REKAYASA
Journal of Science and Technology
https://journal.trunojoyo.ac.id/rekayasa

Rekayasa, 2024; 17(2): 257-266
ISSN: 0216-9495 (Print)
ISSN: 2502-5325 (Online)

Map of The Velocity and Direction of Ocean Currents During The East and West Monsoons of Manakarra Beach Mamuju

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DOI: https://doi.org/10.21107/rekayasa.v17i2.22560
Submitted March 25th 2024, Accepted July 17th 2024, Published August 15th 2024

Abstrak

Karakteristik arus, meliputi jenis arus dominan, kecepatan, dan arah, serta pergerakan arus laut menyebabkan kondisi suatu perairan menjadi dinamis. Tujuan penelitian adalah menghitung arah arus dan menentukan arah arus muson barat dan timur di Pantai Manakarra Mamuju. Penelitian ini menggunakan aplikasi ARC GIS, Aviso, dan MS Excel untuk memanfaatkan data sekunder. Data mentah diunduh di Aviso untuk mendapatkan vektor u dan v. Data yang diperoleh dari Aviso kemudian diolah ke dalam aplikasi MS Excel untuk mendapatkan arah dan kecepatan arus. Setelah diperoleh arah dan kecepatan arus, data kemudian divisualisasikan dalam bentuk arah dan kecepatan menggunakan analisis interpolasi pada ARC GIS. Hasil penelitian berupa kecepatan arus di Perairan Manakarra tahun 2022 pada musim barat (mencapai angka tertinggi 0,876561 m/s dan angka terendah 0,06885 m/s), dan pada musim timur kecepatan arus mencapai angka tertinggi sebesar 0,53816 m/s dan angka terendah sebesar 0,07355 m/s. Selain itu, arah arus di perairan Manakarra tahun 2022 pada musim barat mempunyai tiga arah yaitu dari barat laut, barat, barat daya, dan berakhir di timur laut. Pada musim timur, terdapat tiga arah arus di perairan Manakarra, yaitu dari timur, timur laut, tenggara, dan sebagian dari barat laut.

Kata Kunci : arus, kecepatan, muson, perairan Manakarra,

Abstract

Current characteristics, including the type of dominant current, velocity, and direction, as well as the movement of ocean currents, cause the condition of a body of water to be dynamic. The aim of the study was to calculate the current direction and determine the direction of the west and east monsoon currents at Manakarra Beach in Mamuju. This study used the ARC GIS, Aviso, and MS Excel applications to utilize secondary data. The raw data were downloaded on Aviso to obtain the u and v vectors. The data obtained from Aviso was then processed into the MS Excel application to obtain the direction and velocity of the current. After gaining the current direction and velocity, the data were then visualized in the form of direction and velocity using interpolation analysis in ARC GIS. The results of the study were in the form of current velocities in Manakarra waters in 2022 in the west monsoon (reaching the highest number of 0.876561 m/s and the lowest number of 0.06885 m/s), and in the east monsoon the current velocity reached the highest number of 0.53816 m/s and the lowest number of 0.07355 m/s. In addition, the current direction in Manakarra waters in 2022 in the west monsoon had three directions, namely from the northwest, west, southwest, and ends in the northeast. In the east monsoon, there were three current directions in Manakarra waters, namely from the east, northeast, southeast, and partly from the northwest.

***Key words** : current, velocity, muson, Manakarra waters*

INTRODUCTION

Mamuju town is the capital of West Sulawesi Province. The Mamuju town area is in the form of coastal areas and mountains. The height of the Mamuju town area is between 0 and > 1500 meters above sea level (MASL), with Mount Adang Batambalo as the highest point. The major rivers located in Mamuju town are the Mamuju River, Karema River, Simboro River, Anung River, Taparia River, Anusu River, Tampala River, and Malunda River. Geologically, the Mamuju town area is composed of rocks from the Adang Volcano Formation, including lapilli tuff and breccias interspersed with lava, sandstone, and claystone. Meanwhile, the valley area, which is drained by the Taparia and Karema Rivers, is composed of the Mamuju rocks in the form of marl, calcarenite, and coral limestone interspersed with tuff and sandstone. The town of Mamuju has a tropical climate with two seasons in one year (i.e., dry and rainy seasons), and daytime temperatures range from 24 to 34 ˚C.

