



Numerical Model of Current Speed in Bojong Salawe Beach, Pangandaran West Java Province

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Abstract

The purpose of this study was to determine the hydrodynamic conditions at Bojong Salawe beach. The method used in this research is a quantitative method, where numerical data is collected to support the formation of numerical models such as wind, bathymetry, and tide data. The hydrodynamic model will be made using Mike 21 with the Flow Model FM module to determine the current movement pattern based on the data used. In the west monsoon with a maximum instantaneous speed of 0.04 - 0.08m/s, while in the east monsoon it moves with a maximum instantaneous speed of 0.4 - 0.44. The dominant direction of current movement tends to the northeast. The results indicate the current speed during the east monsoon is higher than the west monsoon. The difference in the current speed is also influenced by the tide conditions; higher during high tide and lower during low tide. Monsoons also have a role in the current movements, though the effect is not very significant.

Keywords: Bojong Salawe. MIKE 21, Modelling, Sediment Transport

1. Introduction

Bojong Salawe Beach has a more complex oceanographic condition which is located along the South Coast of Java. This is because Bojong Salawe Beach is directly adjacent to the Indian Ocean so that the currents and waves are very large (Minarrohman & Pratomo, 2017). This is in line with the opinion of Bird & Ongkosongo (1980) which argues that steep and steep beaches with sand beaches are the dominant component on the South Coast of Java. Because the location of the South Coast of Java is directly adjacent to the high seas, namely the Indian Ocean, this boundary forms the oceanographic parameters of the South Coast of Java. On the South Coast of Java Island, the combination of tides, waves and strong local winds, especially during the West monsoon will cause big waves. Three factors trigger waves, namely tidal currents, coastal winds, and shifting (fluctuating) rock masses on the ocean floor (Minarrohman & Pratomo, 2017).

The wind is one of the climate elements that have an important role in the interaction between the sea and the atmosphere. For the dynamics of marine waters, especially on the surface, the wind is the main source of energy as the driving force for seawater itself. This transfer of energy from the wind to the sea surface will cause waves and ocean surface currents. The currents generated by the wind have different speeds based on depth. The current speed generated by the wind has a small change with increasing depth so that it does not affect at all.

In Indonesia, the wind pattern that plays a big role is the monsoon (monsoon) including the South Coast of Java which is still affected by the monsoon winds (Fadika, Rifai, & Rochaddi, 2014). The period of this monsoon is divided into four, namely the transitional monsoon I, the east monsoons, the second monsoons and the west monsoons. The transitional season I occur from March-May, in this period in April and May there will be a natural phenomenon, namely Kelvin waves propagating at the equator due to the transitional phase of winds at the equator from east to west which causes wind anomalies (Minarrohman & Pratomo, 2017). The month of June - August is called the eastern season where Indonesia experiences the dry season due to the wind that blows with a little water mass. The third period, namely transitional season II which occurs from September - November, is the same as transition one where there is a wind deflection, only in the opposite direction to the first shift, the turning occurs from west to east. And the last period

occurs from December to February because the west monsoon winds blow where the wind carries a lot of water mass, causing Indonesia to experience the rainy season (Yananto & Sibarani, 2016).

Ocean tides are a phenomenon of periodic rising and falling sea levels that occur throughout the hemisphere due to generating forces. The main tidal forces come from the sun and the moon (Douglas in (Ismail & Taofiqurohman, 2012). The dominance of tidal currents is seen in the process of ocean air circulation, especially in coastal waters. When tides occur, tidal currents will transport sea air towards it. Vice versa, when the tide occurs, the tidal currents will transport sea air from coastal waters to the sea (Ismail & Taofiqurohman, 2012). This paper aims to analyze the movement of currents speed in the Bojong Salawe Beach, Pangandaran in two different seasons.

