Distribution of Current and Temperature at Welang Estuary, Pasuruan

Inayatul Lailiyah[1], Suntoyo[1], Wahyudi[1], Fauzy Nasruddin[2] and Liliane Geerling[3]
[1]*Department of Ocean Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember (ITS), 60111 Surabaya, Indonesia*
[2]*Department of Water Resource Management, Public Works and Water Source East Java Province, Surabaya, Indonesia*
[3]*Delta Academy, Water Management, HZ University of Applied Sciences, Middelburg, 4331 NB, The Netherlands*

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Abstract: Welang river estuary has many benefits to the surrounding community, i.e for the fish and shrimp farming. Estuary ecological management in this area is important. In which, it is necessary to understand the dynamics of the waters so that the estuary area can be managed properly. The purpose of this study was to determine the characteristics of the welang estuary using 3D modeling. Welang river estuary influenced by tidal conditions. The current pattern that occurs in the welang estuary moves from southeast to northwest. Current velocity around the welang estuary at the surface of the water tends to be greater than at the bottom of the water. This is because of the influence of the wind. The horizontal temperature distribution tends to be uniform and vertically shows no thermocline layer at the welang estuary.

1 INTRODUCTION

The coastal region of Indonesia has a fairly extensive estuary area, one of which is on the north coast of Java, some researchers have studied related to the estuary environment in several locations, e.g., Porong, Wonorejo and Wonokromo river. (Suntoyo et al., 2015; Suntoyo and Sakinah, 2017; Sakinah et al., 2017; Pahlewi et al., 2017; Kauhl et al., 2018). Welang watershed is located in Malang Regency, Regency and Pasuruan City. The Welang River empties into the Kraton Subdistrict, Pasuruan Regency which is directly related to the Madura Strait (Febriyanto et. al., 2018). Welang estuary is an estuary ecosystem that has an important function as a biota habitat, such as fish. In addition, this area is used by local residents as fish and shrimp ponds. The more activities that occur in estuary areas, the area will have an influence on the quality of estuarine waters, directly or indirectly.

Until now, some informations regarding the characteristics of the welang estuary is currently limited. So the need for further research in the estuary area to be able to develop its designation, such as ports, transportation routes, tourist areas and fish farming. The characteristics of flow patterns, temperature and salinity are important parameters in water dynamics that have an influence on water circulation (Pahlewi et. al., 2017; Suntoyo and Sakinah, 2017; Sakinah et al., 2017).

Determination of estuary type is the initial stage in carrying out development planning in the estuary by taking into account its characteristics such as current, temperature and salinity. Therefore the purpose of this study is to analyze the characteristics of the waters in the welang estuary based on the parameters of current, temperature and salinity and can determine the type of estuary in the estuary of the Welang.

Current and temperature distribution were modeled by using 3-dimensional models in order to explain the distribution horizontally and vertically. Furthermore, these results was analyzed to explain the characteristics of Welang estuary waters.

2 STUDY AREA

The research location is in the Welang River estuary in the Kraton and Ketug Pasuruan Districts. Welang River itself crosses Malang Regency, Pasuruan Regency and Pasuruan City, East Java Province empties into Madura Strait.

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The modeling location in this study is shown in Figure 1, where the blue area indicates the modeling area. Direct measurements consist of current, temperature and salinity carried out at 5 sampling stations with 3 different depths (0.2d, 0.6d and 0.8d). The model simulation was carried out for 6 months, from July 2019 to January 2020. Geographically, the Welang Estuary is located at 112,861ºE - 112,896ºE and 7,584ºS -7,590ºS.

3 METHOD

The methodology used in this research, the first step is the study of literature to support the study to be carried out, followed by the collection of data which includes primary data and secondary data. Primary data were obtained by performing direct measurements in the field which included temperature, flow velocity and salinity data. Whereas secondary data was obtained from various related agencies and this data used for input simulation models such as bathymetry, tides, wind, and river discharge data. After data collection, the next step is to process bathymetry data which will become input data in the simulation of current and temperature distribution using 3D modeling where the output is current and horizontal and vertical temperature distribution. Modeling and simulation was done using computer software with a simulation time of 30 days or 720 hours in November 2019, to obtain the good results, the model validation was conducted. Then analyze the results and finally conclusions.