Hydro-oceanographic factors such as waves, ocean currents, and tides greatly influence conditions in a body of water (Muskananfola *et al.,* 2021; Hidayah *et al.,* 2021). Current is the mass transfer of water caused by several factors, including differences in the density of water, differences in pressure, and other generating forces such as long waves and wind. In addition, the oceanographic factors that also have an effect are waves (Tarhadi *et al.* 2014; Adalya and Mutaqin 2022). Waves that lead to the beach will break in shallow waters caused by changes in depth (Vuik *et al.,* 2020; Purkis *et al.,* 2014). These breaking waves will stir up the coastal sediments, resulting in the displacement of the bottom sediments. Continuous movement of sediments will cause sedimentation or erosion in waters (Lloyd *et al.,* 2016).

Current patterns and characteristics (which include dominant types of currents, velocity, direction, and movement of ocean currents) cause water conditions to become dynamic (Putri *et al.,* 2021). The movement of the currents transports the materials and properties contained in the water. Strong ocean currents are also caused by variations in sea level height, which are influenced by tidal conditions and water topography. This happens because Cilacap waters are part of the Indian Ocean waters, which have deep and steep water bottoms (Widyartini *et al.,* 2021; Taufiqurrahman *et al.,* 2020). The results of models that have been validated and have shown correlations or similarities with actual conditions in the field can be used to predict the dynamics of various processes that occur in water (Tehrany *et al.,* 2014; Tiyasha *et al.,* 2020). This illustrates that currents have an important role in determining water conditions (Cantwell *et al.* 2016). This study aimed to study the movement pattern of sea surface currents in the east-west monsoon on the Manakarra coast. The results can be used to determine the characteristics and patterns of current changes that occur every year during the rainy and dry seasons, which will then be presented in map form.

RESEARCH METHOD

This research was carried out for 2 months, namely October – December 2022 in Mamuju town, which is located on the western edge of Sulawesi Island. The Mamuju area is between 2˚8′24″S - 2˚57′46″S and 118˚45′26″E – 119˚47′48″E (Figure 1).

