

Spatial Distribution Trend of Plankton in Sungai Pulai Estuary, the Straits of Johor, Malaysia

(Pola Taburan Ruang Plankton di Muara Sungai Pulai, Selat Johor, Malaysia)

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ABSTRACT

A spatial distribution study was carried out to investigate the influence of some environmental factors to planktons using collected samples from the Sungai Pulai estuary, near to the Singapore boarder. Six stations chosen for the field sampling were Port Tanjung Pelepas (S1), Tanjung Bin Charcoal Plant (S2), seagrasses of Pulau Merambong (S4) and Second-Link Bridge (S5) and mangrove areas (S3, S6). There is no significant difference of phytoplankton abundance ($p > 0.05$) between stations. Instead, it differs significantly at the level of $p < 0.05$; $p = 0.0001$ (Two tailed, $t = 14.10$ $df = 34$) between sampling session. In contrast, there is a significant difference of zooplankton abundance ($p < 0.05$) in the sampling stations ($\chi^2 = 17.3, (5)$), but there is no significant difference ($p > 0.05$; $p = 0.8966$) between the sampling session (Two tailed, $t = 0.1310$, $df = 34$). Biplot analysis shows that most species are associated with the stations except for *Protopeiridium sp.*, *Lithodesmia sp.* and *Alexandrium sp.* Copepod species including *Microcalanus sp.*, *Calanus sp.* and *Temora sp.* are associated with S5. *Paracalanus sp.*, *Euterpina sp.*, *Tigriopus sp.*, *Oithona sp.* and *Pseudocalanus sp.* are associated with S1, S2 and S4. The planktons are correlated with the temperature (Pearson's correlation, $r^2 = -0.897$) and salinity (Pearson's correlation, $r^2 = 0.9416$) in March but no correlation is found in November sampling session. The results indicated the important role of certain environmental factors, namely the salinity and temperature to the distribution of the planktons in Sungai Pulai estuary.

Keywords: Copepod; distribution; estuary; plankton; Sungai Pulai

ABSTRAK

Suatu kajian taburan ruang telah dijalankan untuk meninjau pengaruh alam sekitar ke atas plankton menggunakan sampel plankton yang diperolehi dari muara Sungai Pulai, berhampiran sempadan Singapura. Sebanyak enam stesen pensampelan telah dipilih iaitu Pelabuhan Tanjung Pelepas (S1), Kilang Arang Tanjung Bin (S2), kawasan rumput laut Pulau Merambong (S4) dan juga Jambatan Lingkaran ke-2 (S5) serta kawasan hutan bakau (S3, S6). Tiada perbezaan bererti bagi kelimpahan fitoplankton ($p > 0.05$) antara stesen ($\chi^2 = 5.547, (5)$) tetapi perbezaan bererti didapati pada tahap $p < 0.05$; $p = 0.0001$ (Two tailed, $t = 14.10$ $df = 34$) antara sesi pensampelan. Sebagai bandingan, terdapat perbezaan bererti untuk kelimpahan zooplankton ($p < 0.05$) di antara stesen ($\chi^2 = 17.3, (5)$) tetapi zooplankton tidak menunjukkan perbezaan bererti ($p > 0.05$; $p = 0.8966$) antara sesi pensampelan (Two tailed, $t = 0.1310$, $df = 34$). Analisis biplot pula menunjukkan kebanyakan spesies fitoplankton berkait dengan stesen-stesen kecuali *Protopeiridium sp.*, *Lithodesmia sp.* dan *Alexandrium sp.* Spesies Kopepod termasuk *Microcalanus sp.*, *Calanus sp.* dan *Temora sp.* berkait dengan S5. *Paracalanus sp.*, *Euterpina sp.*, *Tigriopus sp.*, *Oithona sp.* dan *Pseudocalanus sp.* menunjukkan kaitannya dengan S1, S2 dan S4. Plankton adalah berkait dengan suhu (Pearson's correlation, $r^2 = -0.897$) dan kemasinan (Pearson's correlation, $r^2 = 0.9416$) dalam bulan Mac tetapi tiada kaitan ditunjukkan pada bulan November. Keputusan kajian ini menunjukkan kepentingan peranan faktor persekitaran tertentu iaitu kemasinan dan suhu terhadap taburan plankton di kawasan muara Sungai Pulai.

Kata kunci: Kopepod; muara; plankton; Sungai Pulai; taburan

INTRODUCTION

Zooplankton is the second in the trophic level of marine food-web after the primary producer, the phytoplankton. Copepods which are known as the main group in zooplankton (Zou et al. 2006) could directly consume the phytoplankton (deYoung et al. 2004; Üstün & Bat 2014). Both phyto-and zooplankton are influenced by the

environmental factors in their distribution and assemblage (Hsieh et al. 2004; Mwaluma et al. 2003). The presence of ports, power plant and other similar activities in coastal areas would give effect to at least the water physic-chemical parameters such as salinity and temperature which further influence the planktons (Choi et al. 2012; Jiang et al. 2009, 2008). It is hypothesised that the water quality in areas

with industrial activities will be different from those with natural habitat such as seagrass and mangroves.