4 MODEL VALIDATION

The results of the modeling of the current pattern are validated using tidal data obtained from measurement results on November 1, 2019 - December 1, 2019 at the Grati Power Plant and the current velocity measured at point St 21 (Figure 2) by using current meter. In general, the results of the model and measurement data show a trend that is equal to the MAPE (Mean Absolute Percentage Error) value of 0.35% (Figure 3). Current measurements are carried out on 14 November 2019 at 12.00-21.00 WIB within all three depths (0.2d, 0.6d, and 0.8d) using a current meter (Figure 4). The results of the current velocity from the three depths are then averaged. The results of the current validation at point St 21 show a MAPE value of 27.5%, while the RMSE value is below 1.00. Model validation is acceptable because the error is still below 30%. The validation of current velocity modeling is classified as Reasonable forecasting.

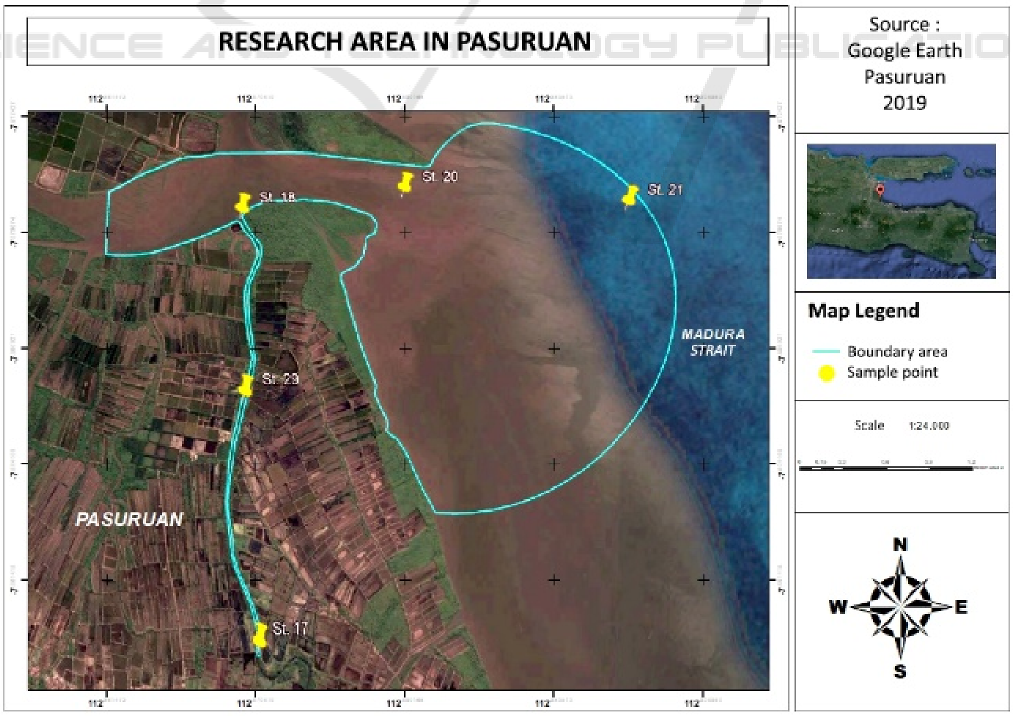

Figure 1: Study Area Including of Observational Stations (Google Earth).

