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Mapping Monitoring of Environmental Conditions In Cilacap Waters

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Abstract

Cilacap waters are said to be busy with sea traffic with many activities being carried out in the Cilacap water area. Environmental monitoring activities are needed to determine the existing conditions in Cilacap waters, in order to support smooth and efficient traffic activities in Cilacap waters. This study uses a method in producing a mapping of environmental conditions, namely by looking at the aspects of changes in coastline, water depth (bathymetry), wind direction, and velocity, as well as models of surface currents speed and direction in Cilacap waters. The results of this study indicate that the environmental conditions in Cilacap waters are still relatively not much different from the conditions in the previous year, namely 2017. The value of modeling ocean currents which are influenced by sea tides and ebbs has a relatively small value with values ranging from 0.1-1.5 m / s with an average speed of 0.4 m / s that occurs in June (east season). In June 2020 the wind in the Cilacap water area blows from the east and southeast with speeds ranging from 2.5 - 7 m / s. The bathymetry measurement results showed a result of less than -2 meters. These results also indicate a relatively gentle seabed slope with a maximum depth of more than -30 meters in Cilacap waters. This clearly shows that the morphology of the coast and the condition of Cilacap waters are not relatively significant, experiencing changes every year.

Keywords: Cilacap waters, bathymetry, ocean currents, wind, tide

1. Introduction

Environmental monitoring is very important, especially in water or coastal areas, which is done using a geographic information system. Water conditions will greatly affect the surrounding environment, both for the community, industry, and government. The effect of the absence of monitoring will eventually cause many things, especially natural disasters and disasters caused by humans themselves. An example of the effect of the absence of monitoring, in this case on the community, is that sedimentation will create unmanned land which can lead to social conflicts (land disputes). The geographical information system is a solution to this problem because a geographic information system is a system that contains attribute data and spatial data in its database that provides information clearly with map results. Geographical Information Systems are very important in monitoring locations, especially in coastal and marine locations (Bachtiar et al., 2014; Bachtiar, 2012).

Cilacap Regency is a coastal area that has a coastline of 201.9 km and an area of 5,200 km2 of coastal fishing area, fishing is carried out up to a distance of 25 km from the coast at a depth of 100m. Cilacap Regency has good fisheries and marine potentials to be developed. The potential of capture fisheries resources in the coastal waters of Cilacap is very large because it is directly adjacent to the Indian Ocean (Arfah, 2018). This is an important role in the waters of Cilacap, where this area has an ideal ocean port and is dense water that is busy with marine fisheries and shipping activities (Widhayanti et al., 2015).
With this research on monitoring, the role of the Geographical Information System can be applied in the waters of Cilacap, which will be related to oceanographic conditions including several parameters, namely; bathymetry, currents, and sedimentation. This will later be related to the linkage to the prevention of abrasion and sedimentation which will have an impact on the coastal environment. This study aims to monitor with several

parameters, namely the existing condition of the location, oceanographic conditions, land boundary conditions, and conditions of the coastline in the Cilacap waters.

2. Methods

2.1 Study Area

This research was conducted in Cilacap waters with the coordinates of the intake canals 1 and 2 Longitude 7 ° 41 '10 "South latitude and latitude 109 ° 5' 13" East longitude, the location of Intake Channels 3A and 4 at longitude: 7 ° 41 '15 " South latitude, and latitude 109 ° 5 '9 "East longitude, and the location of the intake canal 3, namely longitude 7 ° 41' 18" South latitude, latitude 109 ° 5 '31 "East longitude. The research location can be seen in Figure 1.

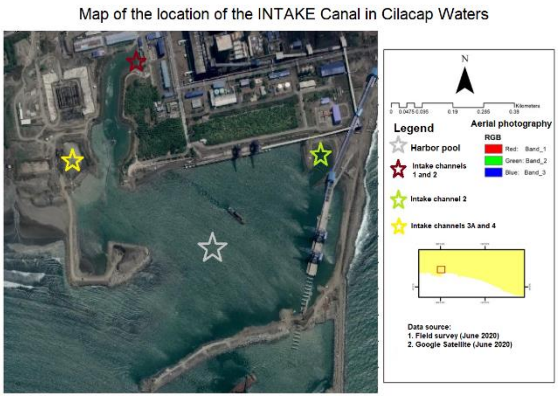


Fig. 1. Research locations

2.2 Shoreline changes

Changes in the coastline in Cilacap waters that support monitoring of environmental conditions using the aerial photography method (Figure 2). The results of taking aerial photographs will be corrected geometrically by spatial analysis using Landsat satellite images, then it will be measured how many meters the distance from the stake to the coastline in Cilacap waters in the intake area. The stages of taking aerial photographs are described in Figure 3. Furthermore, the calculation of the distance from the stake to the beach will be compared with the calculation of the distance.

