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Analysis of Currents in Open Water Southwest of Lae Lae Island

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ABSTRACT

Ocean currents are one of the movements of horizontal or vertical mass movement of seawater that takes place continuously. The purpose of this study is to determine current conditions in open water close to narrow strait waters, as well as canal estuaries. Current data is the result of measurements that have been carried out using ADCP (Acoustic Doppler Current Profiler) mini type ADP-SONTEK equipment on May 16, 2018, while tidal data refers to the recording results of the Makassar BIG tidal station. The results showed that the total surface current speed ranged from 0.017 – 0.375 m/sec with a dominant direction to the west or to open water both at high tide and at low tide. While the result of separation, the speed of tidal currents ranges from 0.032 – 0.343 m / sec.

Keyword: current, Aquatic currents, lae lae island

INTRODUCTION

Ocean currents are one of the movements of horizontal or vertical mass movement of seawater that takes place continuously. The continuity of currents is generated by several factors including wind, tides, and density (Nontji, 1993). Current events can bring water masses to move to other waters (Trujillo & Thurman, 2008) The existence of land landforms can affect the pattern of ocean currents near the coast (Gu & Mao, 2024).

Lae Lae Island is the closest island to Makassar City which is included in the administrative area of Ujung Pandang District (Idrus et al., 2022). The waters around Lae Lae Island have the characteristics of the open sea in the west, the north and east are semi-open strait waters facing the mainland of Makassar City with a closest distance of 1,040 meters, while in the south are open strait waters between Lae Lae Island and the CPI reclamation land of Makassar City with the narrowest distance of 450 meters.

The existence of narrow straits can cause current strengthening and has a large potential for ocean current energy (Li et al., 2022). In some studies show strong currents in some strait waters, as in table 1.

Table 1. Maximum Current Speed in Several Straits in Indonesia

No	Location	Current Speed (m/sec)	Source:
1	Bali Strait	1,08	(Tsanyfadhila et al., 2022)
2	Mansuar Strait	1,576	Measurement results of the P3GL Team in the Raja Ampat Mansuar strait in 2013 (Nusratina et al., 2023)
3	Lampa Strait Natuna Islands	1,28	(Raharjo & Saputra, 2017)

Losari Beach facing Lae Lae Island and extending from the Port to the south to the mouth of the Jongaya canal is a protected water, has waters that are the outlet of wastewater channels from urban land, and has the potential to spread towards open water through the straits around Lae Lae Island. Increased flow speed when passing through narrow strait, and has an effect on strengthening currents in open water. This can cause an acceleration of water flow from Losari waters through the strait and into open waters, and vice versa.

Jongaya Canal is one of the largest outlets that divides the southern part of Makassar City and affects water quality for Losari Beach Waters (Faizal et al., 2023). In high rainfall, millions of cubic meters of water are collected in the canal, resulting in high discharge and entering the waters of the losari. The discharge capacity of Jongaya canal is 51.72 m3/sec (Director General of Cipta Karya, 2016). The construction of the CPI southern canal connecting the Jongaya Canal with open sea waters, made room for the flow of the canal and its material directly into the open sea and dispersed by current events in the sea, as by Duxbury et all. (2000) in Respati, et. All (2017), suggests that current circulation patterns affect the distribution of material in waters.

The confluence of currents from the strait, as well as the estuary of the southern canal of the CPI, causes the potential for the spread of water into the open sea, whose distribution depends on the current pattern that occurs, so it is necessary to measure the existing currents at locations that also aim to determine the direction and speed of currents as a result of the confluence of strait currents, currents from canals, and open water currents. The benefits of current measurement as material for verification and validation of data from current modeling at the location, as well as an indication of the direction of distribution of wastewater from the Jongaya Canal and Losari waters in open water.

METHOD

Research Material

Research conducted using primary / insitu data is data on the zonal component of currents / east west (u) and meridional components of currents / north south (v) which are then processed into current direction and speed data at several depth stratifications, as well as depth data at the current measurement location. While secondary data is tidal data which coincides with the time of current measurement.

Research Methods

This research uses quantitative methods, using numbers, and empirical equations to get good research results. Selection of research sites according to the purposive sampling method, namely at one sample point that can represent the research location (Sugiyono, 2011).

