Type of mixing confluence between Mahakam and Karang Mumus Rivers based on temperature and salinity distribution tidally

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Abstract. Observations of physical oceanographic parameters including temperature and salinity were carried out in Estuary Mahakam and Karang Mumus Rivers, on July 8, 2018, and July 14, 2018, to determine the vertical distribution patterns of temperature and salinity used to identify the type of estuary confluence Mahakam and Karang Mumus Rivers. Observations were conducted at 9 points and 11 points when the neap tide and the spring tide conditions were in the estuary area to enter the Karang Mumus river at the surface, middle and bottom layers. Temperature and salinity parameters were measured using the CTD Minos sensor system equipment. X PDC-B0900 which can simultaneously record profiles of temperature and salinity parameters lowered to the bottom of the water while the point position was determined using GPS. The results of the observation of temperature distribution showed that in the Estuary between Mahakam and the Karang Mumus Rivers did not have a thermocline layer. This was because of the depth of the water under study including shallow water. Salinity distribution was obtained with a relatively homogeneous salinity towards depth water. Homogeneous salinity is an indication of a well-mixed vertical process between seawater and freshwater.

1. Introduction

Estuaries are regions where rivers meet inlets of the sea, and most estuaries still retain the main features of river valleys, often having meandering courses and numerous tributaries. Their upper limit is generally considered to be the furthest point where the tidal rise and fall can be detected. Estuaries can usually be divided into three sections: a lower (or marine) estuary, in free connection with the open sea; a middle estuary, where most of the mixing between seawater and river water takes place; and an upper (or fluvial) estuary, dominated by freshwater influences but nevertheless subjected to daily tidal rise and fall, like the rest of the estuary [1]. The estuary region is a semi-enclosed coastal with a water body having a free relationship with the open sea and dissolved seawater in freshwater from the river [2]. A characteristic of the interaction between land and oceans in estuary waters is the mixing and distribution of freshwater from the river towards the sea and vice versa. Water from rivers mixed with salty seawater will result in increased salinity, where salinity will increase to the sea [3].
Based on the interaction between freshwater flow and tidal circulation, classifies estuaries: *Salt wedge estuary* is an estuary that has a weak mixture. Formed by a strong river flow from large rivers entering the sea and weak tidal currents. *Well-mixed estuary*, it is a perfectly mixed estuary. These estuary waters occur due to strong vertical mixing caused by tidal motion to cause the waters to become vertically homogeneous. Because it is under tidal control, the salinity at all points can change drastically, depending on the position of the tides. At low tide, salinity is dominated by freshwater coming from the river, while at high tide salinity is dominated by sea water. *Partially-mixed estuary*, this estuary was formed if the condition of the river water discharge and the tidal current was strong. On the surface, water tends to flow out while seawater flows below the mixed layer. As a result, the isohaline line has a tendency to lean towards the sea [4].

Each water has different distribution characteristics. The description of mixing in estuary waters, including horizontal and vertical distribution of estuary water temperatures, has been reported [5,6]. The extended salinity intrusion may cause higher salt flux during peak ebb although mixing is lower on ebb for a partially stratified estuary [7].

Based on hydrological conditions, Samarinda influenced by 20 basins and Karang Mumus Basin is the largest. Most of a half area of Samarinda is included in Karang Mumus Basin (KMB), with approximately 365.27 Km² (50.09% of the total area of Samarinda) with a total length of the river around ± 40 km [8]. The estuary of confluence Mahakam and Karang Mumus rivers was an area where the river meets which becomes the entrance and exit of the flow from the Karang Mumus river and as a shipping channel for fishing boats. The depth of the water is shallow, the width of the river is relatively narrow and some of the Karang Mumus rivers are still common, there are still people who live on the banks of the river or equivalent to the river, thus increasing the constriction of the river body. Temperature and salinity are very important factors for the distribution of organisms in estuaries. Characteristics of the vertical distribution of temperature and salinity in Estuary of confluence Mahakam and Karang Mumus rivers are unknown. In this paper, a quantitative analysis of the distribution of temperature and salinity is discussed in the Estuary waters of Mahakam and Karang Mumus rivers using data of temperature and salinity to determine the type of estuary confluence Mahakam and Karang Mumus rivers.

