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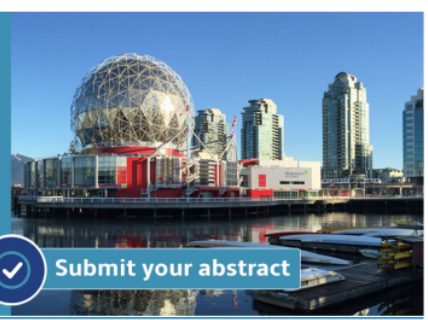

Spatial mapping of water mass structure in the estuary of Jeneberang river

R Karamma[1], M S Pallu[2], M A Thaha[2], M P Hatta[1] and M Ihsan[3]

[1]Lecturer, Department of Civil Engineering, Faculty of Engineering, Universitas Hasanuddin
[2]Professor, Department of Civil Engineering, Faculty of Engineering, Universitas Hasanuddin
[3]Lecturer, Department of Civil Engineering, Sekolah Tinggi Teknik Baramuli

Email: riswalchiwal@gmail.com

Abstract. This paper presents a geographical information system approach in the description of water mass structure in the vicinity of Jeneberang river estuary. An ArcGIS application has been employed in developing such a description. Tidal effects are alleged to be the factor influencing flow circulation in the estuary, including flow velocity, water level profile, and saltwater intrusions. The research has been measured the element of water mass, including salinity, temperature, and density. The measurements are then charted in spatial models using ArcGIS^{TM}, presenting the distribution pattern of water mass structure as the effect of the tidal process.
Keywords: Estuary, ArcGIS, Water mass, Salinity, Jeneberang.

1. Introduction

With the situation as semi-closed water, the estuary is largely influenced by the tides and tides of seawater which causes the phenomenon of water mass mixing [1,2]. The same situation occurs in the estuary of Jeneberang River which is influenced by tides with semi-diurnal characteristics [3,4]. Tides will transport water from the sea to coastal waters at high tide and from coastal waters to the high seas at low tide [5]. This mixing process often dominates the hydrodynamic process in estuarine waters. The distribution of salinity in estuarine waters is strongly influenced by depth, tidal currents, surface flow, evaporation, and freshwater entering sea waters. The salinity distribution of the mixed layer is relatively less intense than that occurring in the inner layer. Salinity is an important factor for the spread of marine aquatic organisms and oxygen can be a limiting factor in determining the presence of living things in water [6,7]. Estimates of salinity distribution have also been carried out at the estuary of the Jeneberang River with the help of the ArcGIS application, but have not in-depth examined the problem of stratification of water mass structures [8]. The location of research has been investigated in some research works [9-12].

This study aims to spatially map the distribution pattern and stratification of water mass structures during spring tide and neep tide in the estuary of Jeneberang River.

2. Research methodology

Their Location of the study was conducted at the Jeneberang River Estuary. Located on the coordinates UTM 50S UTM 763000m E 767000m E and 9426000m S-9426000m S, as shown in figure 1.

Figure 1. The research location in the estuary of Jenebarang River

Retrievals of flow data were conducted in the Euler method. The equipment used in this research includes GPS Hand, GPS Echosounder, Waterpass, Logger, Acoustic Doppler Current Profiler (ADCP), and Conductivity Temperature Depth (CTD) or the like. Measurement using ADCP Argonaut SonTek XR worked at 0.75 MHz wavelength sensor beam and autonomous multi-cell system. The set of equipment is depicted in figure 2.

Figure 2. Research equipment setting

The Euler method is the ADCP working principle in measuring currents with the concept of following the motion of water particles by single beaming at a certain depth in a set of layers. ADCP Argonaut SonTek XR is placed at each location at a depth of ± 3.6 meters for station 1 and a depth of ± 2.7 meters for station 2. The sensor forms an angle to the upright axis of 20° and above and forms a cartesian coordinate system of the current component in the direction u (west-east/E), v (north-south/N), and z (vertical water column/U). The locations of the ADCP Argonaut SonTek XR are as described in figure 3.