2. Methodology

2.1. Methods

The method used in this research is a quantitative method, where numerical data is collected as a support in the formation of numerical models and validated by statistical calculations (Supian et al., 2020). The method used in this research is observation and simulation; an examination of natural conditions by describing a parameter simply and systematically using hydrodynamic and sediment transport modeling in MIKE 21 (Lumborg & Pejrup, 2005).

The model is run by the Hydrodynamic Module (HD) and simulate an examination of natural conditions by describing a parameter simply and systematically using hydrodynamic modeling in MIKE 21 (Lumborg & Pejrup, 2005). This simulation uses a two-dimensional numerical method by inputting hydrodynamics (wind, bathymetry, tides) validated with field data (DHI, 2012). The results of the two-dimensional model of the movement of currents speed in the Bojong Salawe Beach, Pangandaran in two different seasons. Hydrodynamic is simulated for three months during the West Monsoon (December, January, February) and the East Monsoon (June, July, and August) in 2017, 2018, and 2019 to determine the sediment transport patterns in the estuary and Bojong Salawe Beach by comparing it during high tide and low tide conditions (Husrin et al., 2014).

2.2. Data

The data used in this research is secondary data taken from the following sites.

Table 1: Data required in the study

No.	Data	Source	Resolution	Note
1	Bathymetry	GEBCO	30 Arc-Second	The General Bathymetric Chart of the Oceans
2	Tides	IOC-UNESCO	Every 1 hour	<i>Intergovernmental Oceanographic Commission of UNESCO</i>
3.	Wind	ECMWF	Every 1 hour	<i>Europe Centre for Medium-Range Weather Forecasts</i>

2.3. Research Limits and Scenarios

This research will be carried out in Bojong Salawe Pangandaran Coast by modeling it using MIKE 21. The tools needed to support this research are Google Earth, Laptop, Ms. Office and MIKE. The materials used in modeling it are tides, wind and bathymetry. The study boundaries are at the coordinate point 7°41'28.6" S, 108°32'20.6" E to 7°42'55.2" S, 108°29'55.9" E.

The research was conducted in two different seasons, namely the west season and the east season. This aims to see the differences in oceanographic conditions in the two seasons. 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 (Supian et al., 2020). The model equation used in this study is as follows (DHI, 2012).

Continuity Equation:

$$\frac{\partial \zeta}{\partial t} + \frac{\partial p}{\partial x} + \frac{\partial q}{\partial y} = \frac{\partial d}{\partial t} \quad (1)$$

Momentum of mass on the X axis:

$$\frac{\partial p}{\partial t} + \frac{\partial}{\partial x} \left(\frac{p^2}{h} \right) + \frac{\partial}{\partial y} \left(\frac{pq}{h} \right) + gh \frac{\partial \zeta}{\partial t} + \frac{gp\sqrt{p^2+q^2}}{C^2 \cdot h^2} - \frac{1}{\rho_w} \left[\frac{\partial}{\partial x} (h\tau_{xx}) + \frac{\partial}{\partial y} (h\tau_{xy}) \right] - \Omega p - fVV_x + \frac{h}{\rho_w} \frac{\partial}{\partial x} (p_a) = 0 \quad (2)$$

Momentum of mass on the Y axis:

$$\frac{\partial q}{\partial t} + \frac{\partial}{\partial y} \left(\frac{q^2}{h} \right) + \frac{\partial}{\partial x} \left(\frac{pq}{h} \right) + gh \frac{\partial \zeta}{\partial y} + \frac{gq\sqrt{p^2+q^2}}{C^2 \cdot h^2} - \frac{1}{\rho_w} \left[\frac{\partial}{\partial y} (h\tau_{yy}) + \frac{\partial}{\partial x} (h\tau_{xy}) \right] - \Omega p - fVV_y + \frac{h}{\rho_w} \frac{\partial}{\partial y} (p_a) = 0 \quad (3)$$