2. Materials and methods
Oceanographic parameter data which includes temperature and salinity, obtained from sampling that has been done, in neap tide conditions on July 8, 2018, with 9 points and spring tide conditions on July 14, 2018 with 11 points. The distribution of water temperature and salinity was measured in Estuary waters of confluence Mahakam and Karang Mumus rivers and several points along the Karang Mumus river (Figure 1 and 2). Measurement of temperature and salinity using CTD Minos X PDC-B0900 sensor system equipment products from AML Oceanographic are headquartered in British Columbia, Canada which can simultaneously record profiles of temperature and salinity parameters that lowered to the bottom of estuaries. Parameter measurements were carried out on the surface and middle and near the base layers. For data acquisition, the AML Oceanographic program package that is used is the Seacoast AML Oceanographic Software based on the manual they provide.

In addition, we also take Bathimetric measurements using the Sounder Ceescope 2.5.3 tool and this tool is also supported with built-in D-Gps from the tool and Gps to determine the dots where the data is taken while the tidal measurements were done manually with 10 minute intervals during 15 days in the estuary of confluence Mahakam River and Karang Mumus rivers. To illustrate the two tidal conditions mentioned above, the data recorded by CTD Minos X PDC-B0900 with 3 layers, namely layers at the top, middle and bottom with a 15-second interval layer in each point along the Karang Mumus river to the estuary of confluence, then can download and view data using SeaCast or HyperTerminal. The measurement procedure described was carried out on July 8, 2018, during neap tide conditions and on July 14, 2018, during spring tide conditions (figure 2).
Figure 1. CTD Retrieval Position there are 9 points, July 8, 2018 at neap tide conditions.

Figure 4 describes the CTD data retrieval hours both on Neap tide condition on July 8, 2018 and Spring tide condition on July 14, 2018. All measurements can be seen in Table 1. Where the collection time can be seen in Table 1, during Neap tide condition on July 8, 2018 sampling was taken at the time the lowest ebb tide to flood tide (or the water began to move up) around 09.00 to 11.00 at the locations of points 1, 2, 3, 4 and 5, continued from 2:00 p.m. to 3:15 p.m. at locations 6, 7, 8, 9 at the time the high flood tide to ebb tide (or the water began to move down). Subsequent sampling was taken at Spring tide condition on July 14, 2018 at around 09.00 to 11.00 when the highest flood tide to ebb tide (or the water began to move down and these is the highest flood tide within 15 days) at all locations point A, B, C, D, E, F, G, H, I, J, and K or 11 location points. Different from the date of July 8, 2018 in sampling which must be done with 2 time intervals that are very different between points 1, 2, 3, 4 and 5 with points 6, 7, 8, 9 due to the problem that the ship used to sail to each sampling point could not be traversed due to shallowness of water so it must use land routes to be able to reach every point that has been plotted to be surveyed in the retrieval CTD sample.
Figure 2. CTD Retrieval Position there are 11 points, July 14, 2018 at spring tide conditions.

Figure 3. Tidal measurements for 15 days at point 1 station from July 6 to 20, 2018.
Figure 4. blue line Measurement of nead tide conditions and orange line measurement of CTD clock time information on July 8, 2018 While yellow line Measurement of spring tide conditions and red CTD Clock measurement time information on July 14, 2018.

3. Results and discussion
In full, the results of measurements of temperature and salinity in the surface, middle and bottom layers of the Karang Mumus river to the estuary of meeting between Mahakam and Karang Mumus rivers are presented in figures 5 to 8.