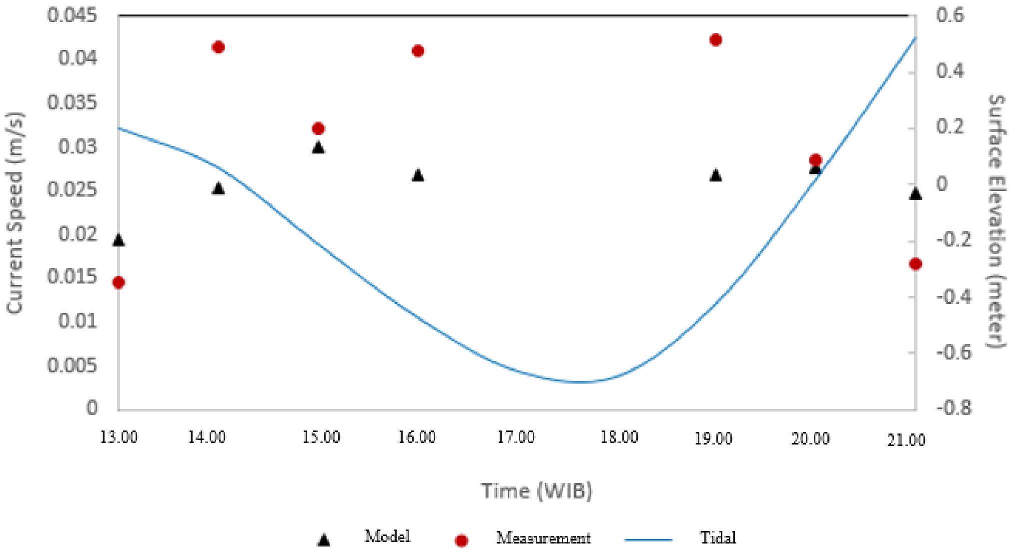

Figure 2: Validation of Current Velocity at Point St 21.

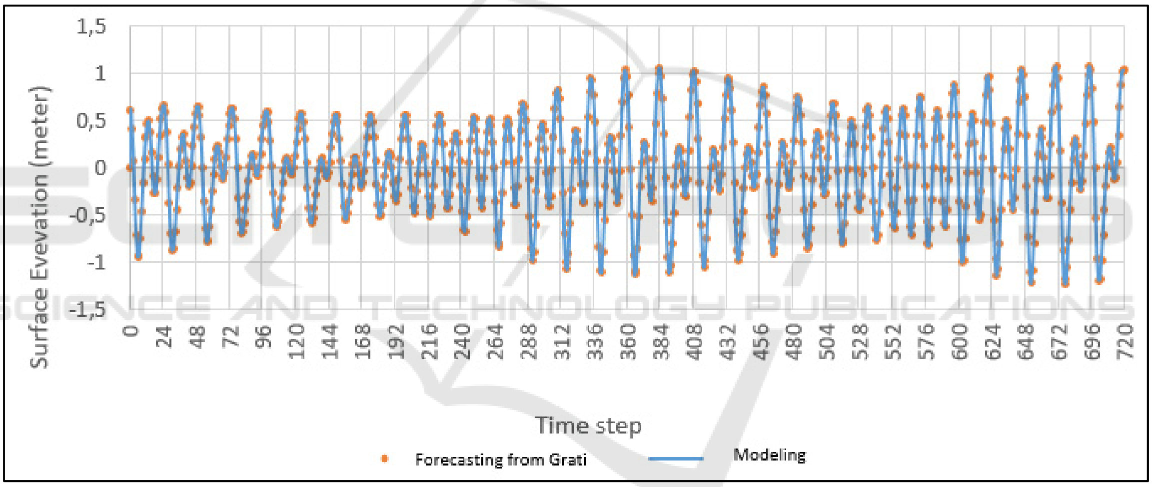

Figure 3: Comparison of Tidal Elevations between Forecasting Data and Model Results.

5 RESULTS AND DISCUSSION

The modeling results presented in this paper are the horizontal and vertical distribution of velocity and temperature. From the simulation results, the sea level with the highest tide is 1.052 m in step 384, while the lowest tide with -1.132 m in step 366. Where the highest tide conditions occur on November 17, 2019 at 00.00 WIB and the lowest tides occur on November 16, 2019 at 06.00 WIB. Based on tidal data analysis, the Welang estuary is a valid semi-diurnal tidal type (Figure 4).

At highest tide conditions, the current pattern moves from southeast to west toward the estuary, while the current pattern at lowest ebb moves east towards the sea. The frequency of the direction current is more dominant in the west-northwest direction, this is due to the east monsoon wind pattern as well as shown by (Sugianto, 2009). The current velocity at point 18 show that the highest tide occurs between 0-0,06 m/s and the lowest tidal current between 0.015-0.105 m/s presented in Figure 5.A and 5B. The current velocity at the highest tide tends to be lower than at lowest ebb. The Reason is at high tide, seawater moves into the river and at the same time, the river water pushes upstream. At lowest ebb, currents tend to be higher because the water just pushes out towards the river mouth and increases the current velocity.

From the distribution of current at the highest tide and lowest ebb shows that the value of the current speed at the top is greater than at the bottom of the waters. this is due to the effect of the wind coming from the southeast as well as the bottom shear stress reduced the velocity in the sea bottom (Figure 6).