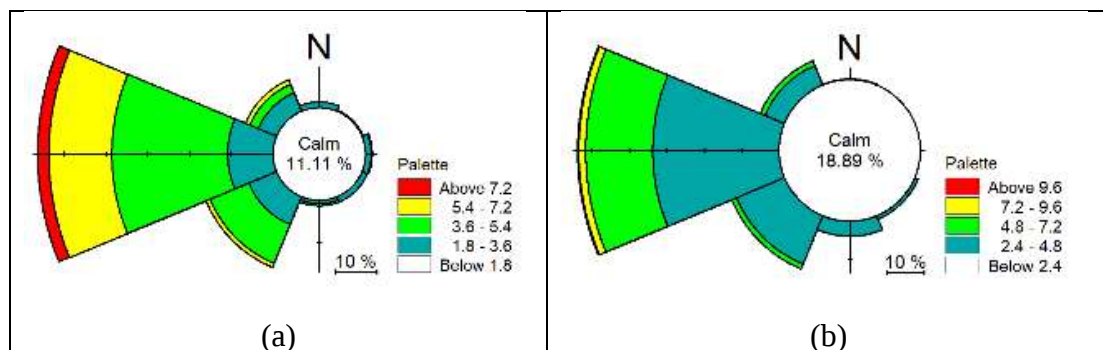
where:

$h(x, y, t)$	: Depth (= $\zeta - d$, m)
$d(x, y, t)$	: The variation in depth with time (m)
$\zeta(x, y, t)$	: Water level (m)
$p, q(x, y, t)$	: Flux density in the x and y directions ($m^3s^{-1}m^{-1}$)
$C(x, y)$	: Chezy resistance ($m^{1/2}/s$)
g	: Acceleration due to gravity (m/s^2)
$f(V)$	: Wind friction factor
$V, V_x, V_y(x, y, t)$	: Wind speed component in the x and y direction (m/s)
$\Omega(x, y)$	: Coriolis parameter (s^{-1})
$p_a(x, y, t)$	: Atmospheric pressure ($kg/m/s^2$)
ρ_w	: Density of water (kg/m^3)
t	: time (s)
$\tau_{xx}, \tau_{xy}, \tau_{yy}$	: Effective shear stress component

3. Results and Discussion

3.1. Wind

Figure 1 is a visualization of wind direction and speed downloaded from the European Center for Medium-Range Weather Forecasts (ECMWF) in the form of a time series every three hours in 3 months each, namely December, January and February in 2017, 2018 and 2019 as a comparison of the west monsoons each year. Taking the coordinates of wind data in this model is assumed to be the regional winds in the research area.