The present paper aimed to report the distribution trend of phyto- and zooplankton inhabiting the Sungai Pulai estuary in The Straits of Johor and how the environmental parameters in the study area affect the communities. The estuary is located in a busy Straits of Johor where there are ports, power plant and factories at Malaysia and Singapore sides thus made the study relevant.

MATERIALS AND METHODS

Two field samplings were conducted at six selected stations in Sungai Pulai estuary (Figure 1) in November 2013 and March 2014. Six sampling stations represented a possible different water environment (Table 1) were selected to cover the 22.6×2.83 km river and estuary area.

In the field, YSI multi-probe meter was used to measure the water parameters including temperature, salinity, pH and dissolved oxygen (DO). The depth of the light penetration was measured using the Secchi disc. The 20 and 100 µm nets were used to obtain the phyto- and zooplankton samples. All samplings were carried out in the morning time during the high tide. Phytoplankton and zooplankton samples were fixed with a Lugol's iodine and 5% buffered formalin, respectively.

Phytoplankton cell counting was done using a haemocytometer under a compound microscope. Zooplankton samples were diluted to 1 L before a sub-sampling strategy is carried out to get only 1/32 parts for quantification. Examination and counting was made under a dissecting microscope using a Bogorov tray. All data were analysed statistically using SPSS version 21.

RESULTS

ENVIRONMENTAL PARAMETERS

Table 2 summarizes the environmental condition of the estuary during the study period. Dissolved oxygen (DO) and pH shows in good condition for organism to survive and grow. Light penetration is up to 2.00 m depth particularly in November. Temperature (range of 29.09 - 29.71°C) has the fluctuation of less than 1°C. Salinity (range of 29.21 - 32.39 ppt) follows the contrast trend as the temperature, become more salty in March than in November.

DISTRIBUTION PATTERN OF PLANKTON SPECIES

A total of 12 and 14 phytoplankton species were identified during the first and second sampling session, respectively. Five species (*Pleurosigma* sp., *Chaetoceros*



FIGURE 1. Six sampling stations in Sungai Pulai estuary, the Johor Straits, Peninsular Malaysia

TABLE 1. Sampling stations in Sungai Pulai estuary and the environmental condition/ human activities (S – station)

Sampling station	Site description
S1 (N 01°20.714' E 103°32.431')	Coastal area of Port Tanjung Pelepas
S2 (N01°19.844' E 103°32.742')	Coastal area of Tanjung Bin Charcoal Power Plant
S3 (N 01°23.885' E 103°32.718)	Upper reach of Sungai Pulai
S4 (N 01°18.977' E 103°36.599')	Seagrass bed of Merambong island
S5 (N 01°20.976' E 103°37.800')	Seagrass bed under the Second Link Bridge
S6 (N 01°22.529' E 103°38.362')	Mangroves area in inner part of the Johor Straits

TABLE 2. Water parameter at each sampling station in Pulau River estuary in November 2013 and March 2014

Station	Water parameter				
	Temperature (°C)	Salinity (ppt)	DO (mg/L)	pH	Light depth (m)
1 st Sampling (November 2013)					
S1 Port of Tanjung Pelepas	29.31	29.32	4.18	7.29	1.50
S2 Tanjung Bin Charcoal Power Plant	29.65	30.64	5.25	7.58	0.50
S3 Upper reach of Sungai Pulai	29.34	30.54	5.82	7.42	2.00
S4 Merambong Island	29.66	29.21	4.10	7.69	2.00
S5 Second Link Bridge	29.71	31.69	3.95	7.39	0.70
S6 Mangrove Area	29.57	29.70	5.13	7.75	0.90
2 nd Sampling (March 2014)					
S1 Port Tanjung Pelepas	29.34	32.39	6.38	7.96	1.50
S2 Tanjung Bin Charcoal Power Plant	29.29	32.35	5.54	8.21	1.00
S3 Upper reach of Sungai Pulai	29.09	32.35	2.56	8.19	0.50
S4 Merambong Island	29.09	31.84	4.94	8.41	0.75
S5 Second Link Bridge	29.64	31.22	3.82	8.40	1.00
S6 Mangrove Area	29.20	30.82	3.14	8.34	1.00

sp., *Pseudonitzschia* sp., *Thalassionema* sp. & *Cosanodiscus* sp.) were found in both but other 14 species occurred in separate sampling session. *Skeletonema* sp. dominated the sampling area with the highest percentage of contribution (89.31%) to the phytoplankton community. Zooplankton was dominated by the copepods which contributing more than 95% of the composition. Out of the 8 calanoid species, the highest percentage occurred during the first sampling was the *Oithona* sp. (37.24%), followed by *Microcalanus* sp. (26.63%) and *Paracalanus* sp. (15.56%). On the second sampling, *Microcalanus* sp. maintained its dominance in S1, S3, S5 and S6 with the highest percentage of 31.91% in S5.

