

World News of Natural Sciences

An International Scientific Journal

WNOFNS 35 (2021) 135-143

EISSN 2543-5426

Seasonal Variations of Sea Surface Temperature and Sea Current in the Celebes Sea

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ABSTRACT

The waters of the Celebes Sea are an area that has quite complex dynamics because it is influenced by several factors, either regionally or globally. This influence certainly has an impact on variations in oceanographic conditions in waters such as Sea Surface Temperature (SST) and sea currents. Currently, there are many observations of oceanographic data, one of which is by using remote sensing methods. The purpose of this study was to determine the seasonal variations in sea surface temperature and sea surface currents in the Celebes Sea using a remote sensing system in a time series for 5 years (2014-2018). The results of this study indicate data on seasonal variation of SST and sea surface currents have an average maximum SST value for 5 years occurring in the eastern season and the second transitional season (May, June, July) with an average value range of 30.6 °C - 31.1 °C and the average maximum sea current velocity for 5 years occurs in the western monsoon with a value range of 0.72 m/s - 0.77 m/s. The high SST value and sea current velocity are caused by the influence of the season which causes variations in the ongoing rainfall, also presumably due to the opposite direction between the monsoon wind and the direction of the main current flowing in the Celebes Sea.

Keywords: Sea Surface Temperature, Sea Current, Celebes Sea

1. INTRODUCTION

Indonesian waters are a region that is quite unique, which is located between two continents and large oceans, namely the Asian and Australian Continents and the Pacific and Indian Oceans. Therefore, the dynamics of Indonesian waters cannot be separated from the

influence of both regionally and globally such as the Monsoon phenomenon. One of the areas that is strongly influenced by these factors is Celebes Sea Waters. Some of these phenomena certainly have an influence on the oceanographic conditions of the waters.

Oceanographic conditions of the waters are an important indicator related to water productivity. The Celebes Sea is one of the main gateways for the entry of the Indonesian Through Flow (ITF) from the Pacific Ocean to the Indian Ocean, which is an extension of some of the Mindanao Current (MC) jets sourced from the North Equatorial Current. ITF that enters the Celebes Sea mostly flows into the Makassar Strait and the rest flows back into the Pacific Ocean as part of the North Equatorial Countercurrent (NECC).

The phenomenon of water mass movement occurs throughout the year in Indonesian waters, one part of which is the Celebes Sea, which causes variability of oceanographic parameters in terms of temperature, salinity, and currents. This variability can occur in periods of intra-seasonal fluctuation, seasonal (seasonal), annual (annual), and inter-annual (inter-annual), which can be seen through the time series data analysis.

Sea surface temperature (SST) is one of the oceanographic parameters that characterizes the water mass in the oceans and is related to the state of the seawater layer beneath it, so that it can be used in analyzing phenomena that occur in the ocean. Temperature is an important factor for the life of organisms in the sea that can affect metabolic activity and development, in addition to being an indicator of the phenomenon of climate change.

This study aims to determine the seasonal variations of sea surface temperature and sea currents in the Celebes Sea using a remote sensing system in a time series for 5 years (2014-2018).

2. MATERIALS AND METHODE

Research Area

The research study area is in the Celebes Sea as shown in Figure (1).

Data and Method

The research method used in this research is descriptive method with a quantitative approach. The descriptive method is used to describe or analyze the seasonal variations in sea surface temperature and sea surface currents in the Celebes Sea, while the quantitative approach is used for statistical calculations which are interpreted in the form of numbers and graphs, both of which show the value of seasonal variations in sea surface temperature and sea surface currents in the Celebes Sea.

The data used in this study are surface current and sea surface temperature data in the Celebes Sea, sourced from The European Earth Observation Program (COPERNICUS), with the website address www.marinecopernicus.eu. This data is from 2014 - 2018, with a spatial resolution of 4 km² and a monthly temporal resolution.