| Points | Tidal Conditions | CTD Sampling Hours | CTD Sampling Date | Points | Tidal Conditions | CTD Sampling Hours | CTD Sampling Date |
|--------|------------------|--------------------|-------------------|--------|------------------|--------------------|-------------------|
| A      | Spring tide      | 9:09:25 AM         | July 14, 2018     | 1      | Neap tide        | 10:12:25 AM        | July 8, 2018      |
| B      | Spring tide      | 9:19:41 AM         | July 14, 2018     | 2      | Neap tide        | 10:23:39 AM        | July 8, 2018      |
| C      | Spring tide      | 9:29:51 AM         | July 14, 2018     | 3      | Neap tide        | 10:30:09 AM        | July 8, 2018      |
| D      | Spring tide      | 9:41:14 AM         | July 14, 2018     | 4      | Neap tide        | 10:38:21 AM        | July 8, 2018      |
| E      | Spring tide      | 9:52:00 AM         | July 14, 2018     | 5      | Neap tide        | 10:45:56 AM        | July 8, 2018      |
| F      | Spring tide      | 9:57:58 AM         | July 14, 2018     | 6      | Neap tide        | 2:14:42 PM         | July 8, 2018      |
| G      | Spring tide      | 10:03:39 AM        | July 14, 2018     | 7      | Neap tide        | 2:47:32 PM         | July 8, 2018      |
| H      | Spring tide      | 10:11:08 AM        | July 14, 2018     | 8      | Neap tide        | 3:00:20 PM         | July 8, 2018      |
| I      | Spring tide      | 10:19:03 AM        | July 14, 2018     | 9      | Neap tide        | 3:13:54 PM         | July 8, 2018      |
| J      | Spring tide      | 10:36:05 AM        | July 14, 2018     |        |                  |                    |                   |
| K      | Spring tide      | 10:47:17 AM        | July 14, 2018     |        |                  |                    |                   |

3.1. Temperature distribution
The distribution of water temperature at the surface and bottom layers in the Estuary waters of Mahakam and Karang Mumus rivers in July 2018 shows horizontal stratification although spaced at a distance. This can be seen from the difference in water temperature distribution patterns at each observation point. (figures 5 and 6).
Figure 5. Temperature vertical distribution in the location of 9 points during the Neap tide.

Furthermore, because it could not be done by sailing vessel, it was done by reaching the point by passing land and lowering the tool from the bridge starting at around 14.00 to 16.00 at points 6, 7, 8 and 9. When the time the high flood tide to ebb tide. There is a temperature difference from the previous point in the initial survey, it was a recorded temperature increase ranging from 27.88 °C - 28.18 °C which is in the upper mean range of 27.88 °C, the middle layer is 27.88 °C and lower layer 27.89 °C with standard deviation of top layer 0.13 °C, middle layer 0.12 °C and lower layer 0.12 °C. The highest temperature distribution was recorded at point 7 as far as 4053.354 meters from the estuary of confluence with an mean of 28.18 °C in the upper layer, 28.17 °C middle layer and 28.17 °C lower layer while the lowest temperature at point 9 as far as 5076.393 meters from the estuary of confluence with an mean of 27.88 °C on the top layer, 27.88 °C middle layer and 27.89 °C lower layer. Seeing from these two surveys during neap tide, the first began at around 9:00 a.m. until 11:00 p.m. when the time the lowest ebb tide to flood tide carried out points 1, 2, 3, 4, and 5, the temperature moved going up following the movement of moving water where the water enters the Karang Mumus river while the second survey starts around 2:00 p.m. to 4 p.m. at points 6, 7, 8 and 9. When the time the high flood tide to ebb tide where the water from upstream of the Karang Mumus river to the downstream or towards the estuary of confluence. Here the temperature moves up in the direction of the movement of the water which is seen down from the lowest point 9 of the upper point of the surveyed to the highest point 6 of temperature.

Figure 6. Temperature vertical distribution in the location of 11 points during the spring tide.

Figure 6 shows the temperature measurements carried out on June 14, 2018 on spring tides, this survey was carried out entirely using ships sailing and stopping at each point taken, this could be done because the highest flood tide to ebb tide starting at 9:00 a.m. to 11:00 p.m. see table 1. The peak at the flood maximum was taken at points A and B (the estuary of confluence the Mahakam-Karang Mumus rivers) which was 153,749 meters from both temperatures ranging from 27.53 °C – 27.62 °C see table
2, then the ship moves into the Karang Mumus river to be sampled and this is in the opposite direction with the water coming out. Overall survey conducted from point A, B, C, D, E, F, G, H, I, J, and K or 11 location points with a long sail of 5181.099 meters the temperature distribution was recorded around 27.42 °C – 27.65 °C. minimum mean of upper layer 27.42 °C, middle layer 27.42 °C and lower layer 27.40 °C and maximum mean upper layer 27.65 °C, middle layer 27.63 °C and lower layer 27.61 °C with the standard deviation of the upper layer 0.07 °C, the middle layer 0.06 °C and the lower layer 0.06 °C. in Figure 6, the highest temperature increase of the whole is at point E which is located 1441.102 meters. The results showed that neap tide temperature increased by ± 1 °C from ebb tide to flood tide around 27 °C with flood tide to ebb tide around 28 °C, while during spring tide the temperature seemed stable even though it was only observed when the tide headed for water ebb around 27 °C.