In the vertical distribution, reviewed at 2 points namely point IP1 and IP2 (see Figure 7) which are around the point 18 estuary. Current distribution at the highest tide conditions (384 step), at a distance of 0-80 m from IP 1, the speed current is varies from surface to bottom waters. On the surface the current velocity ranges from 0.008 to 0.096 m/s while the current velocity at the bottom of the waters is around 0.008-0.072 m/s. at a distance of 80-220 m, uniform current velocity distribution from surface to bottom. Where the current speed is around 0-0.016 m/s (Figure 8 A.).

Current distribution at the lowest ebb condition (step 366), at a distance of 0-80 m from IP 1, the current speed is varies from surface to bottom of the waters. On the surface the current speed ranges from 0.048-0.120 m/s. while at the bottom of the waters, the current speed is around 0-0,024 m/s. At a distance of 80-220 m, the current surface velocity values are around 0-0,048 m/s and at the bottom of the waters the current speed is around 0-0,032 m/s (Figure 8.B).

At the highest tide conditions, high temperatures from the sea towards the river mouth. The temperature in the river body area ranges from 30.10-30.50 °C. Whereas in river mouths the temperature is around 30.55-30.65 °C, and at sea temperatures above 30.65 °C (Figure 9.A.). The pattern of temperature distribution at the lowest ebb conditions shown in Figure 9.B. In the river body area, the temperature value is around 30.10-30.2 ° C, while the temperature value in the river mouth area is around 30.2-30.45 ° C and in the sea area the temperature value is around 30.5-30.7 ° C.

Overall the temperature at highest tide in the estuary area is caused by the push coming from the sea which has high temperature. Whereas at lowest ebb the temperature in the estuary tends to be low because at ebb the flow is only influenced by the river discharger that goes to the sea, so that the temperature carried from the upstream of the river is low towards the sea gives the effect of decreasing the temperature in the estuary to the sea

The distribution of temperature at the highest tide conditions at a distance of 0-20 meters, the temperature value is around 30.58-30.61 ° C. at a distance of 20-210 meters the temperature value is around 30.61-30.64 ° C and the temperature value at a distance of 210-280 meters is around 30.64-30.67 ° C (Figure 9.A). The distribution of temperature at the lowest ebb conditions at a distance of 0-110 meters around 30.25-30.28 ° C, while at a distance of 110-220 meters the temperature value tends to vary at around 30.31-30.52 ° C (Figure 9.B).

In general, the vertical temperature distribution pattern in both conditions in the welang estuary tends to be uniform from top to bottom. Although the value of the surface layer is greater than the middle and base layers. This is due to the influence of direct sunlight. Distribution of temperature from surface to base there is no thermocline layer. This is because in this area including shallow water so the temperature tends to be uniform as well as shown by (Alosairi et al. 2018).

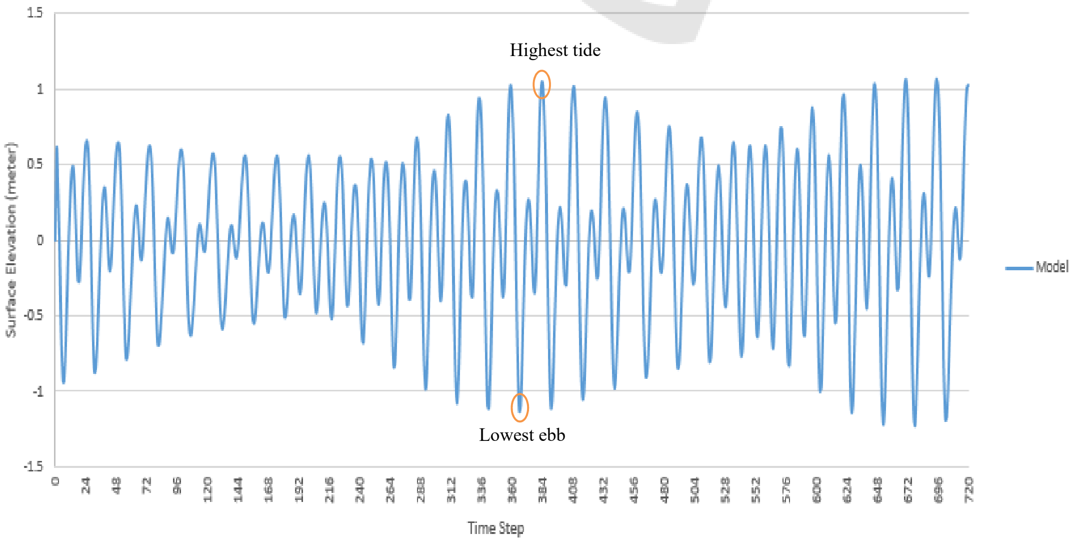

Figure 4: Water Suface Elevation.