Biplot analysis shows the different distribution trend for phytoplankton and zooplanktonic copepods (Figures 2 & 3). Phytoplankton species are separated into two groups, those which are closely associated with the sampling stations and those which are not. The later include *Protoperdinium*, *Lithodesmia*, *Ditylum*, *Eupodisca*

and *Pseudonitzschia*. Biplot analysis shows almost all of the copepod species associated with all stations except for *Acartia* sp. which is associated only with S6. *Eurytemora* sp. and *Microsetella* sp. are quite far from any station but *Macrosetella* sp. is not associated at all with any station.

Kruskal-Wallis test found that there is no significant difference in phytoplankton abundance between stations ($\chi^2 = 5.547$, (5)), $p > 0.05$. The nonparametric Mann Whitney Test indicates that there is a significant different of abundance between March and November sampling ($U = 18776$, $p < 0.05$), $p < 0.05$. In term of density, phytoplankton seemed to be in higher abundance in March (range of mean abundance $515.12 - 1166.05 \times 10^3$ cell/mL) than in November (range of mean abundance $388.89 - 536.11 \times 10^3$ cell/mL). The highest abundance (1166.05×10^3 cell/mL) was found in S3, the upper reach of Sungai Pulai (Figure 2). Stations with industrial activities (S1, S4, S5) comparatively showed high abundance of phytoplankton

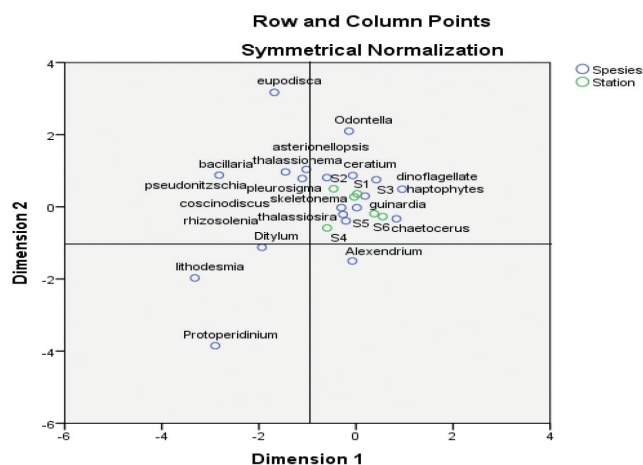


FIGURE 2. Biplot analysis for species of phytoplankton and sampling stations (S1-S6) in Sungai Pulai estuary

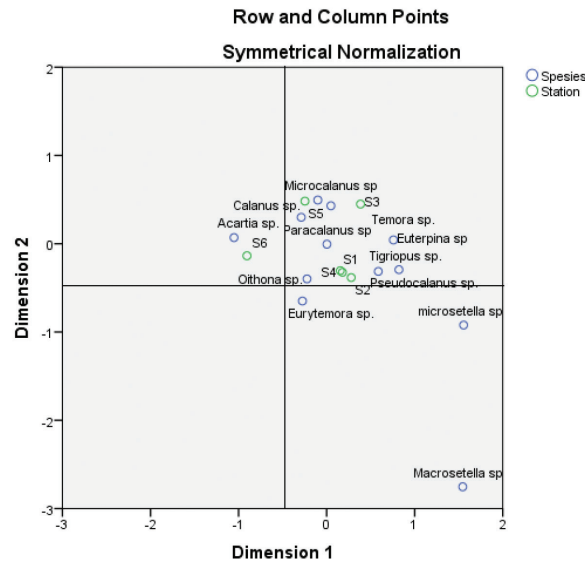


FIGURE 3. Biplot analysis for species of zooplankton and sampling stations (S1-S6) in Sungai Pulai estuary

except for S2 in the charcoal power plant area. In this station the abundance was comparatively low for both sampling sessions.

In contrast to the above results, there is a significant difference of copepod abundance between station ($\chi^2 = 17.3, (5), p < 0.05$). The abundance in S2 is significantly different if compared with S3 and S4. S3 is different from S5 and S6. S4 is also significantly different from S6. Nonetheless, there is no significant difference of zooplankton abundance between the sampling period ($U = 18670.5, p > 0.05$), $p > 0.05$.