Fig 2. Aerial Photography

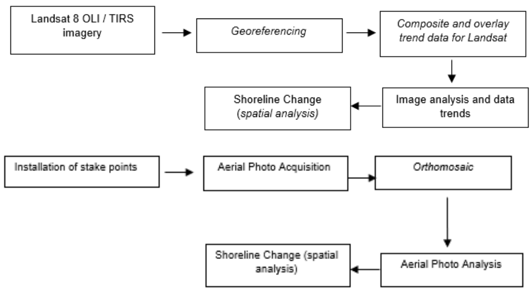


Fig 3. Landsat image processing flow chart and Aerial Photo processing flow chart

2.3. Satellite Image Data Processing

Coastline mapping can be done by direct field measurements, aerial photography analysis, and remote sensing analysis or satellite imagery (Guariglia, et al., 2006). The satellite imagery used in this monitoring activity uses Landsat 8 OLI TIRS satellite imagery. Landsat 8 OLI TIRS is the newest series of Landsat satellites launched by the United States for earth observation. Landsat (Land Satellite) is an observation satellite in collaboration between NASA and the United States Geological Survey (USGS). Detection of shoreline changes around the Cilacap waters area uses the remote sensing approach (Remote Sensing) data from Landsat 8 satellite imagery with path 121 / row 65 on 14 March 2020 and 2 June 2020. Landsat 8 has 11 bands which are shown in Table 1.

Table 1. Eleven bands in Landsat 8

Band	Wavelength	Band	Resolution (meter)
Coastal/Aerosol	0.435 - 0.451	Band 1	30
Blue	0.452 - 0.512	Band 2	30
Green	0.533 - 0.590	Band 3	30
Red	0.636 - 0673	Band 4	30
NIR	0.851 - 0.879	Band 5	30
SWIR - 1	1.566 - 1.651	Band 6	30
TIR - 1	10.60 - 11.19	Band 10	100
TIR - 2	11.50 - 12.51	Band 11	100
SWIR - 2	2.107 - 2.294	Band 7	30
Panchromatic	0.503 - 0.676	Band 8	15
Cirrus	1.363 - 1.384	Band 9	30

Source: Landsat - NASA (2013)

In this study, geometric, digitizing, and overlapping corrections were carried out to obtain information and calculation of shoreline changes at the study location during the period January to June 2020, produce coastline length information, and create boundaries for bathymetric data processing.

2.4 Bathymetry data

The bathymetry survey is a generalization survey, which is a process of measuring the depths aimed at obtaining a description (model) of the surface shape of the water bed (Satriadi, 2012). Bathymetry was measured in situ using the sounding method, using a Single Beam Echosounder, namely the GPSMAP Garmin 585 with an accuracy of 3 m. The bathymetric survey has the ability to describe the condition of the bottom profile of the waters, which aims to obtain water depth data and determine the bottom topography of the waters. The results of recording data will be visualized using the Surfer v15 software. The technique of implementing a bathymetric survey begins with making a tracking survey according to the planned location of the observation.

The bathymetry data obtained from the generalization results are used as depth information data in the intake canal area and the port pool. The bathymetry data collection refers to the predetermined tracking survey (Figure 4). The yellow line shows the route of recording bathymetry data while the red line is the route back to the starting point. Port pool depth data processing using Excel 2013, Surfer v15, and ArcGIS 10.6 software. The bathymetry data obtained from the results of the field survey were tabulated with Excel using coordinate data (x, y) and depth data (z).

Fig 4. Bathymetry survey trackline

After obtaining the bathymetry data from the results, the important thing to do is tide correction. The difference in the bathymetry data collection time causes differences in depth. This difference indifference is caused by the rise and fall of sea levels, which are better known as tides. Tides are measured through in situ observations of changes in sea level for 14 days. Then the in-situ data were analyzed using the admiralty method (using Ms. Excel) to produce tidal constants.

2.5 Ocean surface current modeling

Modeling of sea surface currents is carried out to see differences in oceanographic conditions in Cilacap waters. The hydrodynamic model will be created using Mike 21 with the Flow Model FM module to determine the flow movement pattern based on the data used (Sri Suharyo & Adrianto, 2018). Hydrodynamic modeling is carried out by entering the required data, including water bathymetry data, coastline data, tidal data, and flow data. The hydrodynamic modeling process produces tidal patterns as well as currents from the modeling area.

