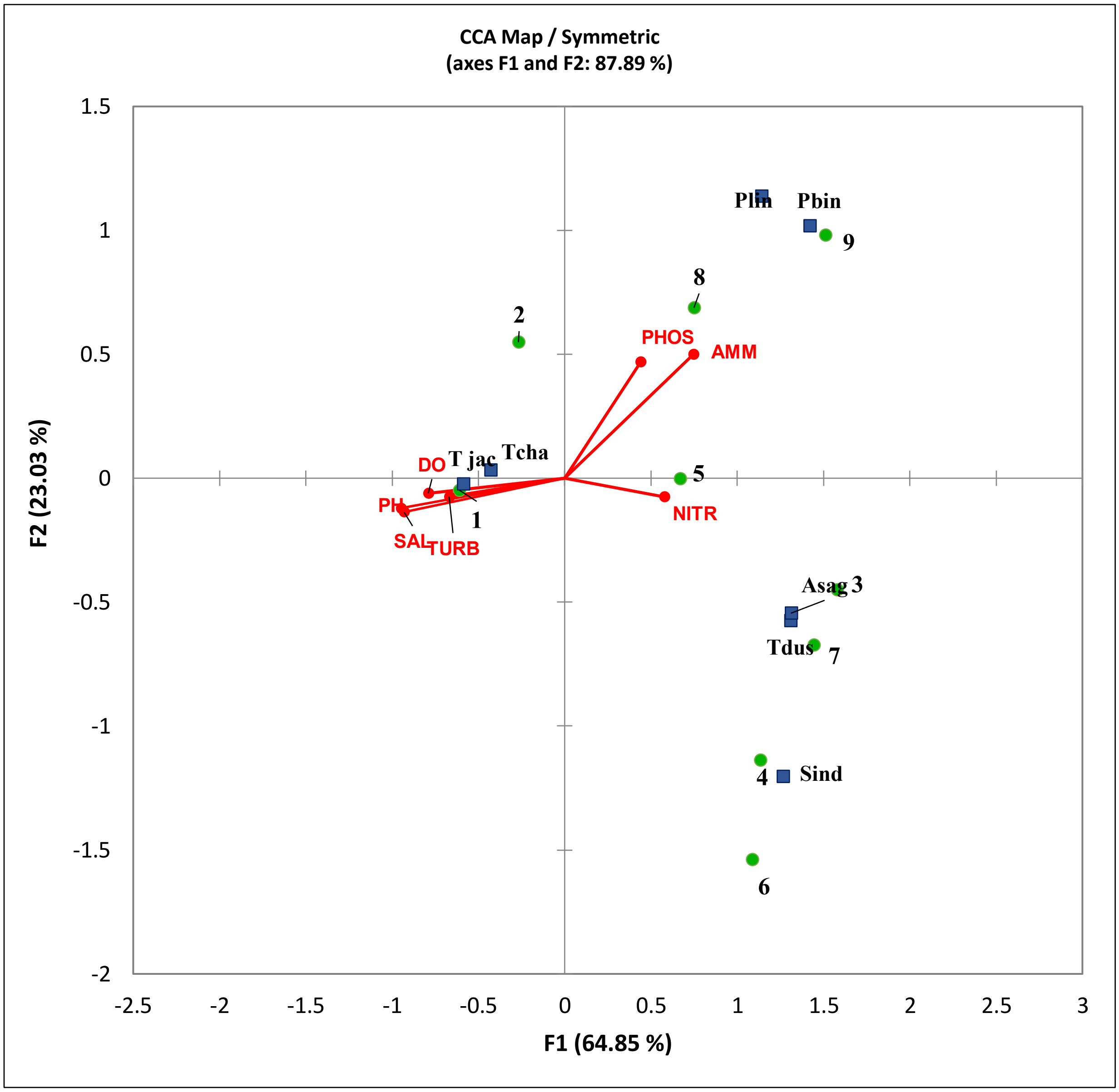

Figure 2: CCA ordination plots for the first two dimensions of CCA of the relationship between the fish species with water physicochemical parameters. Note: DO, dissolved oxygen; SAL, salinity; TURB, turbidity; NIT, nitrate; PHOS, phosphate; AMM, ammonia; Tjac, *Toxotes jaculatrix*; Tcha, *Toxotes chatareus*; Plin, *Plotosus lineatus*; Pbin, *Photopectoralis bindus*; Tdus, *Thryssa dussumieri*; Asag, *Arius sagor*; Sind, *Stolephorus indicus*. Numbers (1-9) represent sampling stations. Red lines depict physicochemical parameters, while coloured shapes depict sampling stations and fish species; Squares, species; circles, sampling stations.

