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Physical Characteristics and Nutrients Status off Pulau Besar, Malacca and Tanjung Tuan, Negeri Sembilan, Malaysia: A Preliminary Study

Zuraini Zainol[1], Azizi Ali[1]*, Mohd Safuan Che Din[1], Mohd Fadzil Akhir[1], Zainudin Bachok[1] and Ahmad Ali[2]

[1]Institute of Oceanography and Environment, Universiti Malaysia Terengganu, 21030 UMT, Kuala Nerus, Terengganu, Malaysia
[2]Southeast Asian Fisheries Development Centre (SEAFDEC/MFRDMD), 21080, Kuala Terengganu, Terengganu, Malaysia

ABSTRACT

Degradation of coastal water quality is one of the major concern in the Malacca Strait since this area is one of the most important fishing ground in Malaysia. Despite being great in the fishery industry, Malacca and Negeri Sembilan somehow recorded the lowest marine fishes landing, which raises a question about dynamics of this area. It is therefore, a preliminary study of the physical properties and nutrient concentrations carried out from 27 March to 4 April 2016 at the coastal water off the southern west coast of Peninsular Malaysia, specifically at Pulau Besar, Malacca and Tanjung Tuan, Negeri Sembilan. Data for temperature, salinity, and dissolved oxygen (DO) was acquired by using Conductivity, Temperature, and Depth (CTD) probe. Meanwhile, nutrient concentrations determination in this study was done by using a Westco Smartchem 200 Discrete Analyser, according to the procedure adopted from United States Environmental Protection Agency (USEPA). In general, results of this study indicated the coastal stations were characterised with cooler, less saline, and high DO waters than stations away from coast. Large sea surface heating and weak winds were determined as the causative factors affecting dynamics of

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E-mail addresses:
zurainizainol0507@gmail.com (Zuraini Zainol)
azizi@umt.edu.my (Azizi Ali)
mscd87@gmail.com (Mohd Safuan Che Din)
mfadzil@umt.edu.my (Mohd Fadzil Akhir)
zainudinb@umt.edu.my (Zainudin Bachok)
aaseafdec@seafdec.org.my (Ahmad Ali)
* Corresponding author

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water column at the study area. At nearshore area, temperature, salinity, and DO variability were modulated by degree of freshwater intrusion. High nutrient concentrations at the stations closer to the coast was believed to be associated with river outflow, which acted as the main source of nutrients supply in this area. Comparison to previous study had shown that nutrient concentrations in this research were low, which could contribute to an insight on declining marine fish catches in these two states. With regard to Malaysian Marine Water Quality Criteria and Standard (MWQCS), mean nutrient concentrations at the study area were in Class 1, which are suitable for marine parks and marine protected areas conservation. Regardless of limited scope, the outcome of this study is believed to be a good baseline reference for future studies seeking to understand coastal dynamics.

Keywords: Freshwater intrusion, Malacca Strait, nutrients, physical parameters, preliminary study

INTRODUCTION

Malacca Strait is located between two large water bodies; the South China Sea and the Indian Ocean. This strait is home to extensive capture fisheries, providing employment to more than 200,000 fishermen (Chen et al., 2014). Facing this strait, are the states of Malacca and Negeri Sembilan on the southern west coast of Peninsular Malaysia. Due to their location, both states are exposed to sea-based activities (Yap et al., 2003). Among the major concerns in these areas are sea reclamation and sand mining activities (Chua et al., 2000), which have led to the degradation of coastal water quality and causing negative impacts on marine ecosystem, aquatic organisms, especially coral reefs (Praveena & Aris, 2013). For example, sea reclamation along 40km stretch of coast in Malacca, which began in September 1999, involved the reclamation of 2,835ha of shorefront and 300ha of sea front (Ling, 1999). The reclamation has negatively affected the livelihoods of fisherman, eroded the shoreline and destroyed marine life (Ling, 1999). These issues deserve a proper attention, since Malacca Strait is an important fishing ground for Malaysia and produces more than 50% of the fish catch for West Malaysia (Ke et al., 2016).