The method used in numerical solutions is the finite difference approach method. This method uses the continuity equation and the momentum equation with the mean depth. The equation is as follows:

$$\frac{D\xi_t}{Dt} = (\xi_a.\Lambda)V - \xi_a(\Lambda.V) - \Lambda_a.\Lambda_p + \upsilon\Lambda^2\xi_a \quad (1)$$

Where Data is a time interval (seconds), is a random number, a is the shift condition, ρ is the mass density of water in the center of the segment (kg / m3), and v is the velocity of flow.
The momentum equation is obtained by equalizing the forces acting with the inertia force for one unit of fluid volume particle. Therefore, in the momentum equation, there is a transfer of momentum which is given by the working and applied force, then the force will cause the inertia force. Then the momentum equation can be written:

On the x axis:

$$\rho\left(\frac{du}{dt} + f^*\omega - f\upsilon\right) = -\frac{\partial p}{\partial x} + \frac{\partial r^{xz}}{\partial x} + \frac{\partial r^{zy}}{\partial y} + \frac{\partial r^{xz}}{\partial z} \quad (2)$$

On the y axis:

$$\rho\left(\frac{d\upsilon}{dt} + f_u\right) = \frac{\partial p}{\partial y} + \frac{\partial r^{xy}}{\partial x} + \frac{\partial r^{yy}}{\partial y} + \frac{\partial r^{yz}}{\partial z} \quad (3)$$

On the z axis:

$$\rho\left(\frac{d\omega}{dt} + f^*_u\right) = \frac{\partial p}{\partial x} - \rho g + \frac{\partial r^{xz}}{\partial x} + \frac{\partial r^{zy}}{\partial y} + \frac{\partial r^{zz}}{\partial z} \quad (4)$$

Information:
f: Coriolis parameter (S-1)
f *: The inverse of the Coriolis parameter
ρ: Density of sea water (kg/m^3)
p: Atmospheric pressure (kg /m/ s^2)
g: Speed of gravity (m^2/s)
t: Normal stress components and shear due to friction

3. Results and Discussion

The results of this study produce shoreline change modeling or sedimentation that requires several other parameters as the generating factor. Some of these parameters include tides, bathymetry, wind, and surface currents, with this this will produce a model of sea surface currents in the research location of Cilacap waters.

Tides (tides) are an important factor in oceanography in surface current modeling (Kusumawati, 2016). Tidal forecasting is carried out to calculate the sedimentation rate and the distribution of TSS in the Cilacap waters. The tide chart results obtained from forecasting from the BMKG website (tides.big.go.id) for one month and one week are presented in Figures 5 and 6.

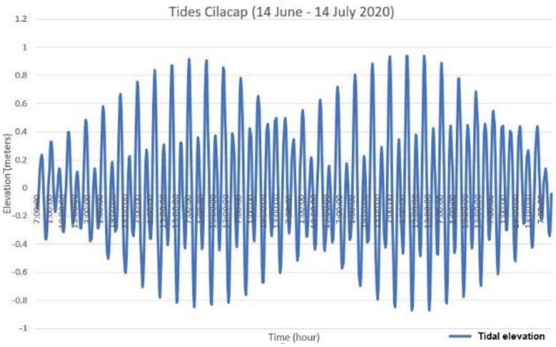


Fig 5. Tidal observations in Cilacap 14 June - 14 July 2020

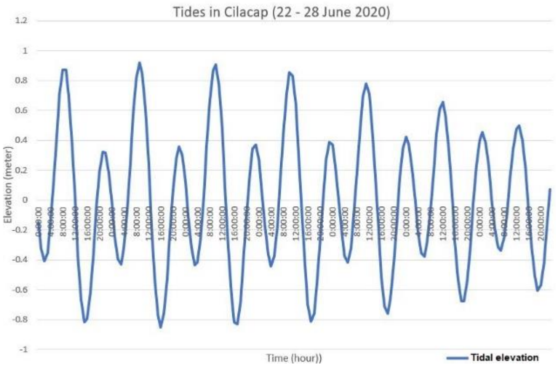


Fig 6. Tide observation in Cilacap 22 June - 28 July 2020

The results of data processing from the tide forecasting data were analyzed using the admiralty method, resulting in tidal constants in the waters around Cilacap. The results of the admiralty method in this study, namely on June 14-28 2020 can be seen in Table 2.