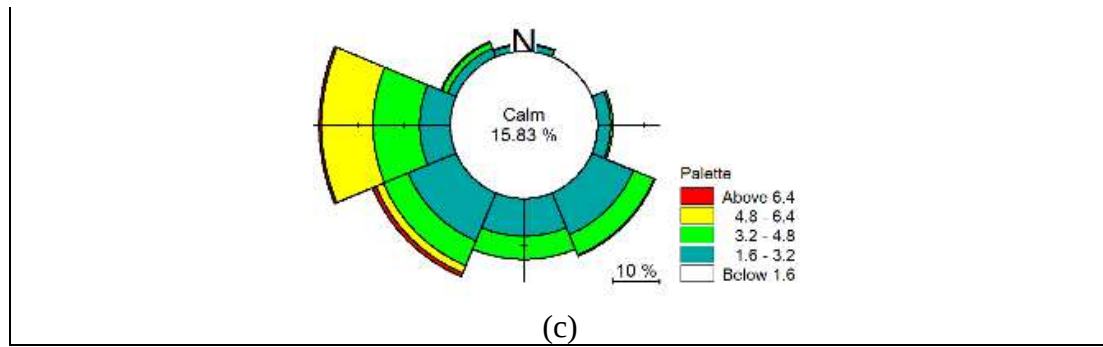


Figure 1: Windrose Chart in West Season (DJF) (a) 2017, (b) 2018, (c) 2019

Based on Figure 1, it can be seen that the dominant winds moved from the west in 2017, 2018 and 2019. In the western season of 2017, the wind speed was in the range of 1.8 m / s - 7.2 m / s. The highest speed reaches 7.2 m / s and the dominant wind speed is at 3.5 m / s - 5.4 m / s. In 2018 wind speeds were in the range of 2.4 m / s - 9.6 m / s. The highest wind speed reaches 9.6 m / s and the dominant wind speed is in the range of 2.4 m / s - 4.8 m / s. In 2019 the wind speed is in the range of 1.6 m / s - 6.2 m / s. The highest speed reaches 6.2 m / s from the southwest direction and the dominant wind speed is at 1.6 m / s - 4.8 m / s. Somewhat different from previous years, the direction and speed of the DJF wind in 2019 experienced a decrease and the direction of the coming of the wind was more varied, with a dominant direction from the west, the wind also moved from the southwest, south, southeast to a little from the east, this is because in 2019 and the west season there has been a weak El Nino phenomenon so that the zonal winds from the west are slightly weakening and the meridional winds from the south are stronger (Athoillah et al, 2017).

Meanwhile, in June, July and August the conditions are normal and there is no global climate phenomenon so that the monsoons move accordingly as shown in Figure 2:

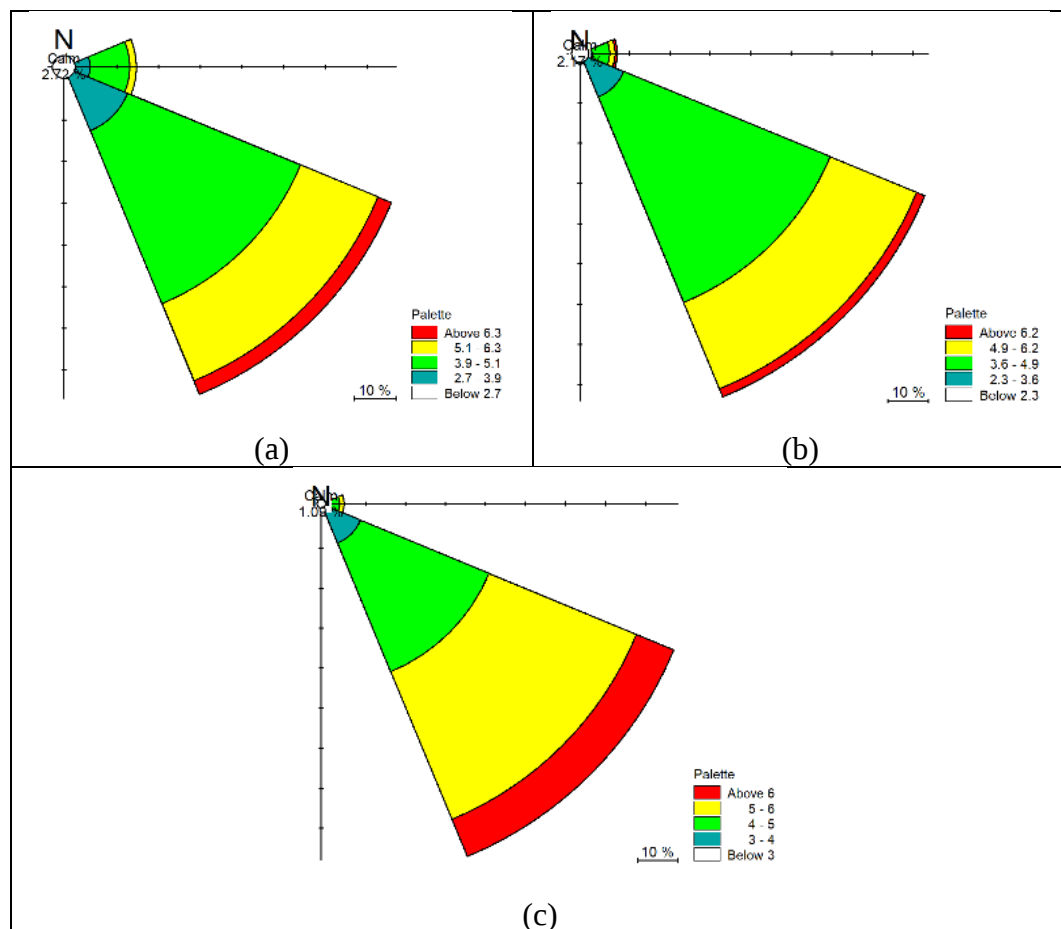


Figure 2: Windrose Chart in East Season (JJA) (a) 2017, (b) 2018, (c) 2019

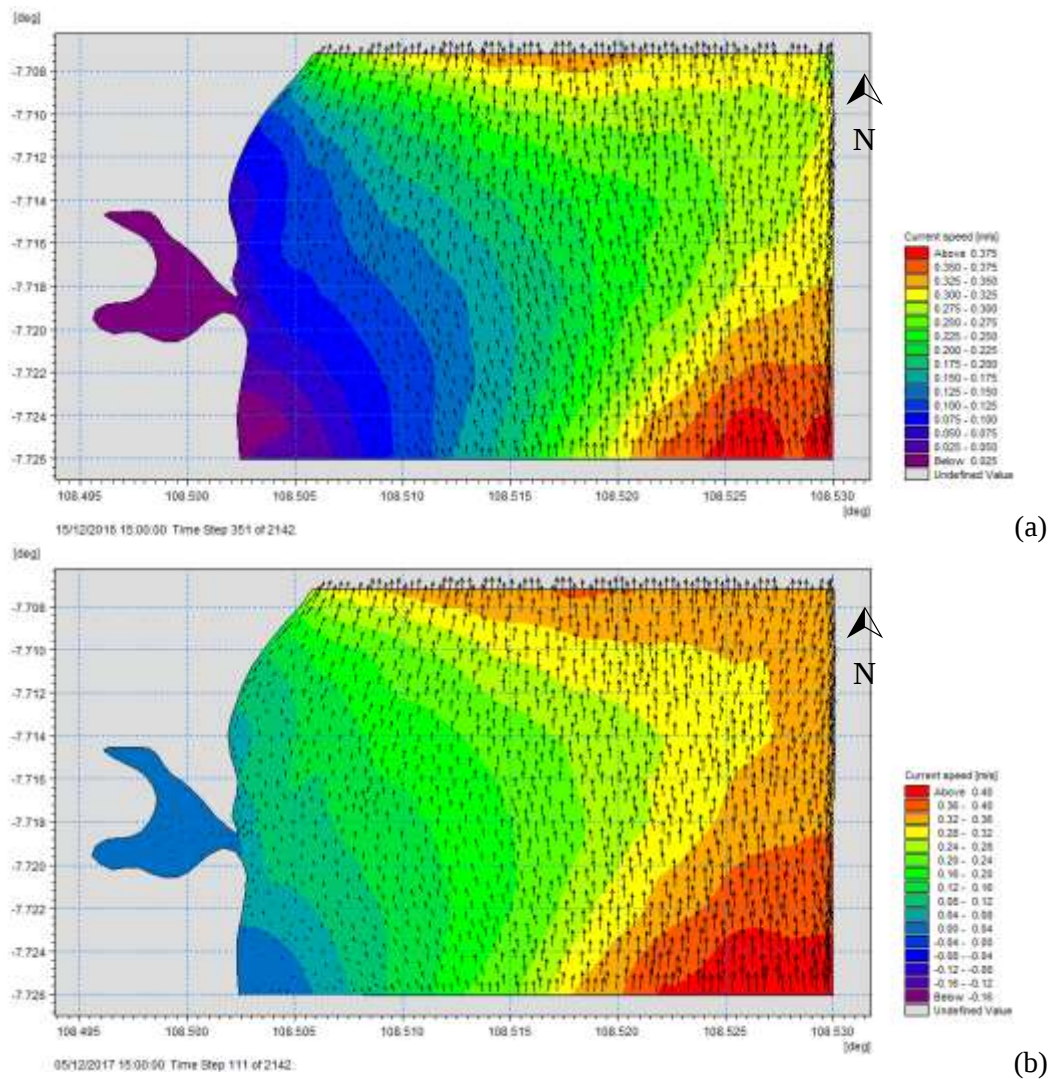
For three consecutive years, namely 2017, 2018 and 2019, the dominant wind moved from the southeast. In the eastern season in 2017, the wind speed was in the range of 2.7 m / s - 6.3 m / s with the dominant speed in the range of 3.9 m / s - 5.1 m / s. In 2018 the wind speed was in the range of 2.3 m / s - 6.2 m / s with the dominant speed in the