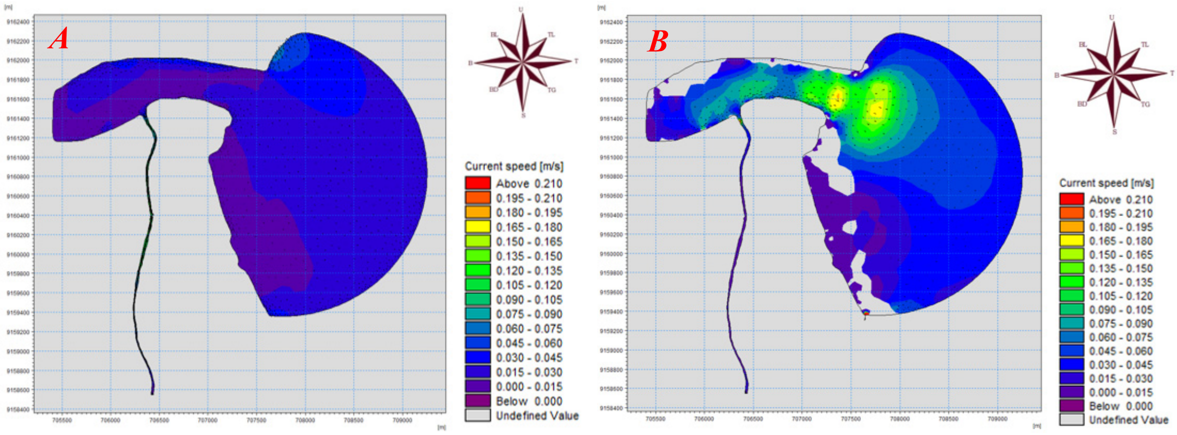

Figure 5: Horizontal Current Distribution in **A**: the Highest Tide, **B**: the Lowest Ebb.

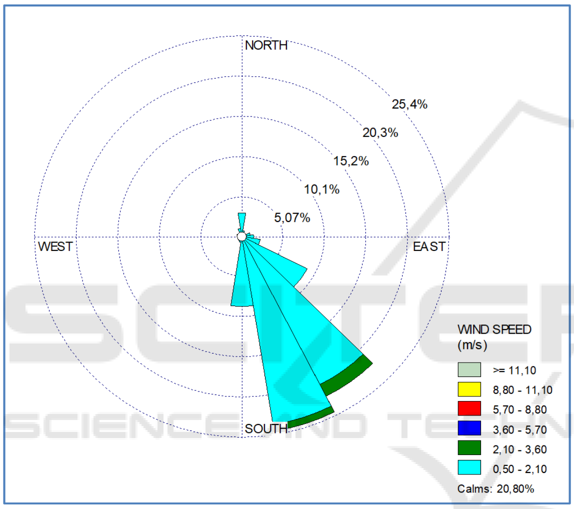

Figure 6: Wind Rose Direction and Speed Current Distribution.

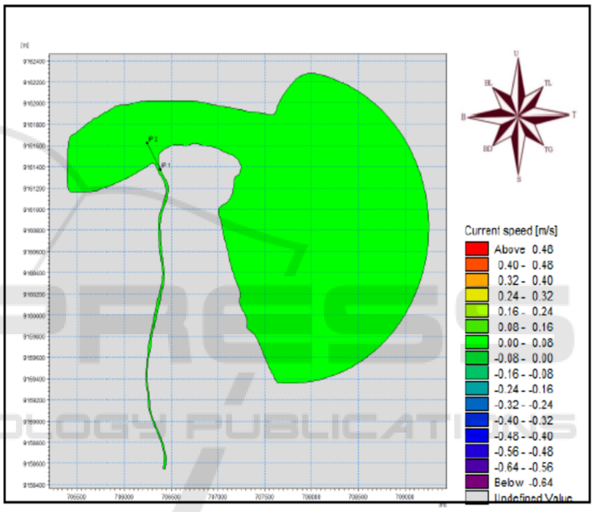

Figure 7: Position IP1 and IP2 Cross-section.