Table 2. Tidal constants admiralty results

The admiralty method results										
	S0	M2	S2	N2	K1	O1	M4	MS4	K2	P1
A (cm)	0.004	0.488	0.245	0.104	0.176	0.131	0.003	0.002	0.066	0.058
g°		225.785	286.507	198.472	273.325	246.878	356.143	124.989	286.507	273.325

After knowing the tidal constant, the formzahl number is calculated to identify the type of tide in the waters around Cilacap waters with the following equation (Pariwono, 1989):

$$F = (AK1 + AO1) / (AM2 + AS2)$$
$$= (0.176 + 0.131) / (0.488 + 0.245)$$
$$= 0.307 / 0.733 = \mathbf{0.4188}$$

Based on the calculation of the Formzahl number (0.4188), the type of tide in the waters around the waters of Cilacap is the Mixed Tides and Mixed Dominance. This type of tide is a tide that occurs twice and twice in a period of one day, but sometimes only one tide and one ebb with different amplitudes (heights). This also obtained the same results as the previous research conducted in Cilacap waters in 2009 (Soedharto, 2009).

3.1 Bathymetry

This study carried out bathymetry data collection activities aimed at one of the generating components in making sea surface currents models. The bathymetry measurement results in Cilacap waters are the result of a combination of the intake canal depth data, the port pool from Lengkong Beach to the Serayu River Estuary around the Cilacap waters. The depth in Cilacap waters varies, especially on the coast, with bathymetry values less than -2 meters. These results also indicate a relatively gentle seabed slope with a maximum depth of more than -30 meters in Cilacap waters (Figure 7).

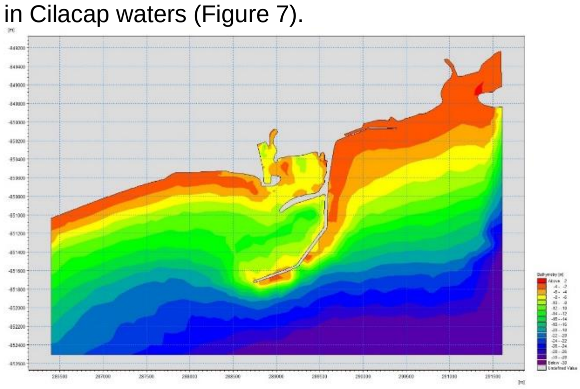


Fig 7. The results of bathymetry measurements in the waters around Cilacap (2020)

The results of this study show the same results as carried out by previous researchers in 2017 with the depth value in the coastal area of Cilacap waters being -0.25 m to -3 meters (Kusnida et al., 2016).

3.2 Wind

The wind data used are the average daily wind speed and direction data with time intervals every 6 hours with a spatial resolution of 0.125 ° x 0.125 ° with global coverage. Wind data as a model input in this monitoring is obtained through the ECMWF (European Center for Medium-Range Weather Forecasts) which is a reanalysis data from a combined data of the Meteorological Agency around the world.

Wind speed and direction data in this activity is displayed for one month (June 2020), consisting of wind direction and speed patterns. The first panel is wind direction and speed data displayed in the form of a time-series graph (Figure 7) and the second panel is wind direction and speed data displayed in the form of a wind rose plot (Figure 8).

Cilacap waters are located in the southern hemisphere (BBS) so that the wind direction and speed patterns in the southern hemisphere are strongly influenced by the dominant monsoon system in Southeast Asian waters (Wyrtki 1961). Prawirowardoyo (1996) explains that the eastern monsoon lasts during April-October and the peak takes place in June-August.

The east monsoon is characterized by a wind pattern blowing from east to west, this is caused by the low air pressure in mainland Asia and high air pressure in Australia (Purba and Jaya 2004). This causes in the east monsoon, wind direction and speed is dominated by winds moving from Australia (southeast) to Asia (southwest). The eastern monsoon period in Cilacap waters lasts from June to August. During June 2020, the wind in the Cilacap waters blew from the east and southeast with speeds ranging from 2.5 - 7 m/s with the dominant southeast direction. Apart from that, during the eastern monsoon, the Cilacap waters are also affected by winds blowing from the east with an average speed of 2.5 - 6.7 m/s.