Although Malacca Strait is known as an important fishing area in Malaysia, somehow Malacca and Negeri Sembilan recorded the lowest landings of marine fish compared to other west coast states, with totals of only 1935.35tonnes and 805.97tonnes, respectively during 2014 (Figure 1; Department of Fisheries, 2017). This raises questions about the possible factors that lead to this problem. To tackle this issue, a baseline study is required to provide insight into the conditions of the area. Therefore, a scientific survey; a collaboration between the Institute of Oceanography and Environment (INOS) and the Southeast Asian Fisheries Development Centre (SEAFDEC), was carried out during March and April 2016, specifically at Pulau Besar, Malacca and Tanjung Tuan, Negeri Sembilan. Our aim was to obtain knowledge of the oceanographic features and nutrients condition within the study area. Hydrographic properties and nutrients distribution are highlighted in this paper because both the flux of nutrients and the physicochemical water properties are largely dependent on mixing of freshwater and seawater (Praveena & Aris, 2013).

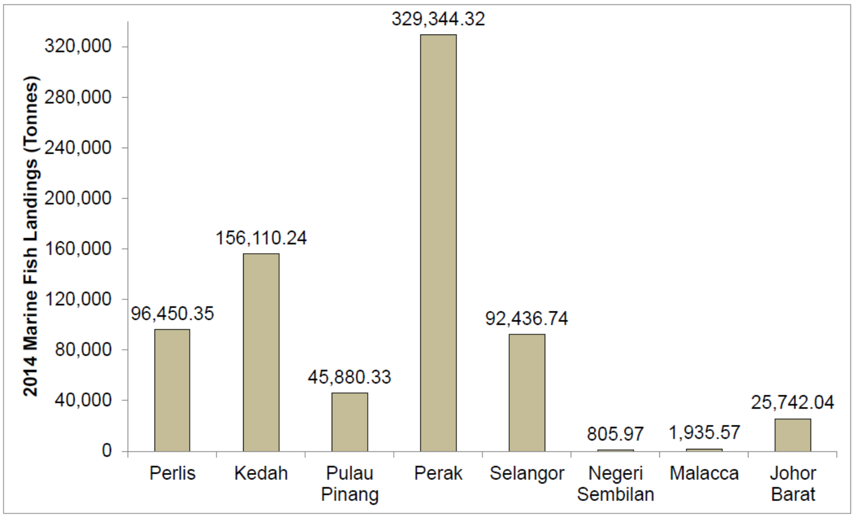

Figure 1. 2014 marine fish landings by west coast states (Department of Fisheries, 2017).

METHODOLOGY

Sampling Location

The oceanographic survey was conducted from 27 March until 4 April 2016. A total of 19 stations were involved in this survey, eight of them are located at Pulau Besar, Malacca and 11 of them at Tanjung Tuan, Negeri Sembilan (Figure 2). Vertical profiles analysis of temperature, salinity, and dissolved oxygen (DO) were made in accordance to longitudinal and latitudinal transects as shown in Figure 2. N1 is an alongshore transect that crosses along PB1 to PB4 of Pulau Besar (Figure 2). Meanwhile, E1 and E2 are the cross-shore transects that cross over PB1, PB5, and PB7 also PB2, PB6, and PB8, respectively (Figure 2). At Tanjung Tuan, N2 and N3 are the alongshore transects that cross along TT1 – TT10, while E3 represents the longitudinal transect that crosses over TT9 – TT11 (Figure 2).

Sampling Method

The main piece of equipment used was an SBE Plus19v2 Conductivity, Temperature, and Depth (CTD) probe, for collection of hydrographic data (*i.e*., temperature, salinity, and DO). The CTD probe was lowered down from the vessel to record the data. For nutrients analysis, a 5L Van Dorn water sampler was used to collect water samples during the sampling trip. The samples were pre-filtered through 0.7µm GF/C glass fibre filter paper and stored in 500mL sample bottles for laboratory analysis. Concentrations of ammonia, nitrate, and phosphate were analysed according to the United States Environmental Protection Agency (USEPA) procedure (U.S. Environmental Protection Agency, 1993) with a Westco Smartchem 200 Discrete Analyser (AMS-Alliance).