3.2. Salinity distribution
Salinity distribution in estuary waters is strongly influenced by the depth, current of tidal conditions, surface flow, evaporation and the contribution of the amount of fresh water entering the ocean waters [9]. The results of observations of salinity in the Estuary waters of Mahakam and Karang Mumus rivers are presented in Figures 7 and 8. Similar to Temperature with the CTD Minos.X PDC-B0900 device. Salinity values had be also been obtained. At the time of neap tide, the date of July 8, 2018 is done 1, 2, 3, 4, and 5 during the lowest ebb tide to flood tide starting at 09.00 to 11.00 and at point 6, 7, 8 and 9. When the time the high flood tide to ebb tide. During spring tide on July 14, 2018, A, B, C, D, E, F, G, H, I, J, and K are taken when the highest flood tide to ebb tide which starts at 09.00 to 11.00.

Table 2. Temperature and salinity in the location of 9 points during the Neap tide.

| Station | Temperature (°C) | Salinity (‰) |
|---------|------------------|--------------|
|         | Surface | Middle | Bottom | Surface | Middle | Bottom |
| 1       | 27.16   | 27.22  | 27.24  | 0.09    | 0.12   | 0.13   |
| 2       | 27.30   | 27.29  | 27.26  | 0.16    | 0.15   | 0.15   |
| 3       | 27.40   | 27.26  | 27.23  | 0.15    | 0.15   | 0.14   |
| 4       | 27.14   | 27.14  | 27.13  | 0.15    | 0.15   | 0.15   |
| 5       | 27.18   | 27.16  | 27.16  | 0.15    | 0.15   | 0.15   |
| Minimum | 27.14   | 27.14  | 27.13  | 0.09    | 0.12   | 0.13   |
| Maximum | 27.40   | 27.29  | 27.26  | 0.16    | 0.15   | 0.15   |
| Means   | 27.24   | 27.21  | 27.20  | 0.14    | 0.14   | 0.14   |
| St Dev  | 0.11    | 0.06   | 0.06   | 0.03    | 0.01   | 0.01   |
| 6       | 28.11   | 28.09  | 28.09  | 0.15    | 0.15   | 0.15   |
| 7       | 28.18   | 28.17  | 28.17  | 0.15    | 0.15   | 0.14   |
| 8       | 28.01   | 28.01  | 28.01  | 0.15    | 0.15   | 0.15   |
| 9       | 27.88   | 27.88  | 27.89  | 0.15    | 0.14   | 0.14   |
| Minimum | 27.88   | 27.88  | 27.89  | 0.15    | 0.14   | 0.14   |
| Maximum | 28.18   | 28.17  | 28.17  | 0.15    | 0.15   | 0.15   |
| Means   | 28.05   | 28.04  | 28.04  | 0.15    | 0.15   | 0.14   |
| St Dev  | 0.13    | 0.12   | 0.12   | 0.001   | 0.001  | 0.001  |

Figure 7 explains the vertical distribution of salinity at 9 points along the Karang Mumus river to the estuary of confluence Mahakam and Karang Mumus rivers on July 8, 2018 at the time of the Neap tide, the lowest salinity recorded is point 1 where confluence of Mahakam and Karang Mumus rivers with value on the surface of 0.09 ‰, the middle of 0.12 ‰ and the bottom of 0.13 ‰ which is the lowest salinity than the salinity at the river level of Karang Mumus with an mean surface layer of 0.15 ‰, the
middle of 0.15 and below 0.14 ‰ with standard deviation 0.001 ‰. Figure 8. Explaining the vertical distribution of salinity in 11 point locations, namely A, B, C, D, E, F, G, H, I, J, and K along the Karang Mumus river to the estuary of confluence the Mahakam and Karang Mumus rivers on July 14, 2018 during spring tide and taken when the highest flood tide to ebb starting at 9:00 a.m. to 11:00 p.m. The salinity value is very low when compared to the time of neap tide where the mean surface layer is 0.04 ‰, middle 0.04 and below 0.04 ‰ with standard deviation 0.03 ‰, the same value as the neap tide is at the farthest point of point K which is 5181.099 meters from the estuary of confluence with a salinity value on surface of 0.13, middle 0.13 ‰ and below 0.13 ‰.