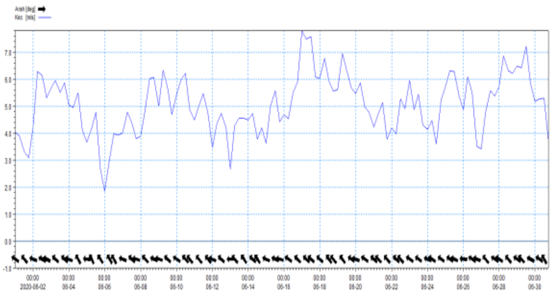


Fig 7. Time series direction plot

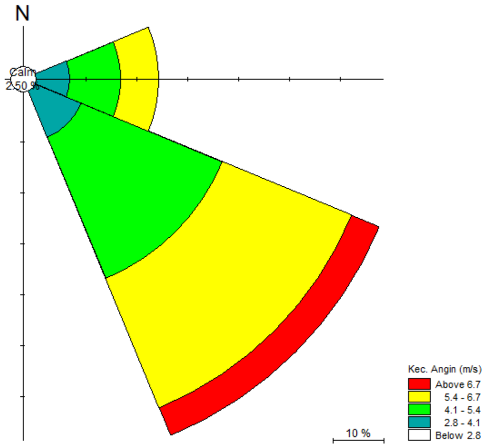
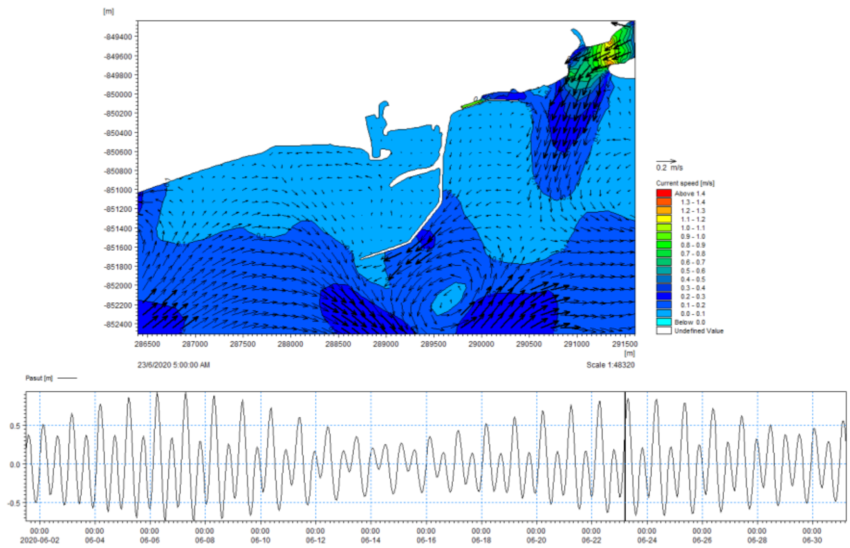