Data Analysis

The collected data were analysed for hydrographic characteristics and nutrients distribution. The CTD data were extracted by using the SBE Data Processing. Vertical profiles of temperature, salinity, and dissolved oxygen (DO) were plotted using MatLab® software to give a clear image of the parameters in the whole water column. Interim Reanalysis (ERA-Interim) with 0.25 X 0.25° resolution wind data obtained from European Centre for Medium-Range Weather Forecast (ECMWF) was used to observe wind pattern at the study area in a form of vector plot. Plotted results were then compared and analysed to characterise variation at each sampling station.

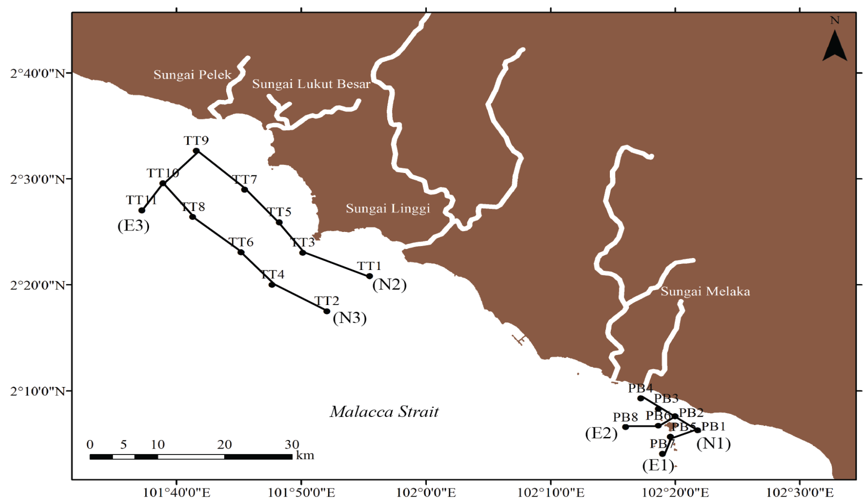

Figure 2. The location of study sites at the west coast of Peninsular Malaysia. The dots indicate locations of the sampling stations for hydrographic and nutrients data. Longitudinal (E1 – E3) and latitudinal (N1 – N3) transects are used to discuss the variability of vertical profiles at the study area. Note: The stations are referred as PB for Pulau Besar and TT for Tanjung Tuan in the explanation part later.

RESULTS AND DISCUSSION

Distributions of Temperature, Salinity and Dissolved Oxygen

In order to observe variations at Pulau Besar and Tanjung Tuan, vertical distributions of temperature and salinity are plotted in Figures 3 and 4. Across the ocean, stratification was observed at transects E1 and E2, where stations closer to the coast (PB1 and PB2) recorded slightly warmer temperature than stations away from the coast (PB7 and PB8; Figures 3a and 3c). It was believed that, large sea surface heating was the causative factor of the presence of warmer temperature at stations closer to the coast. With shallow water depth, solar radiation could penetrate deeper into coastal stations resulting in large sea surface heating and warmer temperature at the nearshore area. Similar finding was observed by Zainol and Akhir (2016), where sea surface heating was identified as the influencing factor that caused the separation of temperature distribution between nearshore and offshore area. Besides, Akhir et al. (2014) and Yanagi et al. (2001) also suggested that large sea surface heating was the possible reason for the development of stratification at water column, similar to those observed in the study area as manifested in Figures 3a and 3c. Similar to temperature trends, salinity across the ocean was also stratified throughout the water column with stations closer to the coast were characterised with less saline water than stations away from coast (Figures 3b and 3d). In general, coastal stations usually have low salinity water due to dilution factor as a result of freshwater outflow from the nearby river. With regards to Pulau Besar, coastal stations are located near Sungai Melaka, where freshwater discharge from this river could lead to the dilution of salinity in this area. Although no river discharge data was available from this study, however the role played by freshwater outflow in diluting the coastal water salinity has been acknowledged in few researches such as Panda et al. (2015) and Yin (2002). Apart from that, Akhir and Yong (2011) also documented low salinity values at stations closer to the coast and suggested it was likely existed due to nearshore water dynamics. At transect N1, the profile showed that the temperature and salinity along the coast were generally stratified for the whole water column (Figure 3e and 3f). The profile also revealed that the temperature decreased from PB1 to PB4, suggesting a presence of cooler water around PB4 (Figure 3e). This is consistent with the location of PB4, which is situated near Sungai Melaka (Figure 2). Figure 3f shows the salinity value along the coast remain constant with a mean surface salinity of 32.61 ± 0.03psu. A weak salinity shift from PB1 to PB4 observed at 5-m water depth indicated the presence of saline water intrusion towards Sungai Melaka. This is a common feature since data collection was done during high tide, where intrusion of slightly saline water into the nearest river is expected to occur.