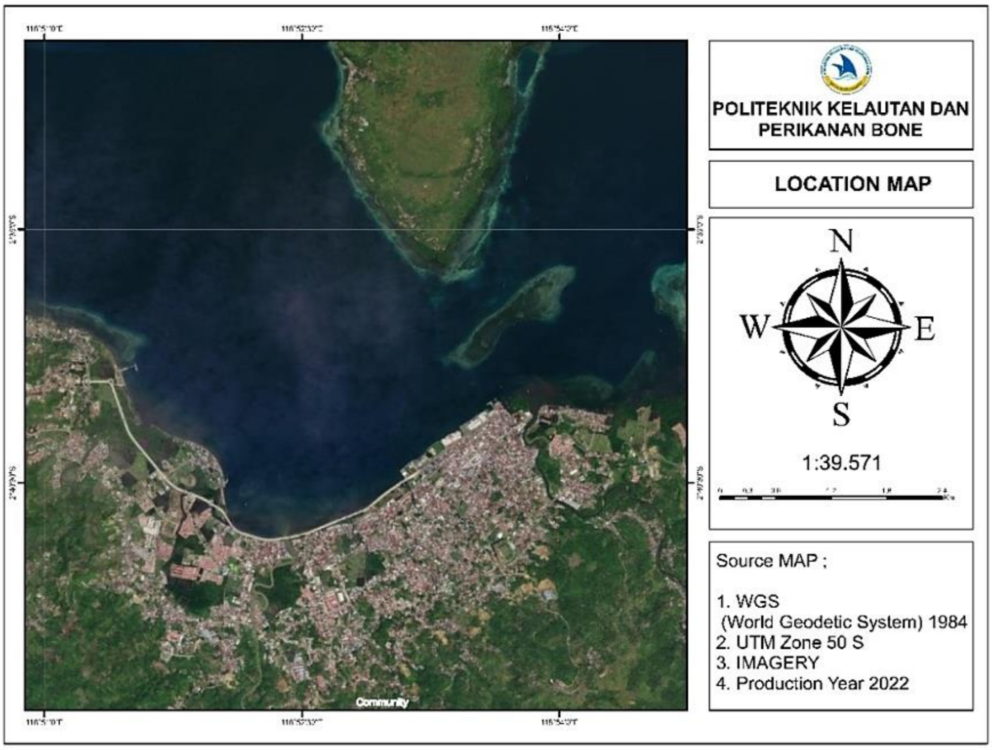

Figure 1. Research location map

The applications used were ArcGIS 10.8 and Ms Excel 2020, which utilized secondary data. The raw data were downloaded on Aviso's website to obtain the u and v vectors. West Monsoon data in October 2021-April 2022 and East Monsoon data in May-September 2022. The data obtained from Aviso was then processed into the Ms Excel application in order to determine the direction and velocity of the current. After getting the current direction and velocity, the direction and velocity were visualized using interpolation analysis in ArcGIS. The calculation of the current vector is done by using the equation obtained from the derivation based on the theory of conservation of mass and momentum where the results of the derivation are as follows:
The current velocity vector formula is:

$$V = \sqrt{(u^2 + v^2)} \text{...(1)}$$

Where:
V = Velocity
U = Zonal velocity (y)
V = Meridional velocity (x)

Alpha formula (direction angle) to get the direction of the surface current with the equation:

$$\alpha = 1/tan(u/v)x180/\pi \text{..................................(2)}$$

Where:
α = Alpha (direction angle)
v = Meridional velocity
u = Zonal velocity

RESULT AND DISCUSSION

Current velocity vector

The current velocity vector was generated by calculating the data u and v to get the velocity value. The value of the current velocity is obtained from the quadrant root of the vector sum of U and V. The two tables below are a set of predicted occurrences every month.

East monsoon

The current velocity results obtained in the east monsoon can be seen in Figure 2, shows the current velocity of the east monsoon. The highest velocity in the east monsoon reached 0.53816 m/s, and the lowest was at 0.07355 m/s. Meanwhile, in the east monsoon, the wind did not blow too hard. This can be seen in the low current vector velocity. In this season, there were a few high tides. On the surface, currents tended to dominate. This was influenced by the response of the wind that blew over it. Winds move at different velocities between warm and cold waters due to changes in the temperature structure of the atmosphere (Chelton, 2013). This high temperature range is characteristic of tropical coastal waters, which are influenced by the dominant heat of the sun. The east monsoon blows at maximum velocity, resulting in low surface temperatures in August (Utama *et al.*, 2017).

The positive impact of the east monsoon is that farmers can harvest comfortably. The positive impact of the east monsoon can be felt by farmers. During the east monsoon, rainfall will be low (Chengappa *et al.*, 2017). This makes farmers worry if heavy rains cannot be controlled. When the east monsoon occurs, the drying of the plants can be done quietly. The results from drying the plants will also be better because they will gain enough sunlight. Fishermen and shipping lines can carry out sea activities safely. Not only farmers feel the positive impact of the east monsoon, but fishermen can also feel the positive impact of the east monsoon (Shaffril *et al.*, 2019). Warm and sunny weather will make sea activities safe for fishermen, so they are not worried about the potential for rain to disrupt their fishing activities. This will certainly increase the productivity of fishermen so that they can work optimally and safely. The shipping lanes will not be hampered and will run smoothly when the east monsoon comes or the dry season comes. Under these conditions, there are several areas that have run out of clean water stocks (Roback *et al.*, 2018), especially for people who live in remote areas, given that remote areas have a higher risk of shortages of clean water. This phenomenon is one of the negative effects of the eastern monsoon. Communities have difficulty obtaining clean water (Kageyama *et al.,* 2013). This makes the fulfillment of life hampered because many plants die as a result of the negative impact of the east monsoon. This happens because these plants lack water, considering that the dry season will cause drought, especially in some areas. This phenomenon also increases the risk of forest fires because there is no running water on these lands. Thus, these plants experience drought (Edwards *et al.*, 2014; Durigan & Ratter, 2016).