Fig 8. Windrose in June 2020

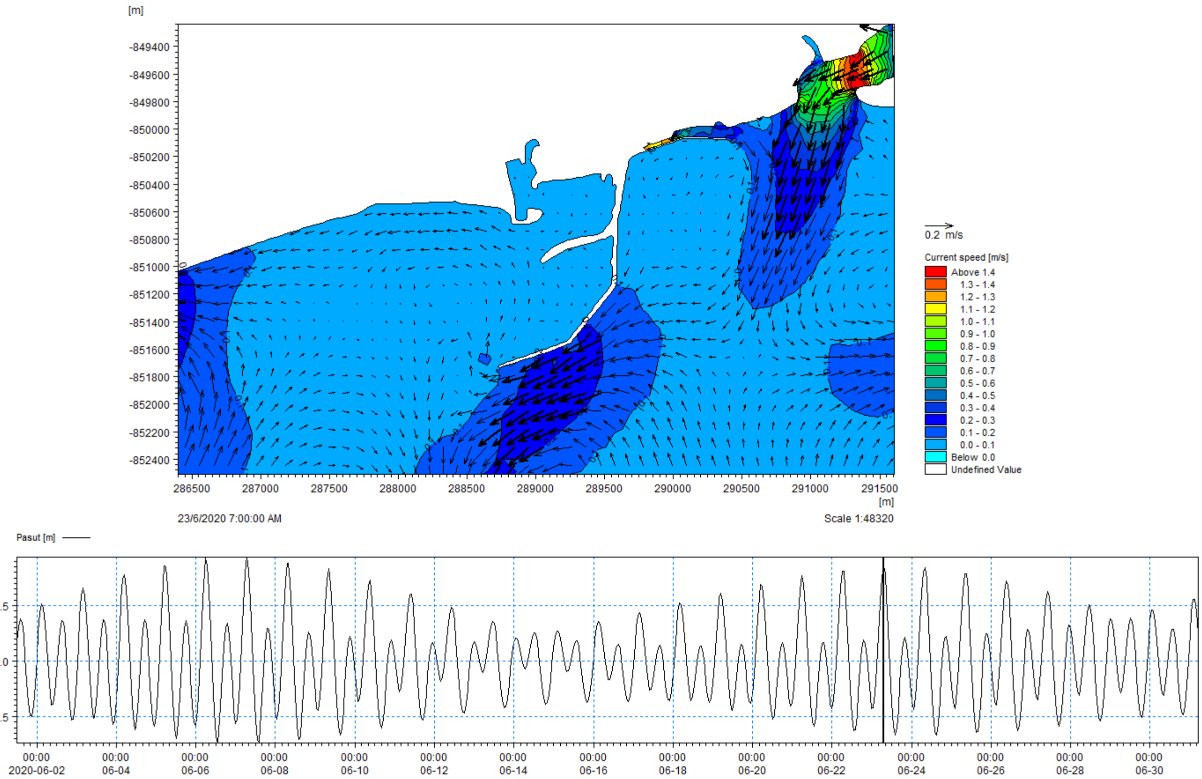
3.2 Wind

The results of the surface current model during June 2020 are presented in four conditions: at high tide (Figure 9a), at high tide (Figure 9b), at low tide (Figure 9c), and at low tide (Figure 9d). From these pictures, several things can be concluded. During June 2020, the current velocity in the water ranges from 0.1-1.5 m / s with an average speed of 0.4 m / s. The current pattern formed at the activity location during June varies depending on tidal conditions. During June the dominant current moves from the southeast in open water, then when it approaches the coast the current pattern is diverted towards the west along the coast of Cilacap.

The condition of the existing waters in Cilacap has created a breakwater that juts towards the sea, so this condition greatly affects the current pattern in these waters. At high tide conditions, currents in open water are relatively weak with speeds of less than 0.4 m / s and move from the south to the north (coast). The current along the coast moves westward. At high tide conditions, the velocity and direction of the flow tends to be the same as the conditions towards the tide, the difference is that the current velocity in the river mouth weakens due to the pressure of the current from open water. Then at low tide, the current from the river gets stronger and juts into open water and the current along the coast begins to weaken and moves eastward. Current conditions at low tide are dominated by strong currents along the coast from the west moving eastward. The results of the elevation model produced by Mike 21 have a value similar to direct observations that occur, where the value is based on TOPEX satellite recording data (Valerina et al., 2017).