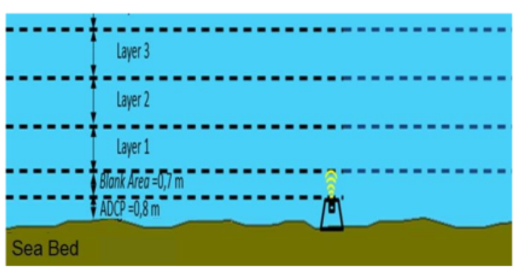

Figure 3. Layers set for ADCP beaming

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Tidal recording in determining water level has been carried out for 15x24 hours with sample intervals of 5 minutes, in variations of depth ranging from 0 - 3 meters, at two sea-current survey stations, at the Jeneberang River Estuary.

Bathymetry has been intended to determine seabed surface formation in the area of the Jeneberang River estuary area with a measured area outside the river mouth has been 1 km x 1 km. Bathymetry data retrieval has been carried out with the Garmin Echo Sounder 585 with 50/200 kHz sonar beam frequency for an accuracy of 0.1 m.

Observations have been conducted at 18 stations on 6 cross-sections of the river in the Jeneberang River estuary, reaching downstream to the inner part of Jeneberang River. The position of observation have been at a depth of 0.2d; 0.6d; 0.8d from the surface of the water, carried out during spring tide and neap tide in the same month.

The stages of development of Geographic Information System maps consist of INPUT, PROCESS (Processing, Analysis and Data Storage), and OUTPUT (Layout). INPUT data in GIS can be obtained from the results of field measurements (terrestrial surveys, photogrammetry, and hydrographic surveys), analog/printed maps, and through the scanning process and data sourced from satellite imagery.

3. Results and discussion

The echo sounder measurement results were converted to spreadsheet data (in this research, MS ExcelTM was employed) before corrected with tidal observational data on the logger and the depth of the transducer, generating actual depth values as shown in figure 4. The obtained depth values have been processed with ArcGIS software to interpolate Topo to Raster on ArcToolbox. The parameters consist of the polygon of the river body as a boundary, polyline of river line as contour 0, and echo sounder measurement point as elevation point with a cell size of 5 meters and the river bed or water profiles have subsequently obtained. Detailed results are as shown in figure 5.

DEPTH CORRECTED				DEPTH SOUNDER				LOGGER			
NO	X	Y	DEPTH F	DATE	DEPTH	TRANDU	D_TRAN	TIDE IN TIM	TIME	TIDE	KONST
1	766340	9425455	-2.96	10/27/2019 7:15	2.6	0.38	-2.98	1.945155938	10/26/19 12:00 PM	-12.2548	-1
2	766331	9425474	-3.26	10/27/2019 7:16	2.9	0.38	-3.28	1.945155938	10/26/19 12:10 PM	-12.4448	-1
3	766320	9425490	-3.66	10/27/2019 7:16	3.3	0.38	-3.68	1.945155938	10/26/19 12:20 PM	-13.8848	-1
4	766311	9425506	-4.06	10/27/2019 7:16	3.7	0.38	-4.08	1.945155938	10/26/19 12:30 PM	-16.8548	-1
5	766300	9425518	-3.76	10/27/2019 7:16	3.4	0.38	-3.78	1.945155938	10/26/19 12:40 PM	-18.4948	-1
6	766289	9425522	-3.66	10/27/2019 7:16	3.3	0.38	-3.68	1.945155938	10/26/19 12:50 PM	-18.0148	-1
7	766274	9425521	-3.16	10/27/2019 7:17	2.8	0.38	-3.18	1.945155938	10/26/19 1:00 PM	-16.4748	-1
8	766262	9425525	3.36	10/27/2019 7:17	3	0.38	3.38	1.945155938	10/26/19 1:10 PM	16.2848	1
9	766251	9425533	-3.06	10/27/2019 7:17	2.7	0.38	-3.08	1.945155938	10/26/19 1:20 PM	-18.9648	-1
10	766238	9425538	-2.76	10/27/2019 7:17	2.4	0.38	-2.78	1.945155938	10/26/19 1:30 PM	-17.8148	-1
11	766228	9425540	-2.86	10/27/2019 7:17	2.5	0.38	-2.88	1.945155938	10/26/19 1:40 PM	-16.3748	-1
12	766218	9425545	-3.06	10/27/2019 7:17	2.7	0.38	-3.08	1.945155938	10/26/19 1:50 PM	-14.9448	-1
13	766207	9425545	-3.16	10/27/2019 7:17	2.8	0.38	-3.18	1.945155938	10/26/19 2:00 PM	-14.5548	-1
14	766195	9425549	-3.26	10/27/2019 7:17	2.9	0.38	-3.28	1.945155938	10/26/19 2:10 PM	-17.7248	-1
15	766184	9425552	-3.16	10/27/2019 7:18	2.8	0.38	-3.18	1.945155938	10/26/19 2:20 PM	-16.5748	-1
16	766171	9425552	-3.16	10/27/2019 7:18	2.8	0.38	-3.18	1.945155938	10/26/19 2:30 PM	-18.8748	-1
17	766159	9425557	-2.56	10/27/2019 7:18	2.2	0.38	-2.58	1.945155938	10/26/19 2:40 PM	-15.8048	-1
18	766147	9425557	-2.86	10/27/2019 7:18	2.5	0.38	-2.88	1.945155938	10/26/19 2:50 PM	-14.5548	-1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DATA BATHIMETRI | DATA LOGGER | KOREKSI