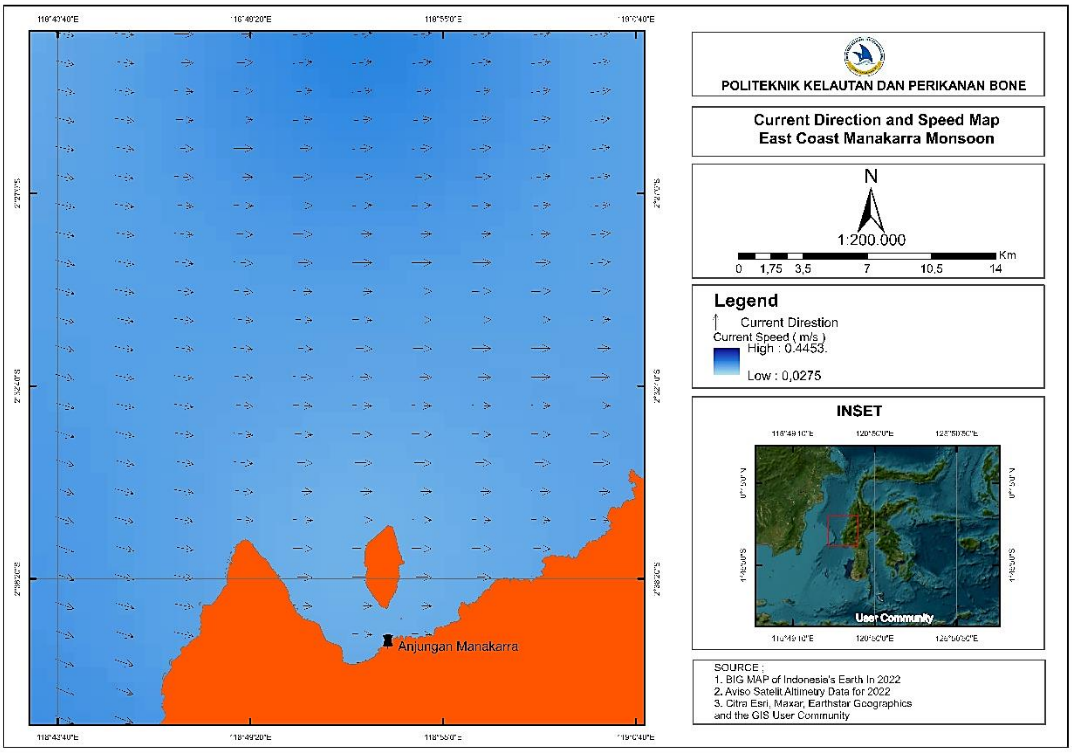

Figure 1. Direction and velocity map of the east monsoon current at Manakarra Beach

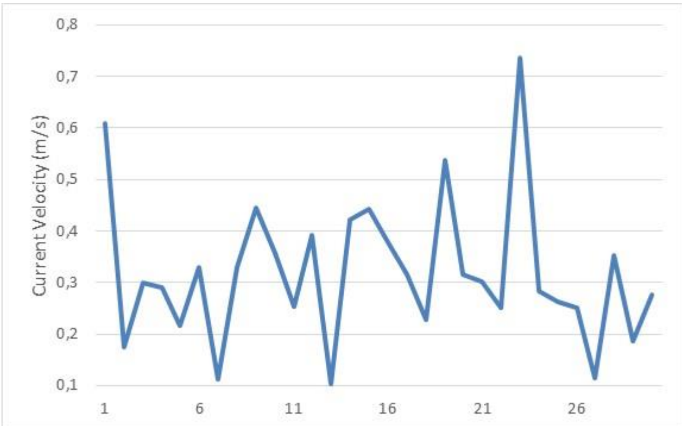

Figure 3. East monsoon current velocity at Manakarra Beach

Figure 2, with a scale of 1:200,000 above, shows the direction of the current that occurred in the east monsoon. The current moved from the northeast, east, and southeast, with the highest velocity reaching 0.53816 m/s and the lowest 0.07355 m/s. On the map, it can be seen in the color interpolation. Arrows in dark blue indicate strong currents in that area. If the arrow was in light blue, then the current in that area was weak. In the east monsoon, the current did not produce big waves. With a map like this, it will be easier for fishermen to carry out sea activities on Manakarra Beach. According to Tokai *et al.* (2021) and Titaheluw *et al.* (2020), weather changes require fishermen to choose the right time to catch fish so that fishing results are optimal. In addition, this strategy will ensure the safety of fishermen. Weather conditions greatly affect the process of fishing operations, as during the East Monsoon in the south of the island of Java, the wind blows from the Australian continent to the west (Muripto, 2016). This causes the movement of surface water masses from the south of the island of Java to the western part of the Indian Ocean (Wirasatriya *et al.,* 2021). The movement of the surface water mass causes an increase in the water mass from the low-temperature interior and replaces the moving surface water mass (Turner *et al.,* 2014).