range of 3.6 m / s - 4.9 m / s. And in 2019 the wind speed is in the range of 3 m / s - 6 m / s with the dominant speed in the range of 5 m / s - 6 m / s.

According to Aldrian (2000), when the west monsoon the zonal wind moves from the west and in the east monsoons, the wind moves from the east. Meanwhile, the meridional wind will move from the north in the west monsoon and in the east monsoons from the south. This is what causes the wind movement to come from the southeast, because there is a meeting of zonal winds from the east and meridional winds from the south. Zonal wind and meridional wind itself is a division of wind types based on horizontal motion based on latitude and longitude. Zonal winds will move in the east and west directions while meridional winds will move in the north and south.

3.2. Hydrodynamic Simulation

The analysis of the simulation results of this hydrodynamic model is based on the highest and lowest tide conditions that occurred in both the western and eastern seasons in 2017, 2018 and 2019. The separation of these conditions is because the currents that occur at that time will have high velocities due to the tidal elevation. also high (Husrin et al, 2014). The following is the visualization of Figures 3 and Figure 4.



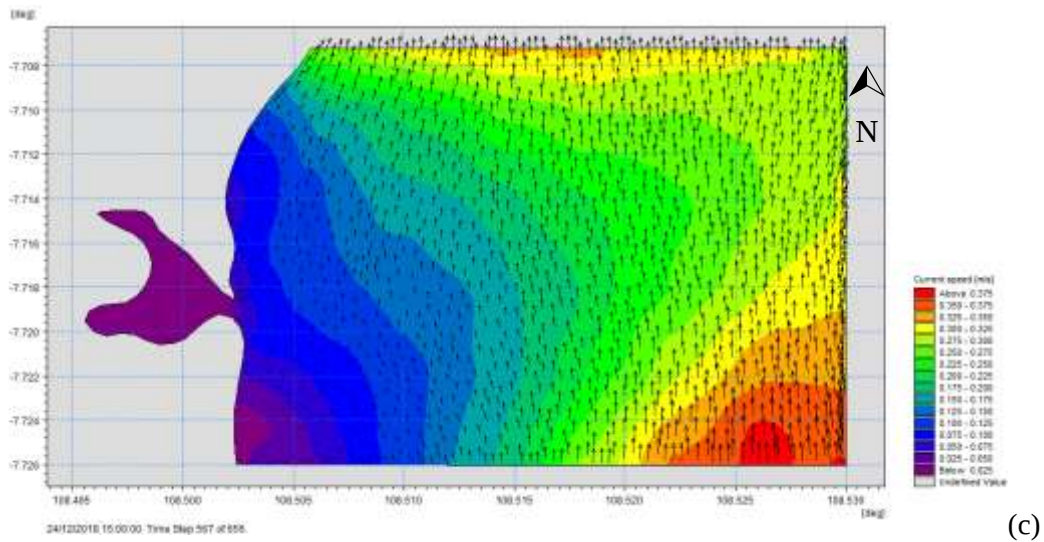
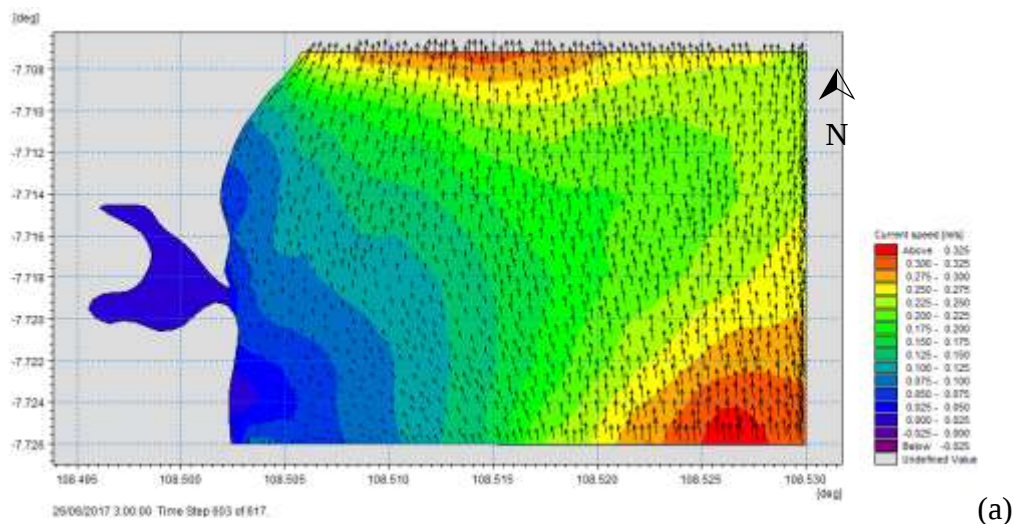