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CONCLUSION

Fish distribution in SSB was influenced by salinity, pH, DO, turbidity, phosphate, ammonia, and nitrate. Fish distribution at the lower reaches was strongly influenced by DO, salinity, turbidity, and pH; ammonia and phosphate at the upper reaches; and nitrate at the middle reaches. The physicochemical parameters of SSB affected not only the distribution but also the abundance of its fish community. However, further studies on the effects of tides, day-night, and season are required to comprehend the temporal and spatial fish assemblage of SSB fully. The findings of this study will be helpful in the management of SSB and its estuary, as well as how land use activities may impact its aquatic environment.

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AUTHOR'S CONTRIBUTION

Nurul Asyikin carried out the research and wrote the article. Harinder supervised the research progress and reviewed and revised the article.

CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted without any self-benefits or commercial or financial conflicts and declare the absence of conflicting interests with the funders.

REFERENCES

[1] Ambak, M. A., Isa M. M., Zakaria, M. Z., & Ghaffar, M. A. (2012). *Fishes of Malaysia Second Edition* Penerbit UMT.
[2] Amneera, W. A., Najib, N. W. A. Z., Yusof, S. R. M., & Ragunathan, S. (2013). Water Quality Index of Perlis River, Malaysia. *Int. J. of Civil & Environmental Engineering IJCEE-IJENS* Vol: 13 No: 02, 6p
[3] Deacon, J. R., & Mize, S. V. (1997). Effects of Water Quality and Habitat on Composition of Fish Communities in the Upper Colorado River Basin. Upper Colorado River Basin NAWQA Fact Sheet FS–122–97, 6p

https://scilett-fsg.uitm.edu.my/
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DOI:

[4] Nyanti, L., Nur 'Asikin, R., Ling, T. Y., & Jongkar, G. (2012). Fish diversity and water quality during flood mitigation works at Semariang mangrove area, Kuching, Sarawak, Malaysia. *Sains Malaysiana* 41:1517–25

[5] Dando, P. R. (1984). *Reproduction in estuarine fish* in: Potts, G.W., Wootton, R.J. (eds.) Fish reproduction strategies and tactics, Academic Press, London. 155-170.

[6] Akin, S., Buhan, E., Winemiller, K. O., & Yilmaz, H. (2005). Fish assemblage structure of Koycegiz Lagoon-Estuary, Turkey: Spatial and temporal distribution patterns in relation to environmental variation. *Estuarine Coastal Shelf Sci*., 64, 671-684

[7] Ismail, A., & Ramli, R. (1997). Trace metals in sediments and molluscs from an estuary receiving pig farms effluent. *Environmental Technology* 18(5): 509 -515

[8] Zulkifli, S. Z., Mohamat-Yusuff, F., Arai, T., Ismail, A., & Miyazaki, N. (2010). An assessment of selected trace elements in intertidal sediments collected from the Peninsular Malaysia. *Environ Monit Assess* 169, 457-472

[9] Ali, M., Humrawali, N., Ying, P., Latif, M., & Zakaria, M. (2011). Fatty Alcohol Variations in Surface Sediments of Sungai Sepang Besar, Sepang, Selangor. *Sains Malaysiana*. 40. 841-851

[10] Lim, C. Y. (2015). Keeping a river clean: - The Sepang river is cleaner than it used to be, but pollution concerns remain. *The Star*, p. 8. (Call Number: 2015/06-033)

[11] Mokhtari, M., Ghaffar, M. A., Usup, G., & Cob, Z. C. (2015). Determination of Key Environmental Factors Responsible for Distribution Patterns of Fiddler Crabs in a Tropical Mangrove Ecosystem. *Plos One*, 10(1), e0117467. doi:10.1371/journal.pone.0117467

[12] Ya, N. A., & Singh, H. R. (2018). Abundance and Length-Weight Relationship of Fishes from Sungai Sepang Besar, Selangor *Int. J. of Engineering & Technology* 7(4.14) 26-30

[13] Kottelat, M., & Whitten, T. (1996). Freshwater biodiversity in Asia with special reference to fish, *World Bank Technical Paper* No. 343. Washington, DC, USA. The World Bank. 1-47

[14] Ya, N. A. (2020). *MSc Thesis* Universiti Teknologi MARA

[15] Magurran, A. E. (2004). *Measuring Biological Diversity*. Blackwell publishing. Pp 107-115

[16] Pielou, E. C. (1966). The measurement of diversity in different types of biological collections. *J. Theoret. Biol*., 13. pp 131-144.