West monsoon

The current velocity results obtained in the west monsoon can be seen in Figure 4 shows the highest velocity, with a value of 0.876561 m/s. This highest velocity occurred because the wind was blowing hard at the time of the recorded incident, so the current wave experienced an increase. In addition, the lowest velocity was obtained with a value of 0.06885 m/s. The lowest velocity value in the west monsoon was still relatively high and still caused strong waves. High velocity values allow for heavy rain and strong winds. This west monsoon occurs in the October–April period.

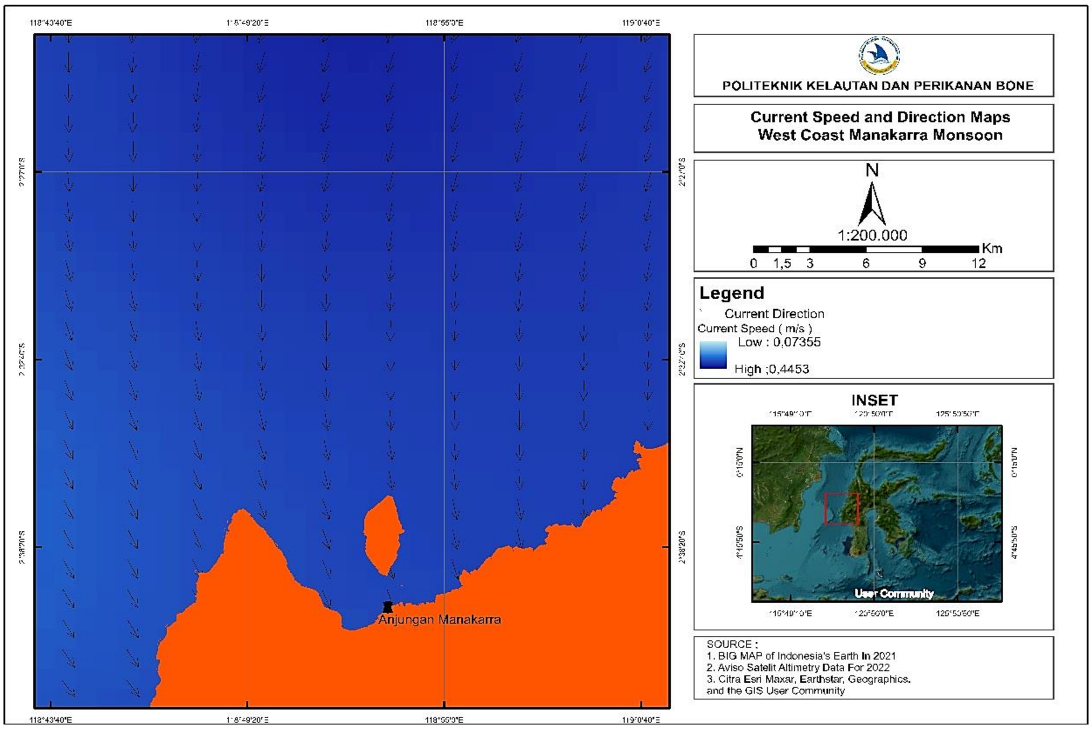

Figure 4. Direction and velocity map of the west monsoon current at Manakarra Beach