Figure 4. Process of correction of measurement data by data logger and transducer

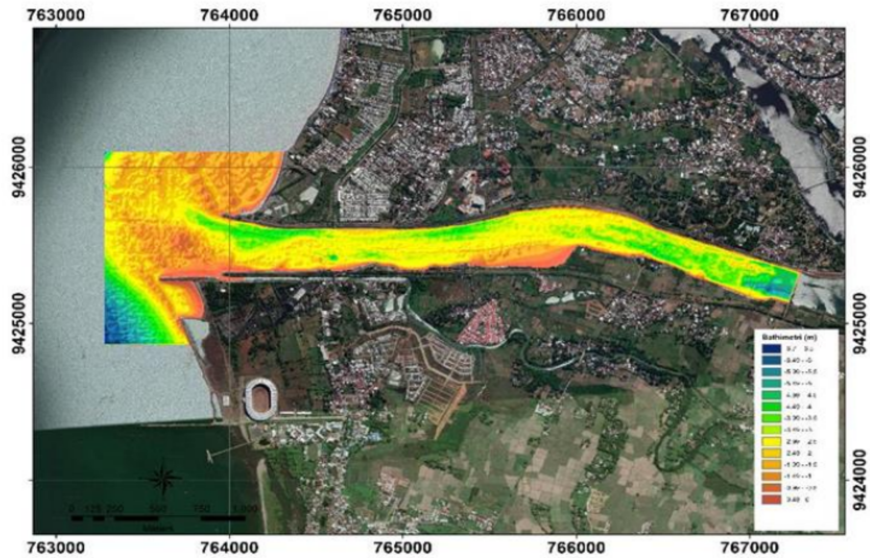

Figure 5. Profile of the floor of estuary after correction of echosounder measurement

After interpolation, the river bed profile data will be obtained. To get the contour line, the data extraction process is done using spatial analyst - surface - contour tools. The interval used is 0.5 meters to get the results as shown in figure 6.

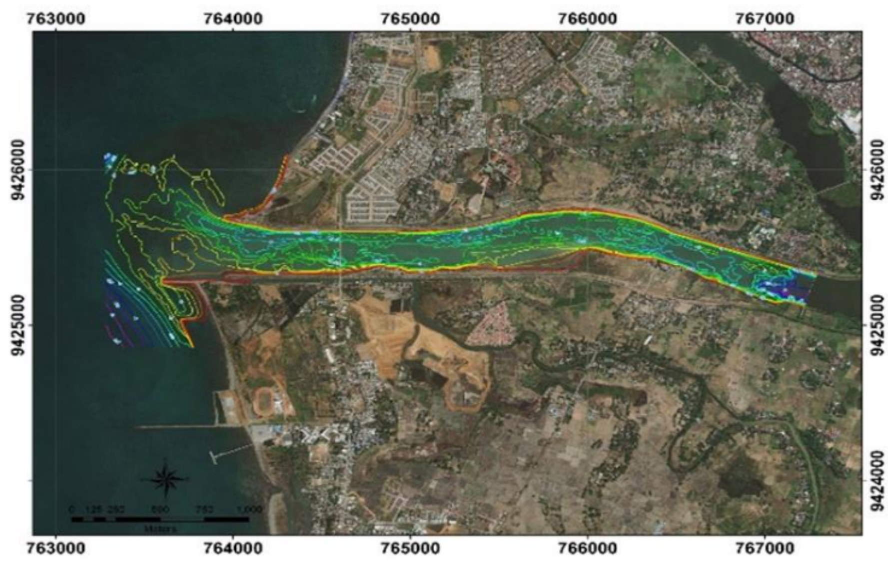

Figure 6. Results of contour line extraction

The next step is to process data for water mass structure mapping. The process is arranged in a flow chart depicted in figure 7.