At Tanjung Tuan, transect E3 showed opposite trend from alongshore transects at Pulau Besar (E1 and E2), where station closer to the coast (TT9) recorded slightly cooler temperature than station away from coast (TT11) with an average surface temperature difference of 0.21°C (Figure 4a). Interestingly, a clear salt wedge was noted in the vertical profile of salinity, where the inflow of saline water occurred at the surface layer and outflow of less saline water took place at the bottom (Figure 4b). This salt wedge also giving rise to a strong stratification, where sharp haloclines were observed near 12-m water depth (Figure 4b). From latitudinal transects, strong stratification was also observed in the water column

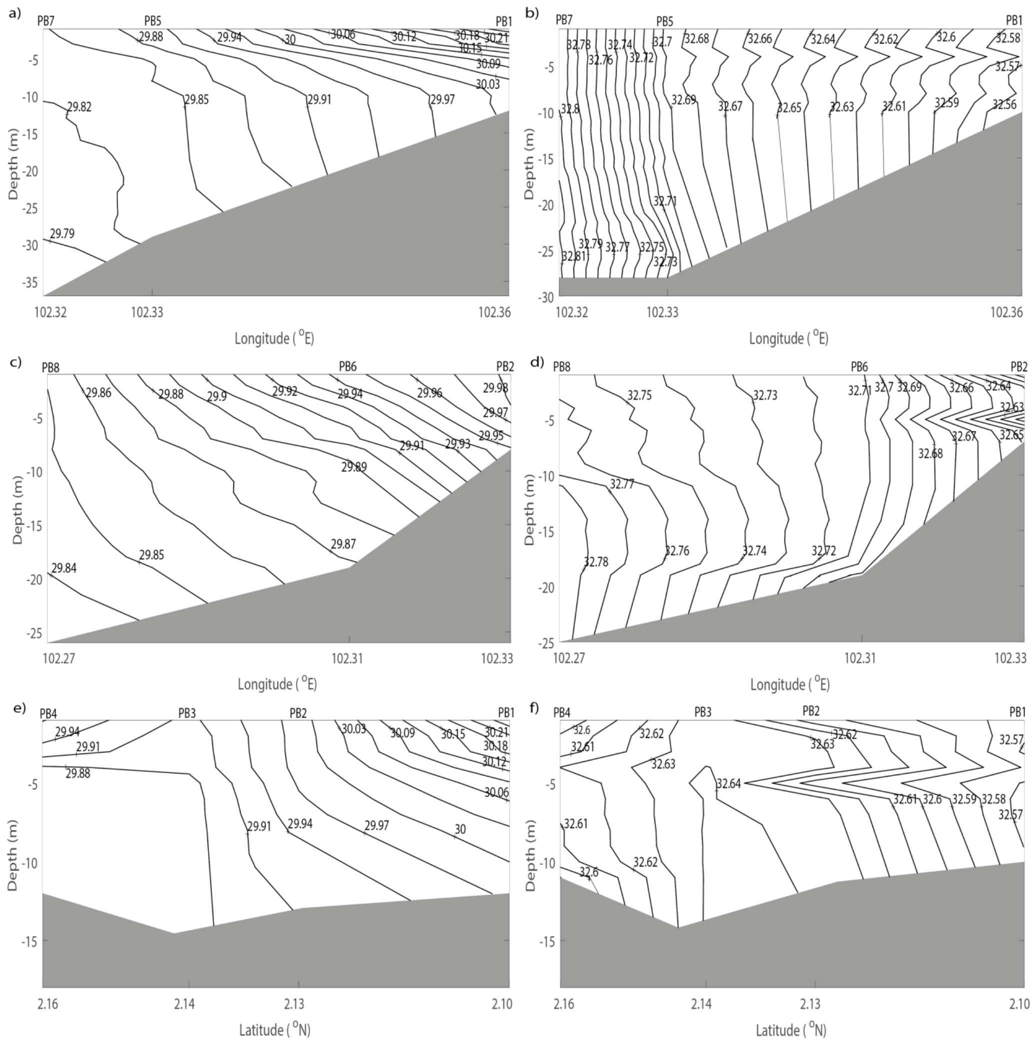

Figure 3. Vertical profiles of temperature (left panel) and salinity (right panel) at transects E1 (a + b), E2 (c + d), and N1 (e + f) of Pulau Besar.

especially along TT5 – TT9 and TT6 – TT10 (Figures 4c – 4f). Apart from sea surface heating, the generation of stratification in water column could also be caused by weak sea surface wind (Akhir, 2014). Surface wind data obtained from the ECMWF supported the statement, where the study area was characterised by weak surface wind with an average speed of 2.02m/s (Figure 5). Therefore, it can be inferred that the formation of stratification in the water column of the study area was under large sea surface heating and weak sea surface wind. Surprisingly, temperature and salinity values around TT9, TT10, and TT11 remained low, indicating these stations were dominated by slightly cooler and less saline water. This situation could be associated to the intrusion of cooler freshwater from Sungai