[17] Krebs, C. J. (1999). *Ecological Methodology*, Addison-Welsey Educational Publisher Inc. Canada

[18] Ter Braak, C. J. E., & Verdonschot, P. E. M. (1995). Canonical correspondence analysis and related multivariate methods in aquatic ecology. *Aquatic Sciences* 57/3, 255-289

[19] Ikhwanuddin, M. E. M., Amal, M. N. A., Shamarina, S., Hasan, H. H., & Jamil, N. R. (2016). Environmental influences on fish assemblages of the upper Sungai Pelus, Kuala Kangsar, Perak, Malaysia. *Sains Malaysiana* 45 1487-1495

[20] Spellerberg, I. F. (1991). *Monitoring ecological change* Cambridge University Press, Cambridge, 334 pp

[21] Heip, C. H. R., Herman, P. M. J., & Soetaert, K. (1998). Indices of diversity and evenness. *Oceanis* 24(4):61-87.

[22] McLusky, D. S., & Elliott, M. (2004). *The Estuarine Ecosystem*. Oxford: Oxford University Press 214 pages

[23] Nabi, M. R., Mamun, M. A., Ullah, M. H., & Mustafa, M. G. (2011). Temporal and spatial distribution of fish and shrimp assemblage in the Bakkhali river estuary of Bangladesh in relation to some water quality parameters. *Marine Biology Research* 7:436–52.

[24] Chong, V. C., Sasekumar, A., Leh, M. U. C., & D'Cruz, R. (1990). The fish and prawn communities of a Malaysian coastal mangrove system, with comparisons to adjacent mud flats and inshore waters. *Estuarine, Coastal and Shelf Science*, Volume 31, Issue 5, Pages 703-722

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[25] EIA Report. (1997). *Detailed environmental impact assessment for proposed Lekir Coastal Development: land reclamation & deep-water terminal at Manjung district, Perak*. DESA Kilat Sdn. Bhd / Perunding Utama Sdn. Bhd.
[26] Chong, V. C., & Sasekumar, A. (2002). Fish communities and fisheries of Sungai Johor and Sungai Pulai Estuaries (Johor, Malaysia). *Malayan Nature J.* 56. 279-302
[27] Jalal, K. C. A., Ahmad Azfar, M., Akbar John, B., Kamaruzaman, Y. B., & Shahbudin, S. (2012) Diversity and Community Composition of Fishes in Tropical Estuary Pahang Malaysia. *Pakistan J. Zool*. Vol 44(1), 181-187
[28] Sasekumar, A., Chong, V. C., & Singh, H. R. 1(994). The physical and chemical characteristics of Matang mangrove waters. *Research Papers. Proc. 3rd ASEAN-Australia Symp. Living Coastal Resources* (Eds: Sudara, C R Wilkinson & L M Chou). Chulalongkorn University, Bangkok. Vol. 2. pp 446-454
[29] Wu, J., Wang, J., He, Y., & Cao, W. (2011). Fish assemblage structure in the Chishui River, a protected tributary of the Yangtze River. *Knowledge and Management of Aquatic Ecosystems* 400: 11
[30] Chowdhury, M. S. N., Hossain, M. S., Das, N. G., & Barua, P. (2010) Environmental variables and fisheries diversity of the Naaf River Estuary, Bangladesh. *J. of Coastal Conservation* 15:163–80
[31] Hossain, M., Nani, G. D., Sarker, S., & Ziaur, R. M. (2012). Fish Diversity and Habitat Relationship with Environmental Variables at Meghna River Estuary, Bangladesh. *The Egyptian J. of Aquatic Research*, Volume 38, Issue 3, 213-226
[32] Blaber, S. J. M. (2000). *Tropical estuarine fishes ecology, exploitation, and conservation. Fish and Aquatic Resources Series 7*, Blackwell Science Limited, Oxford, 372p (http://dx.doi.org/10.1002/9780470694985)
[33] Hoque, M. M., Abu Hena, M. K., Hanafi, M. I., Osumanu, H. A., Saifullah, A. S. M., & Billah M. B. (2015). Status of some fishery resources in a tropical mangrove estuary of Sarawak, Malaysia. *Marine Biology Research* 11:8 834-846 DOI: 10.1080/17451000.2015.1016970
[34] Harlay, X., Koubbi, P., & Grioche, A. (2001). Ecology of plaice (Pleuronectes platessa) in fish assemblages of beaches of the Opale coast (North of France) during spring 1997 *Cybium*, 25: 67-80
[35] Singh, H. R. (2003). The biology of the estuarine ariid catfishes (Fam: Ariidae) of the Matang Mangrove Ecosystem (Perak, Malaysia). *PhD Thesis* University of Malaya 332 pp
[36] Maes, J. S., Damme, V. P., Meire, F., & Ollevier. (2004). Statistical modeling of seasonal and environmental influences on the population dynamics of an estuarine fish community. *Marine Biology* 145 p. 103342
[37] Greig, H. S., Niyogi, D. K., Hogsden, K. L., Jellyman, P. G., & Harding, J. S. (2010). Heavy metals: confounding factors in the response of New Zealand freshwater fish assemblages to natural and anthropogenic acidity. *Science of the Total Environment* 408: 3240-3250
[38] Mills, K. H., Chalanchuk, S. M., & Allan, D. J. (2000). Recovery of fish populations in Lake 223 from experimental acidification. *Canadian J. of Fisheries and Aquatic Sciences* 57: 192-204
[39] Boyd, E. C. and Tucker, C. S. (1998). *Pond Aquaculture Water Quality Management* Massachusetts: Kluwer Academic Publisher.
[40] Nagelkerken, I. (2009). Evaluation of nursery function of mangroves and seagrass beds for tropical decapods and reef fishes: Patterns and underlying mechanisms. In I. Nagelkerken (Ed.), *Ecological Connectivity among Tropical Coastal Ecosystems* 357 – 399 pp
[41] Castillo-Rivera, M. (2013). Influence of rainfall pattern in the seasonal variation of fish abundance in a tropical estuary with restricted marine communication. *J. Water Resources* Protection 5(3A), 311-319