The current data used is the data from recording the ADCP (Acoustic Doppler Current Profiler) mini type ADP-SONTEK tool on May 16, 2018. While the position and depth data were recorded on the same date using the Garmin 585 GPS Map tool.

Research Location

Current measurements were made at the mouth of the strait between Lae lae Island and CPI reclaimed land, and astronomically located at position 05°08'59.41"S 119°23'14.07"E (figure 1).

To represent tidal conditions at the study site based on measurement data at tidal stations owned by the Geospatial Information Agency (BIG) obtained online through the page: http://ina-sealevelmonitoring.big.go.id/ ipasut/data/residue/week/8/2018-05-18. The data used is tidal time series data for 3 piantan with an interval of 1 hour.

The location of the BIG Makassar Tidal Station is 05°06'42.11" LS, and 119°25' 04.44" E.

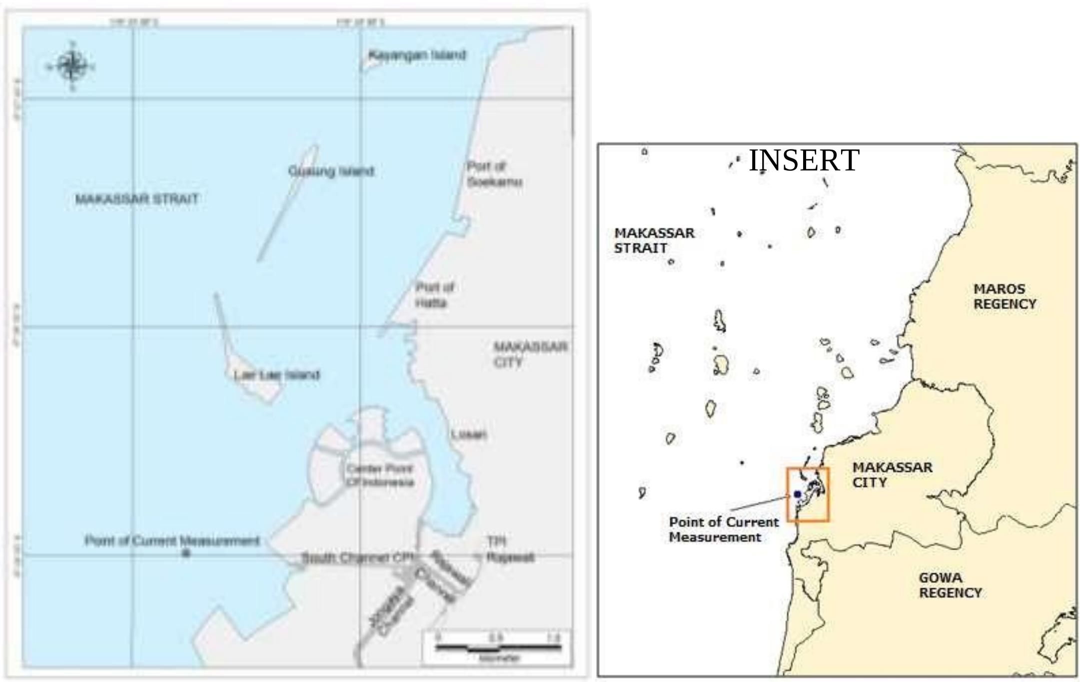

Figure 1. Current Measurement Point and Location of BIG Pasut Station in Makassar City

Data Analysis

The results of recording currents from the ADCP tool are data on the flow of the u component (east - west) and the flow of the v component (north - south) as well as depth data measured from the bottom to the sea level where the ADCP is installed.

The current velocity is calculated based on the resultant of the you and v components using the formula (Dikspespa-Hidros (2010) in Simatupang, et. all (2016):

$$V = \sqrt{u2 + v2}$$

And the direction of ocean currents according to the equation:

$\tan \alpha = \frac{u}{v}$

$$\alpha = \arctan \frac{u}{v}$$

Where:
V= resultant of vectors you and v (m/s)
u = current speed in the x/east - west direction (m/s)
v = current speed in the direction y/north - south (m/s)
α = direction of geographical flow
Determination of the angle of α, according to the division of the quadrant as follows:

Quadrant	v	u	u→/v angle
I	+	+	90
II	+	-	180 + α
III	-	-	180 + α
IV	-	+	360 + α

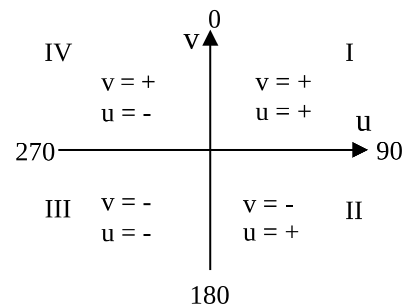

Figure 2. Quadrant division scheme

To calculate tidal currents, several sequences of equations are used, including:
1. The number of northern components (U), is the number of components of the north-south current
Utotal = Σ v
2. Average north-south component,
Average = Utotal/n
n = amount of data
3. The number of components East (T), is the sum of the components of the east - west (u) flow
Ttotal = Σ u
4. Average Eastern component (T),
Average = Ttotal/n
5. Determining the component of the north tidal current (U), is the difference between the component of the north south current and the average northern component:
$U_{\text{of tidal current}}$ = v – Average
6. Determine the components of the East tidal current (T), namely: the Eastern current component (T) minus the Eastern current average (T):
T_{current} = u – Trata
7. Determine the direction of the flow of tidal current:
$\alpha_{\text{of the current}}$ = arctan(T of the current of the tail $_{/\text{ U of the}}$ current of the stake$_{)}$
Determination of the angle of α of $_{\text{the tidal current,}}$ according to the quadrant division as shown in figure 2, but v becomes the tidal current and you becomes the tidal Tarus
8. Determining the speed of the current of the tidal current:
Varus Stake

$$= \sqrt{\left(U_{arus\,pasut}{}^{2}\right) + \left(T_{arus\,pasut}{}^{2}\right)}$$

9. Determining the direction of non-tidal current:

$$\alpha_{arus\ non\ pasut} = Arctan\left(\frac{T_{arus\ \ rata-rata}}{U_{arus\ rata-rata}}\right)$$

10. Determining the speed of non-tidal current:

Varus non tidal $= \sqrt{(U_{arus\ rata-rata}{}^{2}) + (T_{arus\ \ rata-rata}{}^{2})}$

RESULTS AND DISCUSSION

Tidal Conditions

Tidal State for 3 piantans, as shown in figure 3.

Figure 3. Tidal Chart of Makassar Waters

The results of tidal recordings for 3 x 24 hours, show that the type of tides in Makassar waters is a mixture that tends to be diurnal which is characterized by the dominance of one tide or low in one day, but on certain days there are two ups and downs. This type is also in accordance with the results of Arifin's research, et.all. (2012).

The tidal ride was 118 cm which occurred on May 16, 2018, a difference of 12 cm from the measurement results of Arifin, et.all. (2012), with a maximum tidal ride the measurement results of 15 piantan reached 130 cm (figure 4). Similarly, obtained from Rini, et.all (2018) who used measurement data from the Makassar Paotere Maritime Meteorological Station in 2017, found the highest tides occurred in February at 1.3 m and the lowest in October at 0.5 m. There is a difference in tidal rides, because the BIG reference data used for 3 piantan and has not reached full tide conditions.

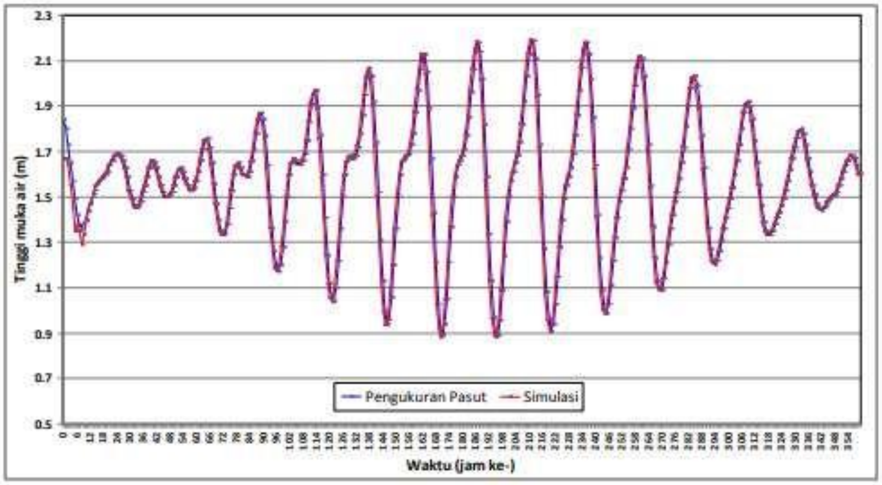

Figure 4. Tidal Measurement Chart for 15 Piantan in April 2012 in Makassar waters (Arifin, et.all., 2012).