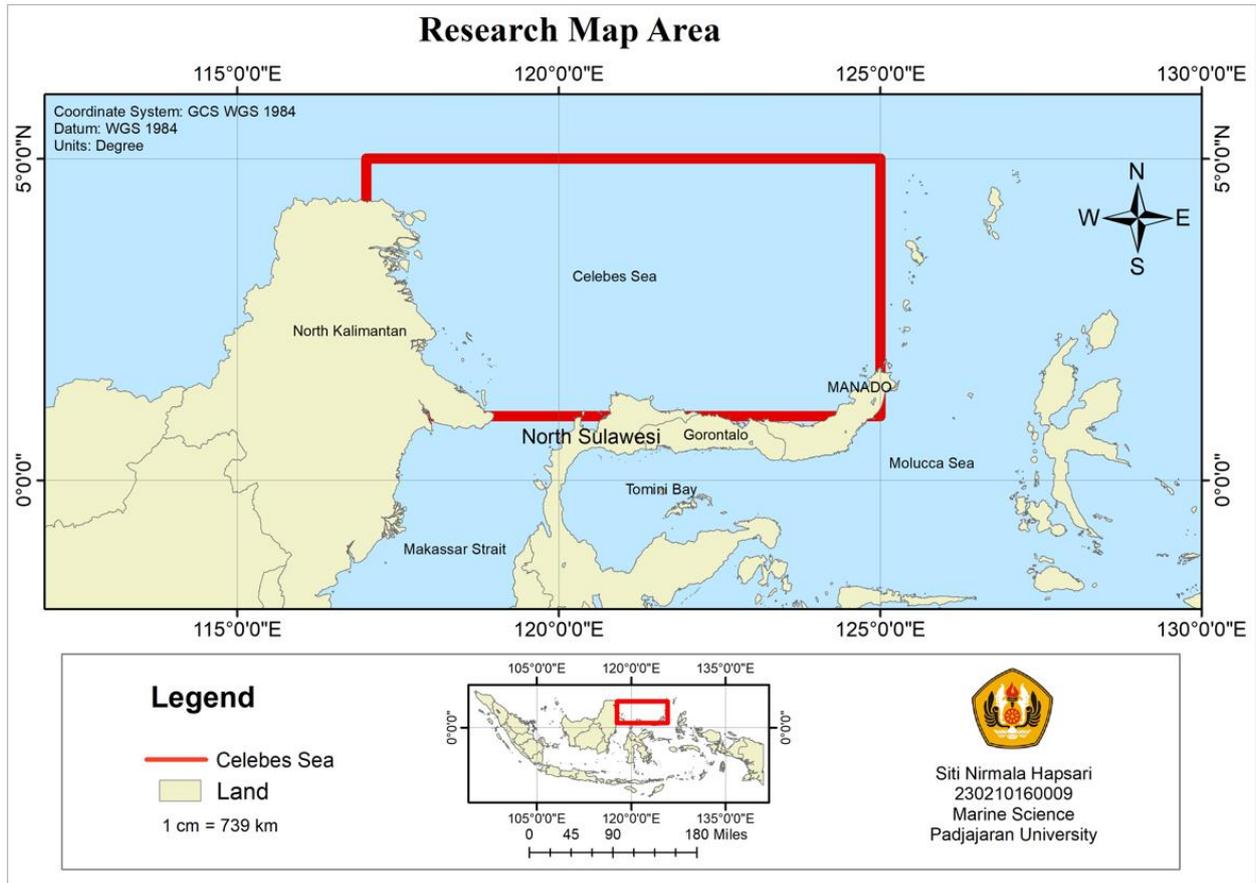


Figure 1. Map of Research Area

3. RESULT AND DISCUSSION

Oceanographic Conditions in Celebes Sea

The range of monthly mean temporal distribution of oceanographic parameters which is: sea surface temperature and sea surface currents velocity can be seen in Figure 2 (A & B).

From a graphical perspective, for 5 years, the average SST value for 5 years in the Celebes Sea has decreased from December to February (west season) with a value range of 29.5 °C - 28.3 °C. The increase in the range of SST values occurred significantly from April to July with a value of 30 °C - 31.3 °C. The range of the lowest current velocity value was 0.33 m / s which occurred in August 2016 and the highest average value was 1.11 m / s which occurred in February 2016.

The maximum SST value for 5 years occurs in the eastern season and the second transitional season (May, June, July) with an average value range of 30.6 °C - 31.1 °C and for the lowest value SST occurs in the western season (December-February) with a range of the average value is 28.3 °C-29.5 °C.

Meanwhile, the highest sea current velocity range occurs in December - February which is the western season with a value range between 0.72 m/s - 0.77 m/s. Meanwhile, in June - August (eastern season) has the lowest current velocity range between 0.38 m/s - 0.4 m/s.