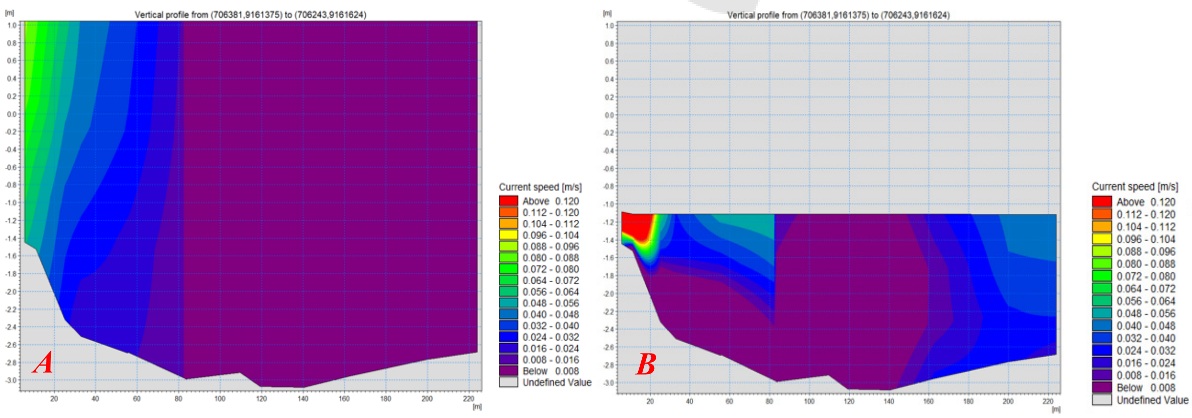

Figure 8: Horizontal Temperature Distribution in A: the Highest Tide, B: the Lowest Ebb.

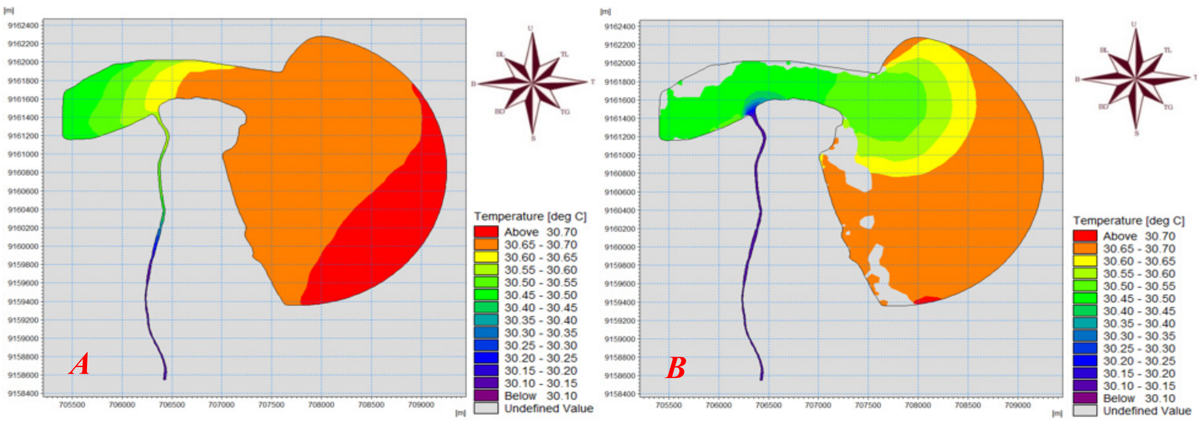

Figure 9: Horizontal Temperature Distribution in A: the Highest Tide, B: the Lowest Ebb.

6 CONCLUSION

The current pattern that occurs in the welang estuary is moving from the southeast toward the northwest. The speed current around the welang estuary at the surface of the water tends to be greater than at the bottom of the water. This is due to the effect of the wind. The horizontal temperature distribution tends to be uniform and vertically shows there is no thermocline layer in the welang estuary and the temperature distribution from the surface to the bottom does not differend so that the distribution is evenly distributed only slightly higher on the surface due to direct sunlight so that the surface is hotter compared to the bottom .

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