(a)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[m]
23/6/2020 7:00:00 AM
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1.3 - 1.4
1.2 - 1.3
1.1 - 1.2
1.0 - 1.1
0.9 - 1.0
0.8 - 0.9
0.7 - 0.8
0.6 - 0.7
0.5 - 0.6
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0.3 - 0.4
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0.1 - 0.2
0.0 - 0.1
Below 0.0
Undefined Value
Pasut [m]
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0.0
-0.5
00:00 2020-06-02
00:00 06-04
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00:00 06-08
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00:00 06-12
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00:00 06-16
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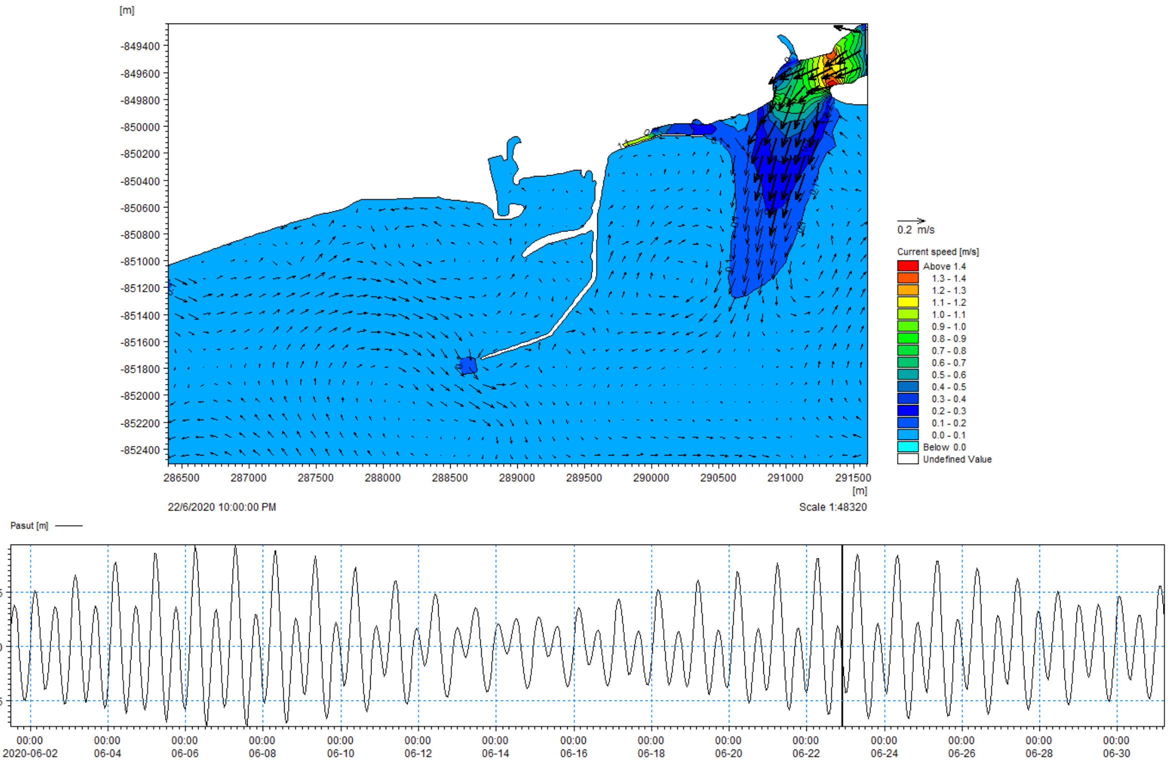
(b)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0.8 - 0.9
0.7 - 0.8
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Undefined Value
Pasut [m]
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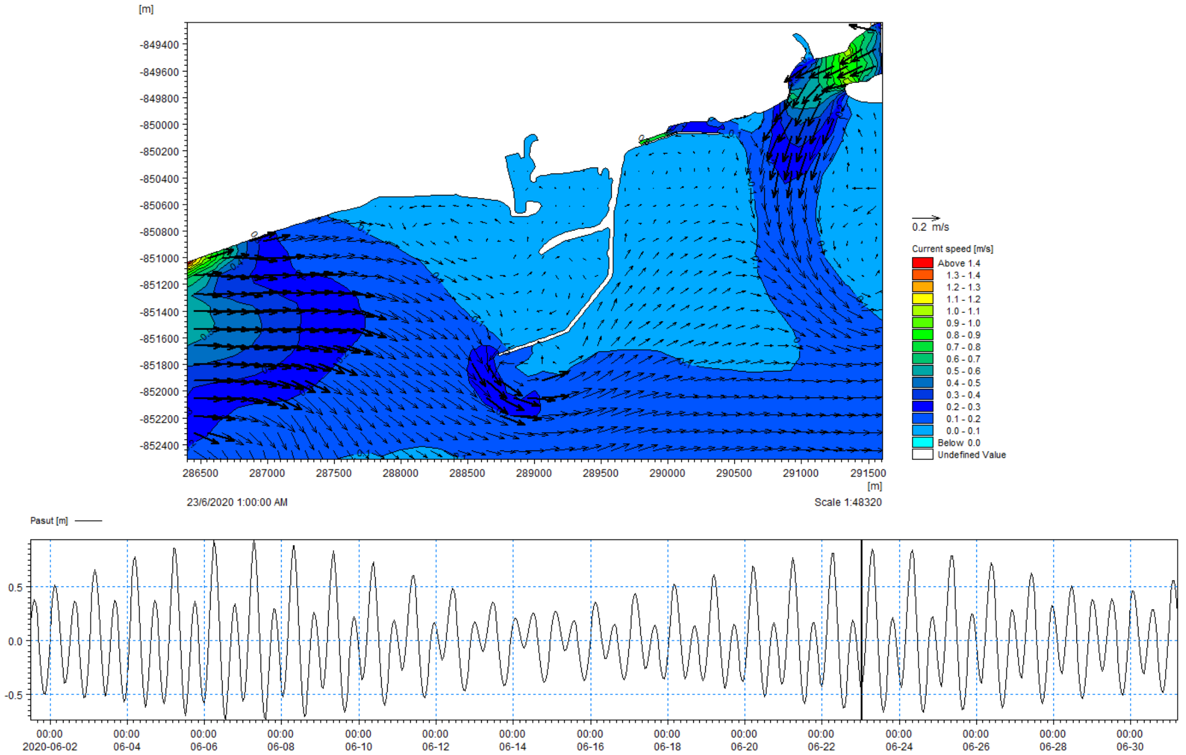
(c)