Current Conditions

Current measurements are carried out for 1 time for 24 hours simultaneously with tidal measurements of the same duration of time. Current measurement results under tidal conditions show speed fluctuations and variations in current direction, as shown in Figure 5.

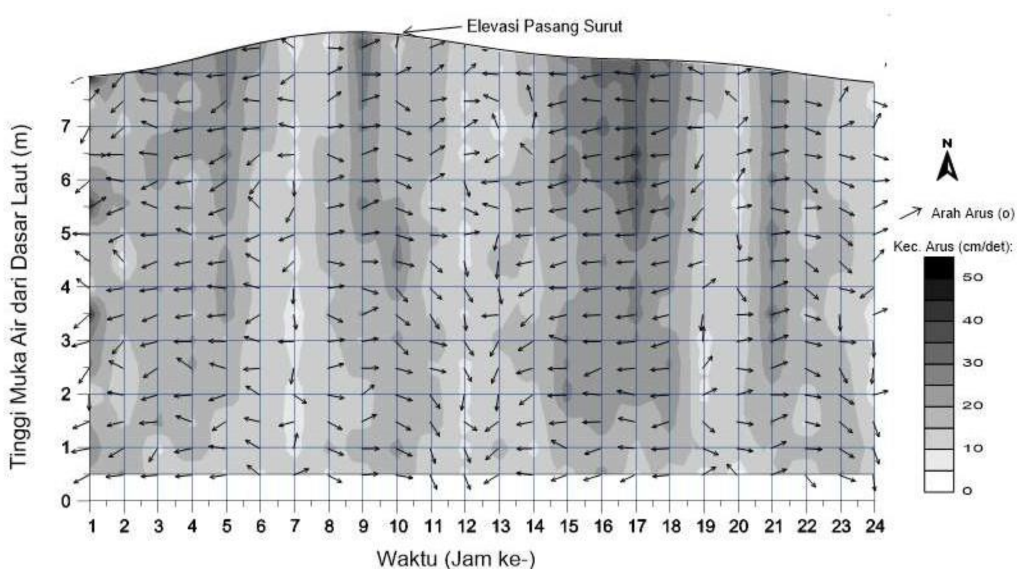

Figure 5. Flow Direction and Speed Fluctuation Graph by time, depth, and tides
Description: the direction of the current according to the cardinal points

The current state as shown in figure 5 shows the direction and speed of the current that occurs for 24 hours, at the bottom of the water to the surface along with the rise and fall of sea levels. The depth of the water changes following the tidal pattern at the plan location. The depth of water when following the tides ranges from 7.75 – 8.86 m. When the tide is low, there is a minimum depth and at high tide there is a maximum depth at the current observation location.

Strong current speeds generally occur on the surface can reach 0.375 m/sec and reach peak speeds when the water recedes. Vertically, strong currents at the surface affect the consistency of current direction up to the seabed (Lu et al., 2021), as in figure 5. And as it gets closer to the bottom of the waters, the current speed decreases (Bernawis, 2000). It can be caused by the decreasing influence of current generation forces from surface to bottom, and Wisha, U.J., and Ilham, I., (2019) suggest that there are physical obstacles at the bottom of the waters. Nusratina, et.all. (2023) suggests that the weakening of currents in the bottom layer is caused by the process of energy propagation eroded by friction between currents and water masses, so that the speed generated by wind and tides will be weaker as they approach the bottom of the waters. The strongest current speed at the bottom of the water reaches 0.224 m/sec (figure 6).

Current attenuation occurs when the current transition changes direction when the water approaches high tide and approaches low tide which affects the pattern of surface currents to the seafloor with inconsistent variations in current direction in a certain direction. Poerbandono et all. (2005), suggests that the minimum or effective zero slack current speed occurs when the water level is highest or lowest (slack water) at which time there is a change in the direction of the slack current.