Figure 3. Current Speed in West Monsoon at Highest Tide (a) 2017 (b) 2018 (c) 2019

Based on Figure 3, the highest tide that occurs in the western season in 2017 is the 351/2142 time step on 15 December at 15.00 WIB having current conditions with a maximum current speed of more than 0.375 m / s and a minimum current speed of less than 0.025 m / s. In 2018 the highest tide occurred at the 111/2142 time step on December 5 at 15.00 WIB having current conditions with a maximum current speed of more than 0.4 m / s and a minimum current speed in the range of 0.04 - 0.08 m / s. And in 2019 the highest tide occurred at time step 567/2142 on December 24 at 15.00 WIB, the maximum current speed was more than 0.375 m / s and the minimum current speed was less than 0.025 m / s. The following explanation is presented in Table 2:

Table 2: Current Conditions during High Tide West Season (DJF) (2017-2019)

No	Period	Time	Time step	current speed (m/s)	
				Max	Min
1	DJF 2017	15.00	351/2142	>0,375	<0,025
2	DJF 2018	15.00	111/2142	>0,4	0,04 – 0,08
3	DJF 2019	15.00	567/2142	>0,375	<0,025



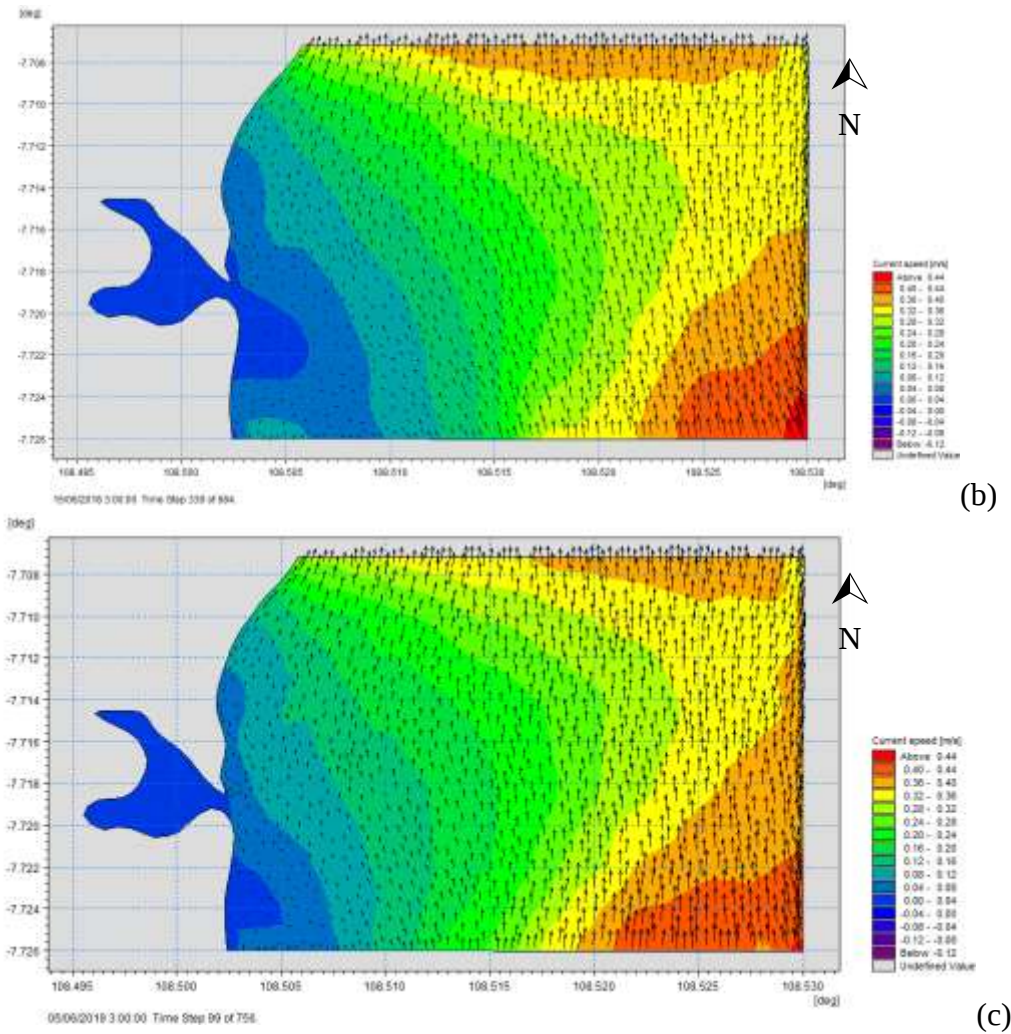


Figure 4. Current Speed in East Monsoon at Highest Tide (a) 2017 (b) 2018 (c) 2019

Based on Figure 4, the highest tide that occurs in the eastern season in 2017 is the 603/2190 time step on June 26 at 03.00 WIB having current conditions with a maximum current speed of more than 0.325 m / s and a minimum current speed of 0 - 0.025 m / s. In 2018 the highest tide occurred at the 339/2190 time step on June 16 at 03.00 WIB having current conditions with a maximum current speed of more than 0.44 m / s and a minimum current speed ranging from 0 - 0.04 m / s. And in 2019 the highest tide occurred at the 99/2190 time step on June 5 at 03.00 WIB, the maximum current speed was in the range of 0.4 - 0.44 m / s and the minimum current speed was in the range of 0 - 0.04 m / s. The following explanation is presented in Table 3:

Table 3: Current Conditions during High Tide East Season (JJA) (2017-2019)

No	Period	Time	Time step	current speed (m/s)	
				Max	Min
1	JJA 2017	03.00	351/2142	>0,375	<0,025
2	JJA 2018	03.00	111/2142	>0,4	0,04 – 0,08
3	JJA 2019	03.00	567/2142	>0,375	<0,025

4. Conclusion

Overall, when the data between 2017, 2018 and 2019 are compared, the highest average current speed in the West Monsoon is during the DJF 2018 period. This is following the average wind speed in the DJF 2018 period. In the East Monsoon of the JJA period, the highest average current speed is at JJA 2019. The current speed during the East Monsoon is higher than the West Monsoon (Supian et al., 2020). The difference in the current speed is also influenced by the tide conditions; higher during high tide and lower during low tide. Monsoons also have a role in the current movements, though the effect is not very significant (Supian et al., 2020).

Acknowledgments

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