https://scilett-fsg.uitm.edu.my/
Vol. 17(2) JUNE 2023

ISSN: 1675-7785
eISSN: 2682-8626

DOI:

[42] Phinrub, W., Montien-Art, B., Promya, J., & Suvarnaraksha, A. (2014) Fish diversity and fish community in seagrass beds at Ban Pak Klong, Trang Province, Thailand. *Int., J. Fish Aquat Stud* 2 (2): 197-201

[43] Tanaka, K. (1995). RunoffRunoff loadings and chemical forms of soil phosphorus from rivers in Japan during the high flow stages. *Japan Agricultural Research Quarterly* 29(4), 223–229.

[44] Nagelkerken, I., Van der Velde, G., Gorissen, M. W., Meijer, G. J., Van't Hof, T., & Den Hartog, C. (2000). Importance of mangroves, seagrass beds and the shallow coral reef as a nursery for important coral reef fishes, using a visual census technique. *Estuarine, coastal and shelf science*, *51*(1), 31-44.

[45] Smith, G. C., & Parrish, J. D. (2002). Estuaries as nurseries for the jacks Caranx ignobilis and Caranx melampygus (Carangidae) in Hawaii. *Estuarine, Coastal and Shelf Science* 55 347-359

[46] Hindell, J. S., & Jenkins, G. P. (2004). Spatial and temporal variability in the assemblage structure of fishes associated with mangroves (Avicennia marina) and intertidal mudflats in temperate Australian embayments. *Marine Biology 144*, 385-395

[47] Chittaro, P. M., Usseglio, P., & Sale, P. F. (2005). Variation in fish density, assemblage composition and relative rates of predation among mangrove, seagrass and coral reef habitats. *Environmental Biology of Fishes* 72, 175-187

[48] DOF [Department of Fisheries] 2017 *Landings of Marine Fish By State And Species* Retrieved on 18 March 2019 [https://www.dof.gov.my/dof2/resources/user_29/Documents/Perangkaan%20Perikanan/2017%20Jilid%201/Jadual_Pendaratan.pdf]

[49] Fadhilah, A., Pulungan, A., Soemaryono, Y., Yusni, E., & Dewinta, A. (2019). CPUE analysis of skipjack tuna (Katsuwonus pelamis) at the Sibolga Nusantara. *Fishery Port*. 10.1088/1755-1315/260/1/012112