Figure 6. Graph of Direction and Speed of Surface and Seabed currents

Overall measurement of current direction and velocity over 24 hours from surface to seafloor, as illustrated in the currentrose diagram as shown in figure 7.

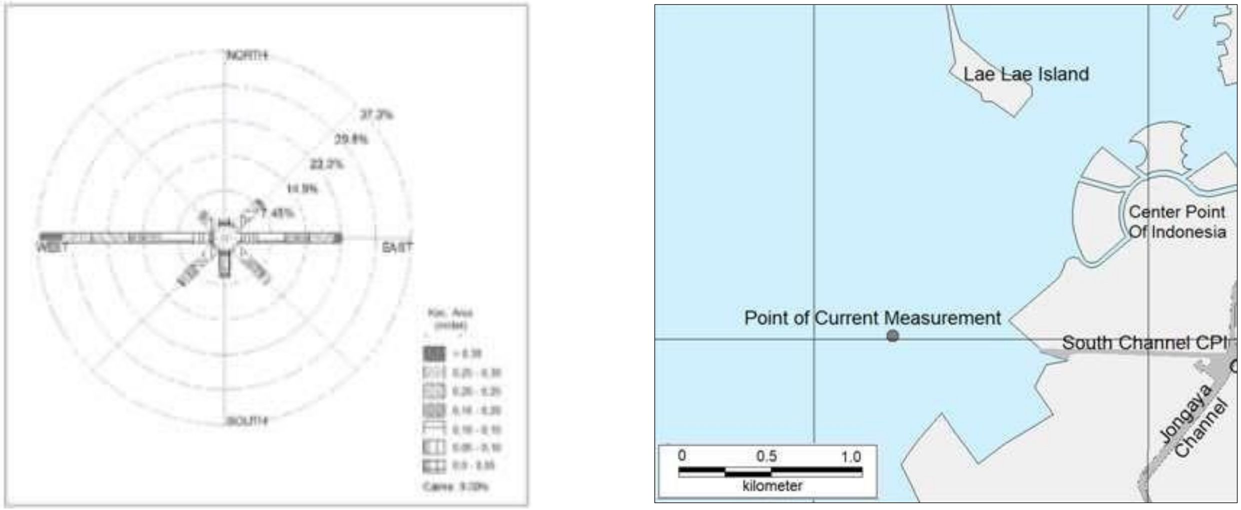

Figure 7. Current Rose Study Location

The tendency of flows at the planned location occurs in two dominant patterns, namely to the west, and to the east. When the water goes to high tide, the surface current state ranges from 0.06 – 0.38 m/sec and the direction of the current is dominant west or towards open water. Similarly when heading towards low tide. The eastward direction of the current, which leads to the CPI coast, occurs when the water has high tide and when the water has receded (figure 6). The occurrence of westward currents illustrates that the occurrence of currents is due to differences in sea level pressure which is influenced by the elevation of the water table in bays and straits, as well as beaches that are higher than the open sea when the water goes to high tide and goes to low tide, so there is a difference in pressure at the water surface (Steward, 2003 in Dewi et all., 2022). Vice versa, when there is a high tide and low tide.

The influence of tides on currents is known by analyzing the separation of tidal currents and non-tidal currents (residual currents). The results of the analysis showed that the influence of tides was still strong on the currents at the study site. The maximum tidal current speed on the seabed reaches 0.222 m/sec and at sea level reaches 0.343 m/sec, while the attenuation of currents due to tides reaches 0.037 m/sec on the water floor, and at sea level reaches 0.032 m/sec.

Figure 9. Graph of Direction and Speed of Measured Currents and Tidal Currents at Sea Level