Table 3. Temperature and salinity in 11 points during the spring tide.

| Station | Surface | Middle | Bottom | Surface | Middle | Bottom |
|---------|---------|--------|--------|---------|--------|--------|
| A       | 27.56   | 27.53  | 27.53  | 0.02    | 0.02   | 0.02   |
| B       | 27.62   | 27.56  | 27.55  | 0.03    | 0.03   | 0.03   |
| C       | 27.58   | 27.57  | 27.56  | 0.03    | 0.03   | 0.03   |
| D       | 27.65   | 27.59  | 27.58  | 0.02    | 0.03   | 0.02   |
| E       | 27.65   | 27.63  | 27.60  | 0.03    | 0.03   | 0.03   |
| F       | 27.63   | 27.61  | 27.61  | 0.02    | 0.02   | 0.02   |
| G       | 27.62   | 27.60  | 27.60  | 0.03    | 0.03   | 0.03   |
| H       | 27.62   | 27.60  | 27.55  | 0.03    | 0.03   | 0.03   |
| I       | 27.60   | 27.58  | 27.58  | 0.03    | 0.03   | 0.03   |
| J       | 27.52   | 27.50  | 27.50  | 0.06    | 0.06   | 0.07   |
| K       | 27.42   | 27.42  | 27.40  | 0.13    | 0.13   | 0.13   |
| Minimum | 27.42   | 27.42  | 27.40  | 0.02    | 0.02   | 0.02   |
| Maximum | 27.65   | 27.63  | 27.61  | 0.13    | 0.13   | 0.13   |
| Means   | 27.59   | 27.56  | 27.55  | 0.04    | 0.04   | 0.04   |
| St Dev  | 0.07    | 0.06   | 0.06   | 0.03    | 0.03   | 0.03   |

In each layer of very small salinity and relatively the same in each depth in along the Karang Mumus river to the estuary of confluence Mahakam and Karang Mumus rivers. It shown no influence of sea water / sea water intrusion into the river and shallow river depth [10]. Field measurements made at various locations in the delta and its front often exhibit small vertical salinity variations [11, 12, 13, 4], and Homogeneous salinity in each depth layer is an indication of a well-mixed vertical mixing process between sea water and fresh water [4].

Figure 7. Distribution of salinity verticals in 9 points during the Neap tide.
Figure 8. Distribution of vertical salinity in 11 points during the spring tide.

The low salinity value in the estuary of confluence Mahakam and Karang Mumus rivers is due to the influence of freshwater to the sea coming from the land. The distance to the estuary of confluence the Mahakam and Karang Mumus rivers is upstream of Delta apex about 20 km and this prove the low salinity of the river water mass that has been mixed with high salinity sea water moving towards the open sea. Overall salinity in the estuary of confluence the Mahakam and Karang Mumus rivers shows relatively unchanged salinity values at each depth. The distribution of salinity values from rivers, estuaries to the high seas shows the tendency of salinity to continue to increase.

4. Conclusion

Based on observations of temperature and salinity at the estuary of confluence Mahakam and Karang Mumus rivers conclusions can be drawn:

This temperature variability shown that these waters are included in homogeneous waters and there was no thermocline layer. This happens because the depth of the waters under study includes shallow so that from the surface layer, middle to the bottom and there is a vertical mixing process between sea water and fresh water. Based on the interaction of freshwater and tidal circulation, the estuary of confluence the Mahakam-Karang Mumus rivers was included in the well-mixed estuary classification, namely waters with strong vertical mixing caused by tidal motion to cause the waters to become vertically homogeneous.

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