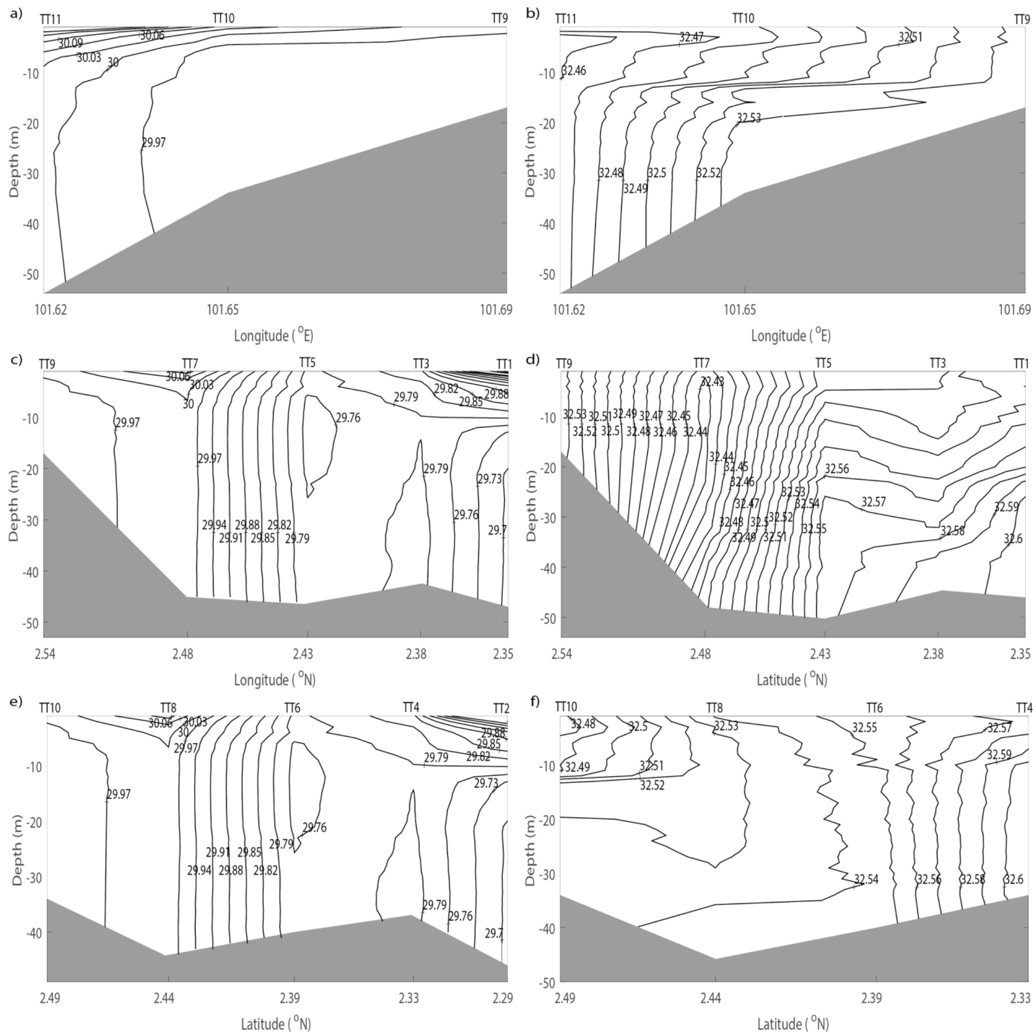

Figure 4. Vertical profiles of temperature (left panel) and salinity (right panel) at transects E3 (a + b), N2 (c + d), and N3 (e + f) of Tanjung Tuan.

Pelek; situated near TT9 and Sungai Lukut Besar; located near TT7. In coastal area, few studies (Akhir et al., 2011; Rojana-anawat et al., 2001) have acknowleged freshwater intrusion as the governing factor that influence the physical characteristic in this area.

Figure 6 illustrates the DO concentrations in the water column of Pulau Besar and Tanjung Tuan during the sampling period. In overall, Figure 6 reveals that DO trends in this study followed an established general pattern of DO distribution, in which coastal water contains more dissolved oxygen (Rojana-anawat et al., 2001). Surface DO values ranged from 6.19 – 6.31mg/L