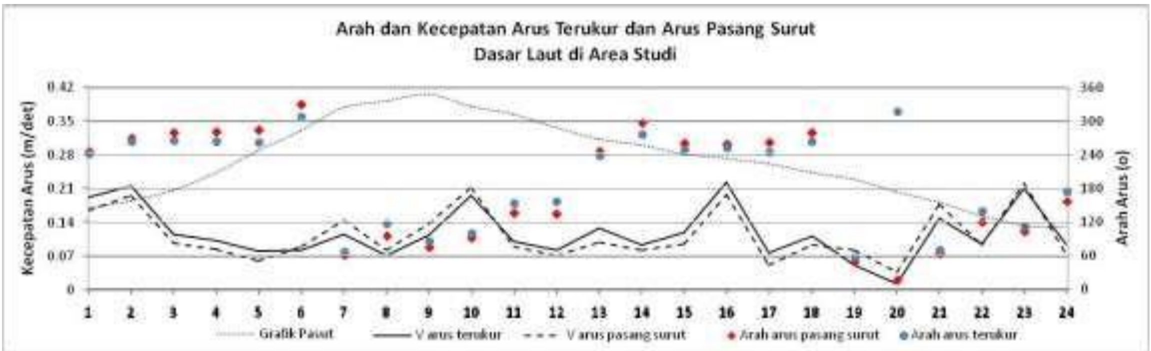

Figure 10. Graph of Direction and Speed of Measured Currents and Tidal Currents on the Seabed

In addition to tidal currents, there are also non-tidal currents (residual currents) that affect the speed of tidal currents (Overes et al., 2024), resulting in sea currents. Mathematically, ocean currents are the sum of tidal currents and residual currents (SUCI, 2023). The residual current resulting from separation shows a weak speed. At sea level, the speed reaches 0.051 m/sec towards 280 ^{o} (west), while on the seabed the speed decreases to 0.032 m/sec towards 217o (southwest).

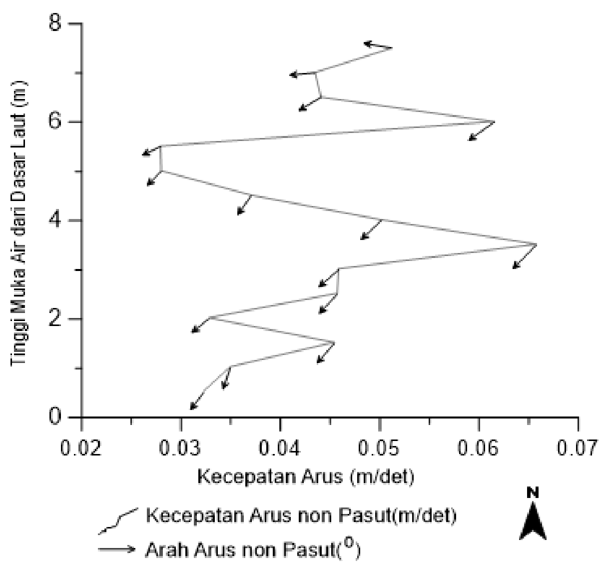

Figure 11. Profile of Direction and Speed of Non-Tidal Current (Residual Current) according to Water Depth.

The residual current increases the total current velocity if it is unidirectional, which is shown in figure 9 and figure 10. The total current speed is higher than the tidal current when heading west and southwest. The role of residual currents According to Surbakti (2012), it is important in the spread of a material in waters. Further by Ramming and Kowalik (1980) in Budiman et.all., (2015), the magnitude and direction of residual current flow affect the mass exchange of water and the process of dispersal and deposition of various materials, sediment composition and pollutants in coastal areas and bays in the long term.

With the condition of the total current that occurs, indicating the spread of water masses from the waters of Losari passing through the strait, and the water of the Jongaya canal has the opportunity to go to open water.

CONCLUSION

The waters southwest of Lae Lae Island are open waters that are still influenced by strait flows, and the channel south of CPI so that it still has a high total current speed and is dominant tidal currents. The speed of currents on the surface has a strong influence on seabed currents, with the consistency of current direction to the bottom of the water The dominant current direction is westward (open water) both when the water goes to high tide and towards low tide, and the current to the east (towards the coast) at high tide and low tide.

BIBLIOGRAPHY

Bernawis, L. I. (2000). Temperature and pressure responses on El-Nino 1997 and La-Nina 1998 in Lombok strait. Proc. The JSPS-DGHE International Symposium on Fisheries Science in Tropical Area.

Faizal, A., Werorilangi, S., & Samad, W. (2023). The Influence of Ocean Current Patterns on Surface Marine Debris Distribution In Makassar City Waters. Jurnal IPTEKS Pemanfaatan Sumberdaya Perikanan, 10(1), 1–15.