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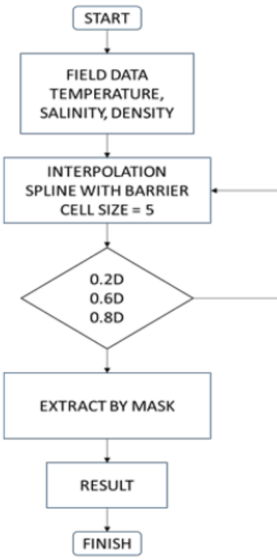

Figure 7. Flow chart of data processing for water mass structure mapping

The measurement results from the CTD have obtained logfiles which then sorted as in figure 8, producing daily data of temperature, salinity, and density for a total of 15 days. The data is presented in the form of spreadsheet tabulation which is then used as basic data. The basic data that has been made is then interpolated with the spline with a barrier method in ArcGIS software with a 5-meter cell size to obtain detailed results as in figure 9. Interpolation processes have been carried out three times at three water depths; 0.2d, 0.6d, and 0.8d to produce patterns of temperature, salinity, and density distribution in three layers of water. After all interpolation processes have been performed, raster data have been subsequently extracted in the specified area as shown in figure 10.

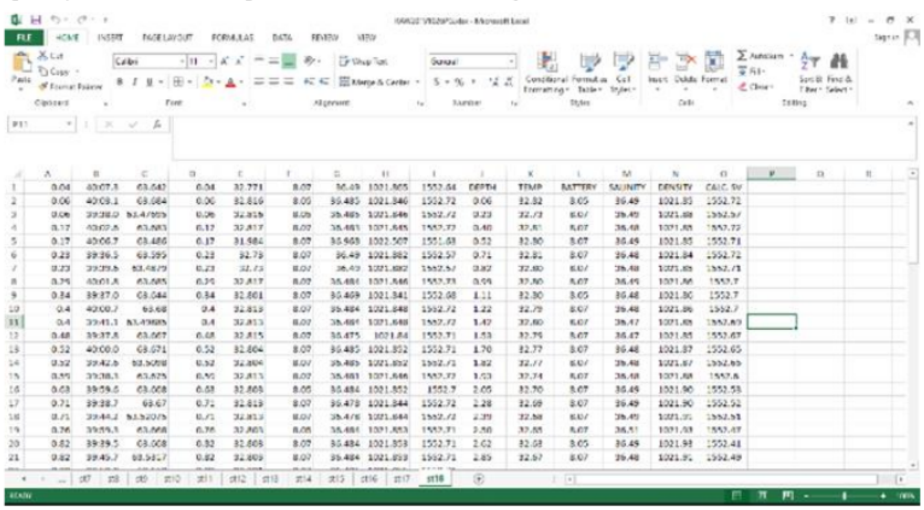

Figure 8. Sorting process of 15-days data from 18 observation stations

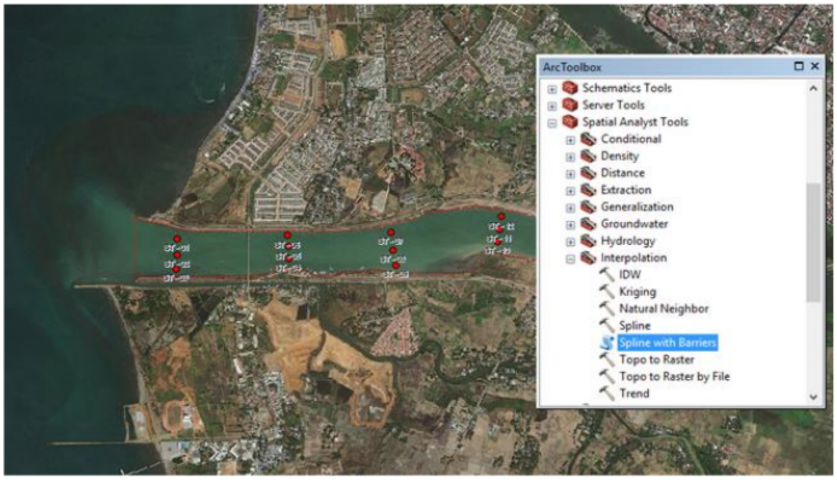

Figure 9. Basic data plotting

Figure 10. Interpolation results for temperature, salinity, and density

Spatial mapping results of the distribution of water mass structure at the estuary of Jeneberang River are shown in two conditions; during spring tide and neap tide. This spatial mapping also illustrates the distribution of water mass structure at the process of high tide to low tide (ebb tide) and low tide to high tide (flood tide) at neap tide and spring tide conditions, respectively. The results of mapping the distribution of water mass structures can be seen in figures 11,12,13 and 14.