and 6.19 – 6.24mg/L at Pulau Besar and Tanjung Tuan, respectively. Similar to temperature and salinity distribution, DO concentration at Pulau

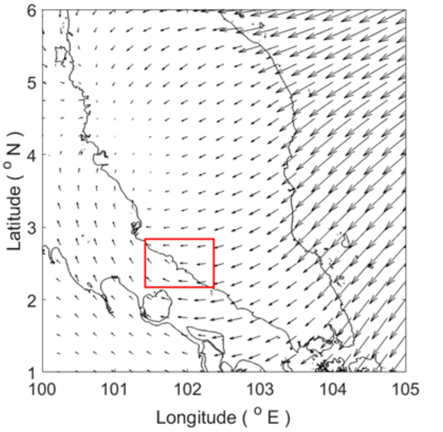

Figure 5. Average surface wind speed during the sampling trip of 27 March – 4 April 2016.
Note: → 2m/s.

Besar and Tanjung Tuan was also stratified throughout the water column as a result of large sea surface heating and weak winds. Compared with previous research, the DO concentration at both Pulau Besar and Tanjung Tuan was relatively constant and within the range (2.2 – 12.03mg/L) reported by Yap et al. (2011).

Nutrients Distribution in the Study Area

Nutrient concentrations at the surface water of Pulau Besar and Tanjung Tuan are shown in Figure 7. In general ammonia concentrations at the study site spread between 0.54 – 1.26µM.