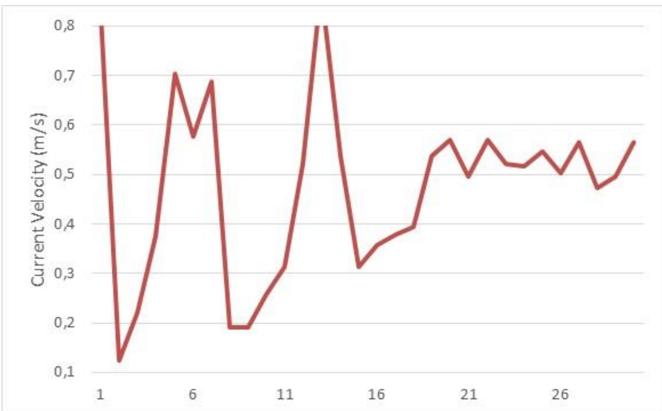

Figure 5. West monsoon current velocity at Manakarra Beach

In this western season, the wind blows from Asia, then moves towards Australia via the Indian Ocean. This will lower the air pressure in Australia, which has relatively high temperatures. On the plains of Asia, winter occurs, and the monsoon blows from October to April. During this period, Indonesia experiences a rainy season, which has a beneficial effect on crops (Tardif *et al.*, 2020). During this season, due to high rainfall, plants absorb more water (Subandi 2014). This makes the plants greener and more fertile, so agricultural development is very good in the western season. Reducing air pollution is also a positive impact of this west monsoon wind. When it rains, air pollution, such as dust flying in the air, will also dissolve. The dust will be washed away with the rain. Therefore, this season will have an impact on reducing air pollution. In addition, aquaculture yields also increase during the rainy season. This is enough to affect the production of cultivated fish because the fish are not often attacked by diseases that can cause crop failure. During this season, the risk of landslides is high because continuous heavy rain will trigger landslides, especially in hilly areas. This, of course, endangers the people around the hills. The rainy season not only has a positive impact on farmers but also has a negative impact on them. One example is farmers who fail because of the rainy season. Farmers who fail to harvest during the rainy season are generally affected by too much rainfall. This causes the rice fields to be inundated by water instead of making the plants fertile. This phenomenon will actually damage the plants. In addition, the process of drying the harvest will also experience problems. The difficulty of getting sunlight during the rainy season is an obstacle for farmers in drying their crops. As a consequence, farmers fail to harvest when the west monsoon arrives, disrupting fishermen at sea and hampering shipping lanes. When they want to do sea activities, fishermen must make sure the weather is sunny and friendly. However, the rainy season will disrupt fishing activities, and the sky will tend to be darker. In addition, heavy rains are always falling (Singh *et al.*, 2019; Wuebbles & Hayhoe, 2014). This will endanger fishermen if they continue their fishing activities, so fish catches this season will decrease.

Figure 5 shows the currents that occurred in the west monsoon in 2022 on the Manakarra coast. The map illustrates that during the west monsoon there were 3 current directions, namely from the northwest, southwest, and west, and then ending in the northeast with a highest velocity of 0.876561 m/s and a lowest velocity of 0.06885 m/s. The map image showing dark color interpolation revealed that this season the currents were fairly strong and the winds were blowing hard. This phenomenon resulted in the emergence of large waves, high seas, and very strong winds. This could have a significant impact on fishing communities. They could not go to sea to find fish, and this affected their economy. Wind movement will supply energy climatically and provide friction between air and water so that water masses move and affect surface currents (Du *et al.,* 2021; Herawati *et al.,* 2021).

Table 1. East monsoon current velocity vector

Longitude	Latitude	U	V	Velocity
117.625	-4.125	-0.0573	-0.0209	0.060993
117.875	-4.125	-0.1536	0.0856	0.175842
118.125	-4.125	-0.2503	0.1636	0.299023
118.375	-4.125	-0.2891	0.0326	0.290932
118.625	-4.125	-0.2048	-0.0723	0.217187
119.375	-4.125	-0.0755	0.3213	0.330051
117.375	-3.875	-0.1082	-0.0289	0.111993
117.625	-3.875	-0.2741	0.1819	0.328966
117.875	-3.875	-0.4039	0.1876	0.445341
118.125	-3.875	-0.2928	0.2046	0.357202
118.375	-3.875	-0.253	0.0055	0.25306
118.625	-3.875	-0.0812	-0.3841	0.392589
119.125	-3.875	-0.1022	-0.0159	0.103429
117.375	-3.625	-0.347	0.2406	0.422253
117.625	-3.625	-0.3458	0.2776	0.44344
117.875	-3.625	-0.3432	0.1566	0.37724
118.125	-3.625	-0.3154	0.0235	0.316274
118.375	-3.625	-0.1311	-0.1859	0.227478
118.625	-3.625	-0.0447	-0.5363	0.53816