Gu, H., & Mao, Y. (2024). Multi-Timescale Characteristics of Southwestern Australia Nearshore Surface Current and Its Response to ENSO Revealed by High-Frequency Radar. Remote Sensing, 16(1), 209.

Idrus, I. I., Ismail, A., & Amandaria, R. (2022). The Vulnerability and Resilience of Fishermen's Household Livelihoods in Lae-Lae Island, Makassar City. SHS Web of Conferences, 149, 2034.

Li, M., Luo, H., Zhou, S., Kumar, G. M. S., Guo, X., Law, T. C., & Cao, S. (2022). State-of-the-art review of the flexibility and feasibility of emerging offshore and coastal ocean energy technologies in East and Southeast Asia. Renewable and Sustainable Energy Reviews, 162, 112404.

Lu, J., Han, G., Song, D., Oliver, T., Teng, Y., Guo, J., Wu, L., Zhang, C., & Jiang, X. (2021). The Cross-Shore Component in the Vertical Structure of Wave-Induced Currents and Resulting Offshore Transport. Journal of Geophysical Research: Oceans, 126(10), e2021JC017311.

Nontji, A. (1993). Laut Nusantara Djambatan. Jakarta.

Nusratina, R. H., Ismunarti, D. H., & Ismanto, A. (2023). Studi Karakteristik Arus Laut di Selat Mansuar, Kabupaten Raja Ampat Berdasarkan Pemodelan Hidrodinamika 2D. Indonesian Journal of Oceanography, 5(2), 151–164.

Overes, P. H. P., Borsje, B. W., Luijendijk, A. P., & Hulscher, S. (2024). The importance of time-varying, non-tidal currents in modelling in-situ sand wave dynamics. Coastal Engineering, 104480.

Raharjo, P., & Saputra, M. D. (2017). Karakteristik morfologi dasar laut dan hubungannya dengan kecepatan arus laut di selat Lampa, Natuna, Kepulauan Riau. Jurnal Geologi Kelautan, 15(1).

SUCI, A. D. (2023). PEMODELAN ARUS PASANG SURUT DAN ARUS RESIDU DI PERAIRAN KAWASAN INDUSTRI MARITIM (KIM) TANGGAMUS.

Trujillo, A., & Thurman, H. (2008). Essentials of oceanography. Pearson Prentice Hall. Upper Saddle River, New Jersey, USA.[Google Scholar].

Tsanyfadhila, S., Ismanto, A., & Helmi, M. (2022). Karakteristik Arus Laut Permukaan dari High

Frequency Radar pada Musim Timur di Selat Bali. Jurnal Kelautan Tropis, 25(3), 279–290.

Arifin, M., Yudhono, A., Trisutomo, S., Wunas S., Jinca Y., Akil, A., Rasyid A.R., Latief I., Ali M., Azmy F., Dewi Y.K., Osman W.W., Ekawati S.A., Wahyuni S., Asfan L.M., Lakatupa G. 2019. Penataan Prasarana Kawasan Permukiman Tepian Kanal Jongaya Berbasis Masyarakat. Jurnal Tepat (Teknologi Terapan Untuk Pengabdian Masyarakat), Volume 2, Nomor 2, Tahun 2019

Arifin T, Yulius M. F. A., Ismail. 2012. Kondisi Arus Pasang Surut di Perairan Pesisir kota Makasar Sulawesi Selatan. Depik. 1(3) : 183-188.

Askara, A.B., Idris, F., Putra, R.D., & Nugraha, A.H. (2020). *Kandungan Logam (Pb) pada Strombus canarium Linnaeus,1758 (Mollusca: Gastropoda) di Perairan Malang Rapat dan Tanjung Siambang Provinsi Kepulauan Riau.* Jurnal Kelautan Tropis, 23(3), 299-304.

Bernawis, L. I. (2000). *Temperature and Pressure Responses on El-Nino 1997 and La-Nina 1998 in Lombok Strait.* The JSPS-DGHE International Symposium on Fisheries Science in Tropical Area.

Budiman, A.S., Koropitan A.F., , dan Nurjaya, I.W., *Perambatan Gelombang Dan Arus Residu Pasang Surut Teluk Mayalibit: Model Hidrodinamika Pasang Surut 2d*. 2015. Jurnal Ilmu dan Teknologi Kelautan Tropis, Vol. 7, No. 1.