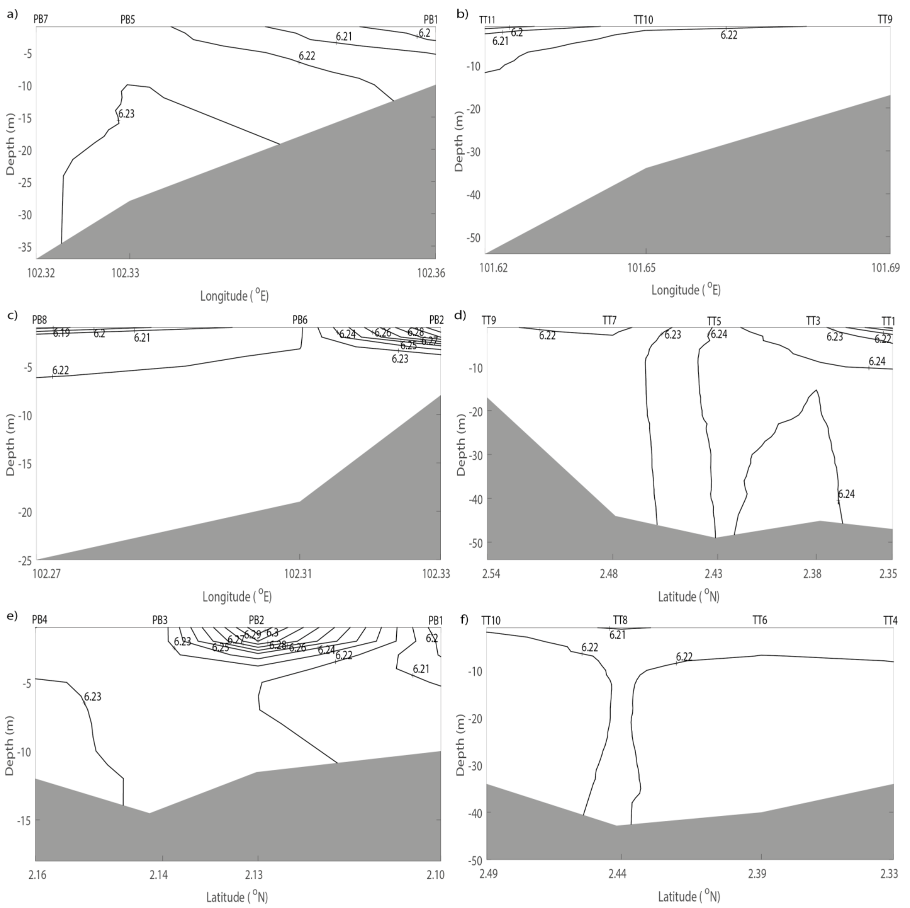

Figure 6. Vertical profiles of DO at Pulau Besar (left panel) and Tanjung Tuan (right panel) at longitudinal (a – c) and latitudinal (d – f) transects.

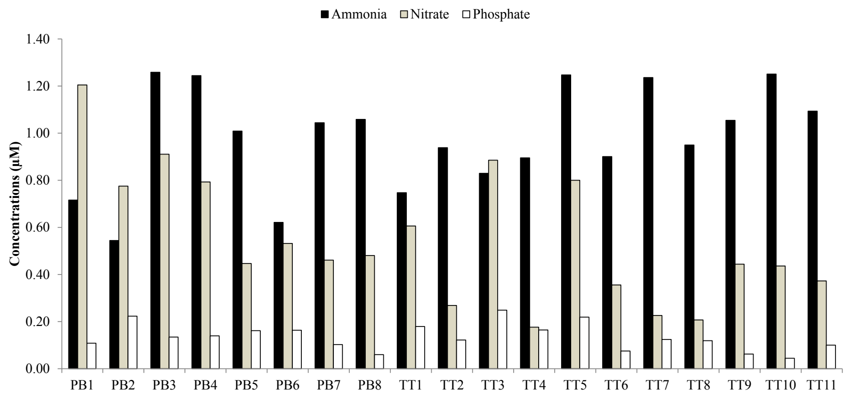

Figure 7. Surface ammonia, nitrate, and phosphate concentrations at Pulau Besar and Tanjung Tuan during the sampling trip.