Longitude	Latitude	U	V	Velocity
117.375	-3.375	-0.254	0.1865	0.315116
117.625	-3.375	-0.2281	0.199	0.302705
117.875	-3.375	-0.1715	0.1829	0.250728
118.125	-3.375	-0.0735	-0.0027	0.07355
117.375	-3.125	-0.2145	0.185	0.283258
117.625	-3.125	-0.1214	0.2331	0.262819
117.875	-3.125	-0.025	0.003	0.025179
117.375	-2.875	-0.0925	0.0674	0.114451
117.625	-2.875	0.0309	0.0172	0.035365
118.625	-2.875	0.1847	0.0261	0.186535
117.375	-2.625	0.211	0.1775	0.27573

Table 2. West monsoon current velocity vector

Longitude	Latitude	U	V	Velocity
117.625	-3.625	0.0723	0.0395	0.082387
117.875	-3.625	0.0809	-0.0937	0.123792
118.125	-3.625	0.0982	-0.1971	0.220208
118.375	-3.625	0.1631	-0.3386	0.375834
118.625	-3.625	0.2223	-0.6679	0.703923
118.875	-3.625	0.3235	-0.4784	0.577511
119.125	-3.625	0.0227	-0.065	0.06885
117.375	-3.375	0.1795	0.0645	0.190737
117.625	-3.375	0.1905	0.0059	0.190591
117.875	-3.375	0.2424	-0.088	0.257879
118.125	-3.375	0.1999	-0.242	0.313885
118.375	-3.375	0.2879	-0.4333	0.520226
118.625	-3.375	0.281	-0.8303	0.876561
118.875	-3.375	0.1585	-0.5129	0.536832
117.375	-3.125	0.3067	0.0678	0.314105
117.625	-3.125	0.3561	0.009	0.356214
117.875	-3.125	0.364	-0.1042	0.378621
118.125	-3.125	0.3224	-0.2262	0.393838
118.375	-3.125	0.3029	-0.4432	0.536819
118.625	-3.125	0.2753	-0.4998	0.570605
117.375	-2.875	0.4903	0.068	0.494993
117.625	-2.875	0.5685	-0.0358	0.569626
117.875	-2.875	0.5201	-0.0473	0.522246
118.125	-2.875	0.4805	-0.1867	0.515497
118.375	-2.875	0.3906	-0.3825	0.546694
118.625	-2.875	0.3256	-0.3818	0.501783
117.375	-2.625	0.564	-0.0337	0.565006
117.625	-2.625	0.472	-0.0178	0.472336
117.875	-2.625	0.495	-0.0075	0.495057
118.125	-2.625	0.5581	-0.0951	0.566145

Tables 1 and 2 show the movement of the current degrees that are affected by the wind, which can be seen in degrees. What can be distinguished from the degrees in the two tables above is that in the west monsoon table, the degree was 81-346˚, and in the east monsoon, the degree was 61-161˚.The direction of the west monsoon degree was greater than the east monsoon degree direction. In the west monsoon, the weather was quite extreme compared to the east monsoon. The direction of the wind blowing or the direction of the current of the wind was expressed in degrees, which was determined by clockwise rotation and started from the north point of the earth (according to the compass point). The sea level at high tide tends to be higher, so the current velocity is faster, whereas the sea level at low tide tends to be lower, so the current velocity slows down (Kay *et al.*, 2015; Balsari *et al.,* 2020). The greater the wind velocity, the greater the frictional force acting on the sea surface, and as a result, the current will also be greater (Hunta & Sajjadib, 2018; Takagaki *et al.,* 2018; Setiawan *et al.,* 2021).

CONCLUSION

The current velocity in Manakarra waters in 2022 in the west monsoon reached the highest value of 0.876561 m/s and the lowest value of 0.06885 m/s. In the east monsoon, the highest value was 0.53816 m/s and the lowest value was 0.07355 m/s. The current direction in the 2022 Manakarra waters in the west monsoon had three current directions, namely the current from the northwest, west, southwest, and ended in the northeast. In the east monsoon, there were also three current directions, namely the current from the east, northeast, and southeast, and partly from the northwest

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