Subsurface Ocean Characteristic in the Mentawai Waters during Monsoon Transition Phase on Last 2020

**J S Hamonangan**, **I P Anwar**, **M Irfan**, **O Moefti** and **D L Rolian**

*Laboratory for Marine Survey Technology, Agency for the Assessment and Application of Technology Jalan M.H. Thamrin 8, Jakarta 103040, Indonesia*  
*Earth Sciences Study Program, Faculty of Earth Sciences and Technology, Institut Teknologi Bandung Jalan Ganesha 10, Bandung 40132, Indonesia*  
*Ocean University of China No.238 Songling Road, Laoshan District, Qingdao City, Shandong Province, China*

julianto.saut@bppt.go.id

**Abstract.** The Indonesia Continental Shelf (LKI) expedition was held during September - October 2020. During the survey, there were ten Conductivity Temperature Depth (CTD) measurement stations that located extending from the west of Mentawai Island to the Indian Ocean. In this study, two-line of subsurface temperature, salinity, and density data were plotted longitudinally. The results show the unique feature between the open ocean and coastal area, the characteristic from open ocean did not affect the characteristic in coastal zone, it is shown from the salinity data. The maximum salinity found in the thermocline layer, between 100-150 m in both of line. The salinity increases from the surface until the thermocline, then slightly decreases to the deep layer. The surface salinity in the coastal area significantly different from the open ocean, it is less than 34 PSU. That is the fact that Wyrtki Jet current did not induce the open ocean water to the coastal water in the subsurface. Otherwise, the temperature and density have a similar pattern with range values around 9-31°C.

1. **Introduction**

The Indonesia Continental Shelf (LKI) expedition is a scientific expedition led by Agency for the Assessment and Application of Technology Indonesia (BPPT) and The Geospatial Information Agency (BIG). It plans to exercise the hydro-oceanography condition in border areas of Indonesia waters extent [1]. One of them is West Sumatra waters. The survey in the West Sumatra waters area was already done in recent years. It retrieved some Conductivity Temperature Depth (CTD) station data and other hydrographic and oceanography data.

The west Sumatra waters have unique features in both hydrographic and oceanography. The depth ranges from 0 to 6500 m. The small island along the coast of Sumatra existed. The Mentawai Islands is the area included in this research. The depth of the sea between Sumatra coast and Mentawai Island is no more than 1200 m. But in the western of Mentawai Island up to 6500 m [2].

Indonesia has been influenced by monsoonal wind. Also, Mentawai Islands is in western part of Sumatra waters. The wind direction has two peaks in a year, Northwest Monsoon (NWM) and Southwest Monsoon...
(SWM). Then among them the transition 1 (T1) and 2 (T2) exist. The NWM occurs during December to March, the T1 in April to May, while NWS in June to August, the T2 in October to November [3]. The wind system affected the current circulation, ocean waves and other ocean dynamics.

The strong current appears in the equatorial tropical Indian Ocean. It exists during the transition season (T1 and T2) at a depth of 80-100 m [4][5]. The strong current was found by Wyrtki. Thus, it is called the Wyrtki Jet [6]. It is characterized by warm water. Then it deepened the mixed layer around the western Sumatra waters, including Mentawai waters. The magnitude of Wyrtki Jet in T1 is reach up to 0.7 m s-1 [7]. While in T2 around 1.0-1.3 m s-1 [8].

Here, we present the analysis of CTD measurement in 2020. This study reveals the unique water mass characteristic in The Mentawai waters and its surrounding area. Understanding the water mass in that area is part of natural resource potential mapping [8].

2. Data and methods

2.1. Field Survey

The Continental Shelf Survey in West Sumatra was held from 27 August – 10 November 2020 using RV Baruna Jaya I. The survey was a collaboration between Geospatial Information Agency (BIG) and Agency for the Assessment and Application of Technology (BPPT). Ten oceanographic stations were conducted to obtain temperature and salinity data from CTD SBE 9Plus (see Figure 1). Research sites were in the western part of Sumatra, within coordinates of 02°33’46” – 05°55’47” and 94°49’09” – 99°26’42”.

2.2 Data Analysis

Figure 1. The location of observation Conductivity Temperature Depth (CTD) in red dots and bathymetry derived from GEBCO 30’
Ocean Data View (ODV) 5.1.2. employed to figure the Temperature (T), Salinity (S), and Density. The vertical and horizontal chart of T, S, and for all stations were plotted to identify general characteristics of water mass. The T-S diagrams were made to analyze the relation between salinity and temperature at the same time along the water column to identify the water mass characteristics. The analysis was made to identify the origin of water masses refer to water mass characteristics of their properties. To present the cross-sectional distribution of the water mass properties, the research stations were grouped into 2 transects as listed in Table 1.

| Table 1. Grouping the Research Stations |
|----------------------------------------|
| Location | Station |
| Transect 1 | 6, 7, 8, 9, 10 |
| Transect 2 | 5, 4, 3, 2, 1 |

3. Results and discussion

3.1. Spatial vertical water mass property

Sea temperature in Indonesian waters usually influenced by monsoon season, besides the topographic pattern[3]. From the sea temperature profile, it shows the mixed layer, thermocline layer, and deep layer. Spatial vertical temperature and salinity for two transects are shown on Figure 2 and Figure 3. Generally, the sea surface temperature is about 29 – 30°C, then gradually drops to 25°C in the 100-150 m depth. The temperature then falls significantly to 15°C until about 180 m depth. Furthermore, there is a slight decrease in the temperature value from 200 m depth about 12.5°C until 1000 m depth with the temperature around 5°C. From transect 1, sea surface temperature in station 10 is cooler than other stations. While in transect 2, the surface temperature in all stations have quite similar patterns.