RELATIONSHIP BETWEEN ABUNDANCE AND ENVIRONMENTAL PARAMETERS

Pearson's correlation analysis summarizes the possible relationship between the abundance of planktons and the environmental parameters during the sampling period. Copepods are significantly correlated to the temperature in the estuary in November ($r^2 = -0.897, p < 0.05$). Copepods increase their abundance in cooler environment. During the same period, phytoplankton significantly correlated with the salinity ($r^2 = 0.9416, p < 0.05$) indicating that in the area of more marine water, the abundance of phytoplankton will be more. In contrast to the results, none of the environmental parameters have significant correlation with the plankton abundance in March.

DISCUSSION

Environmental condition in the Straits, particularly Sungai Pulai estuary is notably comparable to the tropical estuary condition as reported earlier (Arshad et al. 2011; Zaleha et al. 2013, 2009). The water parameter is most likely related to the monsoon (Yoshida et al. 2006;

Zulikha et al. 2013) and the daily salinity and temperature change (Behera et al. 2013).

The phytoplankton abundance is significantly higher when the environment became more salty in March than in November. This could be related to the species which determined the different biochemical response towards salinity exposure (Lionard et al. 2005). At the same time salinity influenced the nutrient uptake by the phytoplanktons for their growth (Marcarelli et al. 2006). Moreover, different phytoplankton species would have preference to different nutrient amount at different salinity (Ganguly et al. 2013; Melo et al. 2007). In a coastal power station in the north part of the Malacca Straits, the salinity combined with other factors to correlate positively with the phytoplankton abundance (Muhammad Adlan et al. 2012). On the other hand, Härnström et al. (2009) highlighted the role of tide and water level which then influence the species composition and abundance of the phytoplankton species in a sampling site.

Sungai Pulai estuary is very near to the Singapore water which is reported as having experience in toxic dinoflagellate incident (Holmes & Teo 2002), thus the occurrence of the dinoflagellate species (*Alexandrium* sp. & *Protoperidinium* sp.) and certain diatom (*Pseudo-nitzschia*) is worth noted. Other phytoplankton species which are associated with most of the studied area in the estuary indicate the common occurrence as reported before (Gin et al. 2003, 2000). The moderate grazing activity of copepod community which is shown by the copepod species in the area could also affect the phytoplankton population density (Li et al. 2003).

The number of copepods species found in the present study is much lower than the recent report from Johan et al. (2013) or the earlier report of Zaleha et al. (2008). The copepod distribution as found in the present study

could indicate on how copepods would travel following their food source (Fetcher et al. 2004; Zamora-Terol et al. 2014). The co-occurrence would also imply the mixing condition of open and coastal water in the estuary (Arshad et al. 2011). O'boyle and Silke (2010) and Ooi et al. (2010) showed the role of tides in controlling the algal abundance in Singapore water. The condition might be important to maintain the composition of plankton species in the Sungai Pulai estuary. The copepods could be more influenced by the diet brought in by the sea current and tide (Araujo et al. 2008; Ara et al. 2011). These include diet such as the detritus (preferred by *Acartia* sp.) and picoplankton (preferred *Parvocalanus* sp.).

It is interesting to find that zooplankton correlated negatively with the temperature increase which is in the fluctuation range of less than 1°C. As reported earlier, copepods such as *Acartia tonsa* usually has a wide range of tolerance in salinity and temperature (Holste & Peck 2006). The existence of coastal power plants could significantly increase the sensitivity of the copepods to thermal stress. Choi et al. (2012) found that thermal stress would significantly cause mortality to *Acartia* sp. Jiang et al. (2009) proved the negative effect of coastal power plant toward particularly the calanoid copepod composition and species diversity. Jiang et al. (2008) also showed how thermal stress from coastal power plant could affect the temperature tolerance in marine copepods which seem to be species specific. The sensitivity towards the temperature could be related to the life history traits of the copepod species (Lee et al. 2003). Further investigation on the seasonal effect of coastal power plants to the phyto- and zooplankton interaction would explain more on how the organism regulate their population abundance in such ecosystem.

CONCLUSION

Despite the limited study period, the present finding is able to improve our knowledge on the influence of the environmental condition to the planktons in Sungai Pulai estuary and potentially in relation to the coastal industrial area. Phytoplankton abundance is significantly different between periods of sampling while zooplankton differed significantly between stations. Phytoplankton could be influenced by the increase of salinity while zooplankton seemed to be influenced by the decrease of temperature. Planktons show their response towards the water parameters particularly in March. Seasonal monitoring is suggested for the interaction of phyto-and zooplankton as to understand the adaptability of the organism to the ecosystem with such industrial activities in Sungai Pulai and the Johor Straits.

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