The analysis of salinity measurement data at the estuary of the Jeneberang River produces information of salinity, ranging from 33 to 36 PSU, where the highest level of salinity found at the process of the tide to ebb and ebb to tide conditions located on the east side of the inclining river bank with intervals ranging from 36.51 PSU. The levels of salinity in coastal areas close to the mouth of the estuary have been about 34.51 PSU to 35 PSU, as shown in figures 11 and 12.

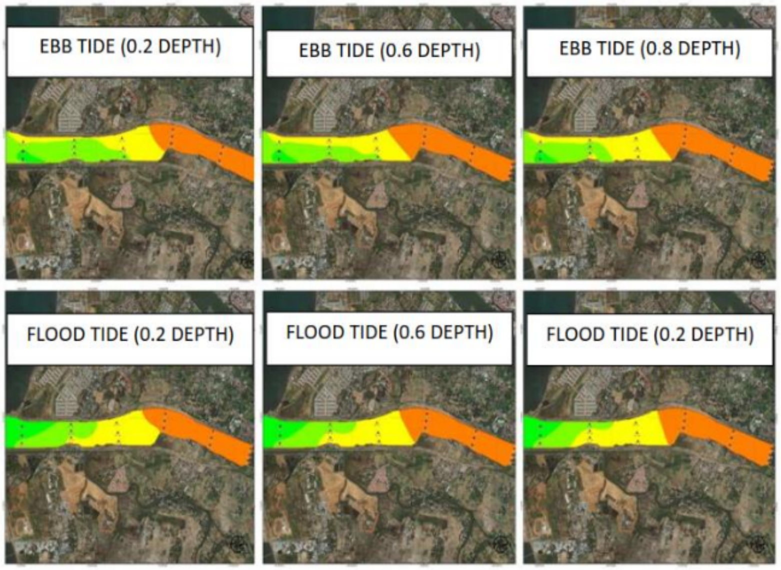

Figure 11. Salinity distribution in spring tide condition

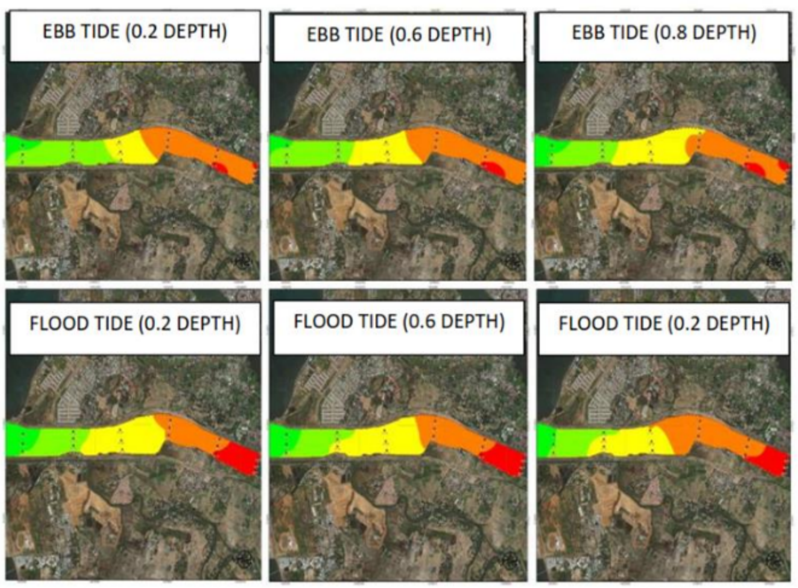

Figure 12. Salinity distribution on neap tide condition

Based on the analysis of temperature measurement data at the Jeneberang River Estuary, it has been found out that temperatures range from 29.5^{o}C to 33.2^{o}C. The maximum temperature in the estuary of the Jeneberang River has been 32^{o}C while the average temperature has been 31^{o}C and the minimum temperature is 29.6^{o}C. The maximum temperature in the upstream area of the study area in the

Jeneberang river has been 33.2ºC. The average temperature has been 32.5ºC and the minimum temperature has been 31.2ºC. Figures 13 and 14 show the distribution of temperature in spring tide and neap tide, respectively.