From transect 1 and 2, the mixed layer shows in 0 – 50 m depth, with the temperature around 29 – 29.5 °C, the thermocline depth shows in 65 – 165 m depth, with the temperature between 14 – 28 °C, and deep later starts from the 180 m depth to the bottom. However, there is an anomaly in station 10 (located near Mentawai Island) when the thermocline shows in 50 m depth. Compared to previous research, [9] the average of thermocline depth in September is around the 96 -112 m depth. The thermocline layer West Sumatra is shallower than other months.

Vertical salinity distribution graph shows the mixed layer, halocline, and deep layer. On the surface, the salinity is about 33.5 – 33.75 PSU. Therefore, there is a relatively increase in the salinity value in the 50 – 150 m depth (halocline), from 34.25 PSU – 35 PSU. In the deep layer, the salinity value reached the highest in the 150 – 300 m depth. Moreover, from 300 m – 1000 m depth, the salinity almost has a similar value, around 34.8 PSU.

From the graph, the surface salinity in station 1 and 10, which is located nearest to Mentawai Island, are lower than other stations. That is because the water mass in those stations is more influenced by the water mass from the coast of west Sumatra.
Figure 2. Vertical temperature (a) and salinity (b) from transect-1 (c)
Figure 3. The vertical temperature (a) and salinity (b) from transect-2 (c)
3.2. Influenced by remote water mass

The T-S diagram was conducted from 10 CTD stations for water mass analysis (Figure 4). Based on the T-S diagram, we identified numbers of water mass in the research area. Based on the known water mass [10][3], we identified four water masses. First, Bengal Bay Water (BBW), which are characterized by temperature around 25-29 °C and salinity 28 – 35 PSU. Second, Subtropical Lower Water (SLW), with the temperature about 16 -27 °C and salinity 34.6 – 36 PSU. Third, Southern Salinity Minimum (SSM), with the temperature around 12 – 17 °C and salinity 34.5 – 34.8 PSU. Fourth, Red Sea Water (RSW), which are characterized with the temperature around 8 -11°C and salinity around 34.7 – 35.1 PSU. Lastly, South Indian Central Water (SICW), that are characterize by temperature 8 – 25 °C and salinity 34.6 – 35.8 PSU.

![Figure 4. The color in the dots map (a) represent to the line color in T-S Diagram (b)](image_url)

The water masses in research area were identified from the Indian Ocean and It is surrounding waters. The Southwest Sumatra waters strongly influenced by Indian Ocean dynamic [11][12][13]. But, in station 10 we could see the coastal characteristic. The thermocline less than 50 m and the salinity under the 33 PSU. It indicated the coastal influenced.

4. Conclusions

Five water mass characteristics were identified in Mentawai waters during October 2020. They area come from Indian Ocean and Its surrounding waters area. The thermocline was existing in 100-150 m depth.
While in Station 10 at 50 m depth. We suggested that the Station 10 more influenced by the coastal area. Then, the almost all of station influenced by Indian Ocean waters dynamic.

References
[1] BPPT 2020 Final Report (Jakarta) p.57.
[2] Zitellini, N et al., 2009. Earth and Planetary Sci. Letters 280, 13-50.
[3] Wyrtki K, 1961, Naga Report 2 (California) p.
[4] Timmermans M Z M 2015 J. Geophys. Res. Ocean. 5302–5317.
[5] Duan Y et al., 2016 Sci. Rep. 6 1–7.
[6] Schott F A, Xie S P, and McCreary J P, 2009 Rev. Geophys. 47(1) 1–46.
[7] Tomczak M and Godfrey J S, 1994, CHAPTER 11 (Amsterdam: Pergamon), p. 193–220.
[8] Purwadana A et al., 2021 IOP Conf. Ser.: Earth Environ. Sci. 789.
[9] Puteri, I.R, 2021, Thesis. (Medan: Universitas Sumatra Utara), p.127.
[10] Emery, W.J. 2003 (United States of America: Elsevier Science Ltd.) p.1556-1567.
[11] Cahyarini S Y et al., 2021 Sci. Rep. 11 14952.
[12] Bernawis, L I et al., 2019 J. Ilmu dan Teknologi Kelautan Tropis 11(3) 713-720.
[13] Anwar I P et al., 2021 J. Enggano 6(2) 223-237.

Acknowledgement
The authors thank to the crew and Captain of the RV Baruna Jaya I for helping with the data acquisition during the observations. Also, thank to Head of Laboratory for Marine Survey Technology (Agency for the Assessment and Application of Technology) and the Geospatial Information Agency (BIG) for support this research.