Dewi , Antasari,A., Kushadiwijayanto, Nurdiansyah,S.I., Yusuf,A., Nurrahman, Y.A., Helena, S., 2022. Arus Residu Pasang Surut di Perairan Kepulauan Tambelan Provinsi Kepulauan Riau. Jurnal Laut Khatulistiwa, Vol. 5 No. 1 (February, 2022), Hal. 10-18. http://jurnal.untan.ac.id/index.php/lk

Direktorat Jenderal Cipta Karya. 2016. Materi Presentase Dokumen SIAP Kota Makassar. Kementerian Pekerjaan Umum dan Perumahan Rakyat.

Fraenkel, P.L.,2002, Marine Current Turbines Limited.2 Amherst Avenue, Ealing, London W13 8NQ, UK

Hadi, S., 2002. Arus Laut. Bandung, ITB. Bandung.

Hutabarat, S dan Evans M.S. 1986. *Pengantar Oseanografi*. Universitas Indonesia Press, Jakarta.

Ilyas, M., Syamsuddin, F., Widodo P., Wahyu, Ganie, Basri M., Sudarto S., Herunadi B., 1996. *Teknologi Survei Laut*. Badan Pengkajian dan Penerapan Teknologi. Jakarta :

Indrayanti, E., Sugianto, D. N., Purwanto, H. S. S., dan Siagian, H. S. R. 2021. *Identifikasi Arus Pasang Surut di Perairan Kemujan, Karimunjawa Berdasarkan Data Pengukuran Acoustic Doppler Current Profiler*. Jurnal Kelautan Tropis Juni, 24(2):247-254

Nontji, 1993. *Laut Nusantara*. Djambatan. Jakarta

Nusratina R.H., Ismunarti D.H. dan Ismanto A., 2023. *Studi Karakteristik Arus Laut di Selat Mansuar, Kabupaten Raja Ampat Berdasarkan Pemodelan Hidrodinamika 2D*. Indonesian Journal of Oceanography (IJOCE) Vol 05 No 02 : 151-164 ISSN:2714-8726. https://ejournal2.undip.ac.id/index.php/ijoce.

Poerbandono D N, Djunarsjah E. 2005. Survey Hidrografi. Bandung : Rafika Aditama.

Raharjo P. dan Saputra M. D. (2017). Karakteristik Morfologi Dasar Laut Dan Hubungannya Dengan Kecepatan Arus Laut Di Selat Lampa, Natuna, Kepulauan Riau. Jurnal Geologi Kelautan Volume 15, No. 1, Juni 2017. Pusat Penelitian dan Pengembangan Geologi Kelautan.

Respati, A.F., Diansyah, G, Agussalim, A. 2020. Analisis Data Arus Pasang Surut Dan Arus Non Pasang Surut Di Sebagian Selat Bangka. MASPARI JOURNAL.

Simatupang, C.M., Surbakti, H., Agussalim, A., 2016. Analisis Data Arus di Perairan Muara Sungai Banyuasin Provinsi Sumatera Selatan. Maspari Journal, 8(1):15

Surbakti, H. 2012. Karakteristik Pasang Surut dan Pola Arus di Muara Sungai Musi Sumatera Selatan. Jurnal Penelitian Sains. 15(1)

Tahang, H., Fahrudin, A., Efendi, H., Muchsin, D. 2012. Model Pengelolaan Pencemaran Perairan Pesisir Bagi Keberlanjutan Perikanan Dan Wisata Pantai Kota Makassar. 10.13140/RG.2.2.19746.07363.

Trujillo, Alan P. and Thurman, Harold V., 2008. Essentials of Oceanography. Pearson Prentice Hall, Pearson Education Inc. New Jersey. 534 pp.

Tsanyfadhila, S., Ismanto, A., & Helmi, M. (2022). Karakteristik Arus Laut Permukaan dari High Frequency Radar pada Musim Timur di Selat Bali. *Jurnal Kelautan Tropis*, *25*(3), 279-290. https://doi.org/10.14710/jkt.v25i3.13978

Wisha, U.J., dan Ilham, I., 2019. Velocity Components of Currents and Transport Mechanism in the Ie Meulee Waters, Weh Island, Indonesia. Jurnal Kelautan Tropis, 22(2): 93-102.