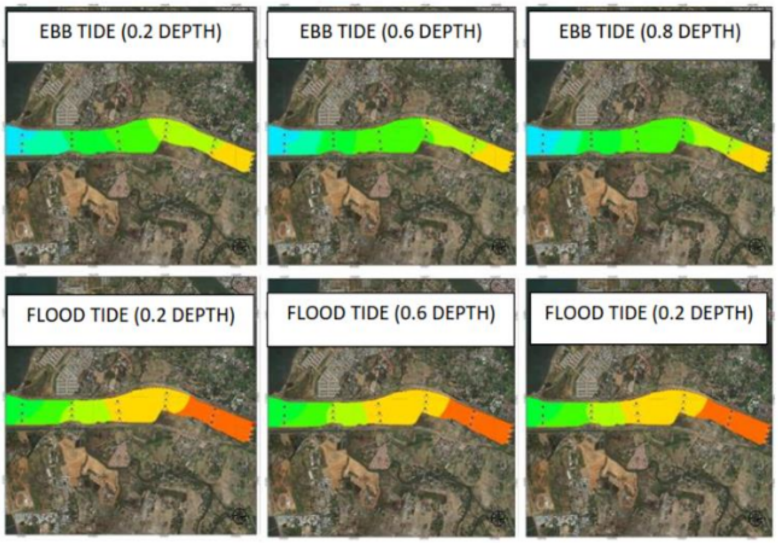

Figure 13. Temperature distribution in spring tide condition

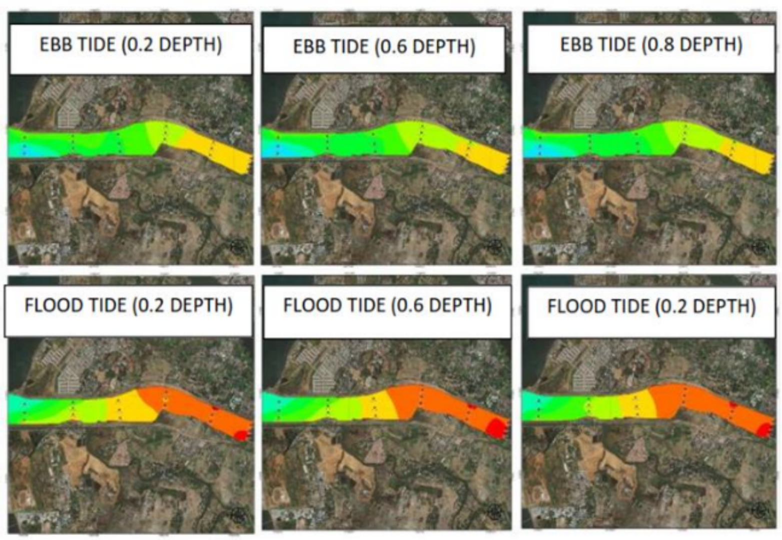

Figure 14. Temperature distribution in neap tide condition

The mapping also shows lower temperature patterns in the mouth of estuary mouth, while higher temperatures have been indicated in the upstream area to the Jeneberang River rubber dam. Based on observations of the bottom waters with the ADCP temperature obtained at Station 1 is higher than the temperature at Station 2.

The maximum temperature difference has been observed at 3.1ºC, with an average temperature difference of 1.21ºC, and the minimum temperature difference has been 0.10ºC.

4. Conclusion

The mapping results have shown the pattern of distribution and stratification of water mass structures in the estuary of Jeneberang River. This pattern of distribution and water mass layering has been depicted spatially during spring tide and neap tide, at the ebb tide and flood tide conditions. This spatial pattern of water mass distribution must be supplemented by vertical distribution cause pattern to better profiling of the water column and the mixing conditions, occurring due to tidal effects.

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