At Pulau Besar, stations closer to the coast (PB1 – PB4) recorded slightly higher ammonia concentrations with a mean of 0.94 ± 0.37µM compared to stations away from coast (PB5 – PB8; 0.93 ± 0.21µM). Similar to Pulau Besar, coastal stations at Tanjung Tuan (TT1, TT3, TT5, TT7, and TT9) recorded slightly higher ammonia concentrations than stations away from coast with a small mean difference of 0.03µM. For nitrate, it was within a range of 0.18 – 1.20µM, where stations closer to the coast of Pulau Besar and Tanjung Tuan documented slightly higher concentrations compared to stations away away from coast with an average difference of 0.44µM and 0.30µM, respectively. Contrary to ammonia and nitrate concentration, phosphate values during the study trip remained low and distributed within 0.03 – 0.13µM. Despite being low, phosphate concentrations at Pulau Besar were still higher at coastal stations (0.15 ± 0.05µM) than stations away from coast (0.12 ± 0.05µM). At Tanjung Tuan, stations closer to the coast also contained higher phosphate with a mean of 0.17 ± 0.07µM than stations away from coast (0.10 ± 0.05µM).

In overall, the nutrients distribution at Pulau Besar and Tanjung Tuan followed the general expected pattern, where stations closer to the coast showed slightly higher nutrients concentration than stations away from coast. Study by Zainol and Akhir (2016) also found similar observation and suggested that it was under the influence of high nutrient input from river transport. In previous research, Bong and Lee (2008) also concluded that antropogenic activities and surface runoff were the responsible factors affecting high nutrients at nearshore area in Malacca Strait. Apart from high nutrient concentrations at coastal station, Figure 7 also shows freshwater-end-stations were characterised with higher nutrient concentrations. This was a predictable finding, since rivers are usually enriched in nutrients, causing nearby areas to show slightly high concentrations, meanwhile dilution effects of seawater lead to low nutrients value (Suhaimi et al., 2004). Comparison with previous study by Praveena et al. (2011) showed that nutrient concentrations in this research was generally low (Table 1).

This finding could be one of the causative factors that lead to the declination of marine fish landings in these two states as illustrated in Figure 1 since nutrients availability is known as the drivers of abundant fish production (Azhikodan & Yokoyama, 2016). In evaluation with Malaysian Marine Water Quality Criteria and Standard (MWQCS; Table 2) obtained from Department of Environment, Malaysia, the mean concentrations of ammonia (13.74 ±3.09µg/L), nitrate (7.65 ±3.91µg/L), and phosphate (4.16 ±1.76µg/L) at the study area are in Class 1, which are suitable for preservation as marine protected areas and marine parks suggesting that these areas need to be conserved.

Table 1

Comparison between nutrients concentration found by the current study and by Praveena and Aris (2013).

Nutrients	Current Study	Praveena and Aris (2013)
Ammonia (µg/L)	7.63 – 17.63	120.00 – 180.00
Nitrate (µg/L)	2.47 – 16.88	10.00 – 50.00
Phosphate (µg/L)	1.38 – 7.70	60.00 – 90.00

Table 2

Marine Water Quality Criteria and Standard for Malaysia.

Parameter (µg/L)	Class			
	1	2	3	E
Ammonia	35	70	320	70
Nitrate	10	60	1000	60
Phosphate	5	75	670	75
Beneficial uses				
Class 1	Preservation, Marine protected area, Marine parks			
Class 2	Marine life, Fisheries, Coral reefs, Recreational and Mariculture			
Class 3	Ports, Oil & gas fields			
Class E	Mangroves, estuarine & river-mouth water			

CONCLUSION

A preliminary study of the physicochemical characteristics of Pulau Besar, Malacca and Tanjung Tuan, Negeri Sembilan gives us an idea about the physical conditions and nutrients status of the study area. Physical parameters at the water column of the study area (temperature, salinity, and DO), are influenced by sea surface heating and weak surface winds. At nearshore area, local setting such as freshwater runoff from nearby rivers shaped the dynamics in this zone. Nutrients distribution suggest that ammonia, nitrate, and phosphate in the study area followed an expected pattern, with stations closer to the coast showing higher nutrients level and classified as Class 1 by referring to Malaysian MWQCS. Low nutrient concentrations at this area could possibly become a reason of low marine fish landings in this area. Although the present study is limited in scope, it provides beneficial information to use as a baseline for future studies in this area. Furthermore, it is believed that this study is important in assessing the past and present water quality for sustainable management of this area.

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