(d)

Figure 9. Pattern of current direction and velocity towards (a) high tide, (b) at tide, (c) current towards ebb, and (d) low tide

4. Conclusion

The results of this study indicate that the value of water depth (bathymetry) in Cilacap waters tends not to experience significant changes from 2017 (by previous researchers) to 2020 (which was done). This research also shows that the value of modeling ocean currents which are influenced by tides and tides has a relatively small value with values ranging from 0.1-1.5 m/s with an average speed of 0.4 m/s that occurs in June. The dominant sea surface currents move from the southeast in open water, then when approaching the coast the current pattern is diverted towards the west along the coast of Cilacap. In June 2020, the wind in the Cilacap water area blows from the east and southeast with speeds ranging from 2.5 - 7 m/s with the dominant southeast direction, while in the east monsoon with the east wind the speed is relatively the same.

5. References

Arfah, S. H. (2018). Analisis Distribusi Sedimen Pantai Akibat Pengaruh Faktor Hidro-Oseanografi Di Pantai Teluk Penyu Perairan Cilacap, Jawa Tengah (Doctoral dissertation, Universitas Brawijaya).

Bachtiar, A. M. (2012). Sistem Informasi Geografis Pemetaan Fasilitas Umum di Kabupaten Sumedang Berbasis Web. Komputa: Jurnal Ilmiah Komputer dan Informatika, 1(2).

Hendro, H., Nadhi, Z., Budiastuti, S., & Purnomo, D. (2014). Pemetaan Lahan Kritis di Kawasan Muria untuk Meningkatkan Daya Dukung Lingkungan yang Berbasis pada Sistem Informasi Geografis (SIG). Ilmu Pertanian (Agricultural Science), 17(1), 46-51.

Kusnida, D., Lugra, W., & Sarmili, L. (2016). Batimetri, Pola Arus dan Perubahan Garis Pantai di Sagara Anakan, Cilacap. Jurnal Geologi Kelautan, 1(3).

Kusumawati, I. (2016). Pemodelan Dinamika Arus Perairan Indonesia Yang Disebabkan Oleh Angin. Jurnal Perikanan Tropis, 3(1).

Nasa. 2013. Landsat Factsheet Project. http://landsat.usgs.gov/about_project_descriptions.php. 26 Oktober 2013

Prawirowardoyo, S. (1996). Meteorologi Umum. Institut Teknologi Bandung. hal, 130.

Purba, M., & Jaya, I. (2004). Analisis perubahan garis pantai dan penutupan lahan antara Way Penet dan Way Sekampung, Kabupaten Lampung Timur. Jurnal Ilmu-Ilmu Perairan dan Perikanan Indonesia, 11(2), 109-121.

Satriadi, A. (2012). Studi batimetri dan jenis sedimen dasar laut di Perairan Marina, Semarang, Jawa Tengah. Buletin Oseanografi Marina, 1(1), 53-62.

Soedharto, J. P. (2009). Pengaruh pasang surut terhadap rekruitmen larva ikan di Pelawangan Timur segara anakan Cilacap. Jurnal Saintek Perikanan Vol, 5(1), 44-48.

Suharyo, O. S., & Adrianto, D. (2018). Studi Hasil Running Model Arus Permukaan Dengan Software Numerik Mike 21/3 (Guna Penentuan Lokasi Penempatan Stasiun Energi Arus Selat Lombok-Nusapenida). Applied Technology and Computing Science Journal, 1(1).

Valerina, E., Hariadi, H., & Setiyono, H. (2017). Studi

Karakteristik Dan Peramalan Pasang Surut Pelabuhan Labuhan Pandeglang Bagian Selatan Pelabuhan Merak Banten. Journal of Oceanography, 6(4), 516-524.

Widhayanti, A., Ismanto, A., & Yulianto, B. (2015). Sebaran Tumpahan Minyak Dengan Pendekatan Model Hidrodinamika dan Spill Analysis di Perairan Cilacap, Jawa Tengah. Journal of Oceanography, 4(4), 641-650.

Wyrtki, K. (1961). Physical oceanography of the Southeast Asian waters (Vol. 2). University of California, Scripps Institution of Oceanography.