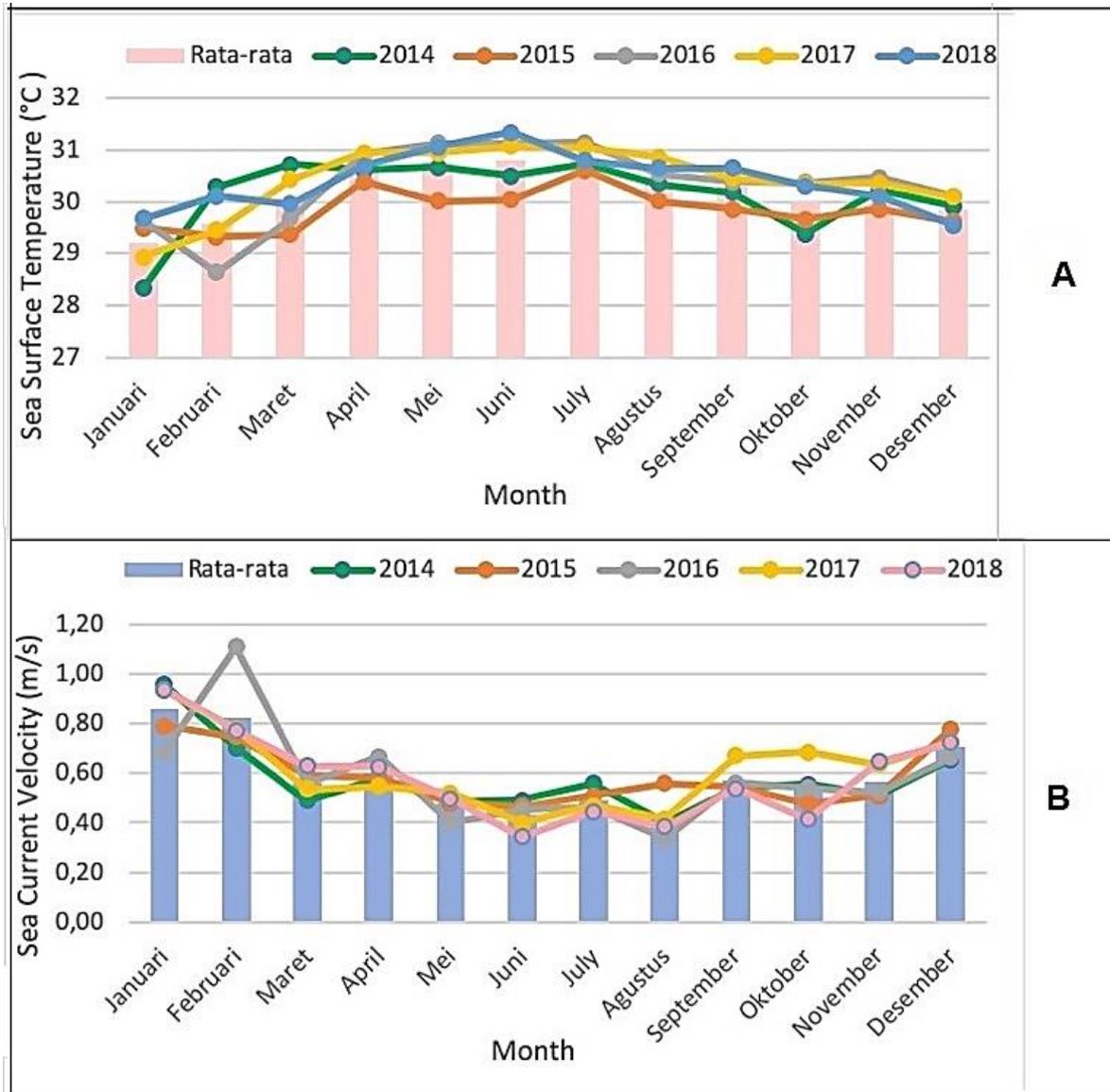


Figure 2 (A & B). Graph of Average Monthly of Sea Surface Temperature (A); Sea Current Velocity, (B) in 5 years (2014-2018).

For 5 years (2014-2018), SST in the Celebes Sea in the eastern season has the highest annual average value, which is around 30.4 °C in 2018 compared to the western season which has the lowest annual average value with a value of 29.9 °C in 2015. The high SST value in the Celebes Sea occurs during the eastern monsoon (JJA). This is in accordance with the statement which states that SST in Indonesia has a relatively warmer due to Indonesia's geographic location which is in the equatorial region and has the most solar heat receiving area and based on research it is known that SST is very affected by monsoons.

Sea Surface Temperature (SST) of Celebes Sea waters based on the Aqua-MODIS satellite ranges from 28.3 °C - 31.3 °C. This is in accordance with the statement according to, which states that the sea surface temperature range in Indonesia ranges from 28.3 °C - 31.3 °C.

The 2018 East Season had SST with the highest average value over the 5 year period (2014-2018).

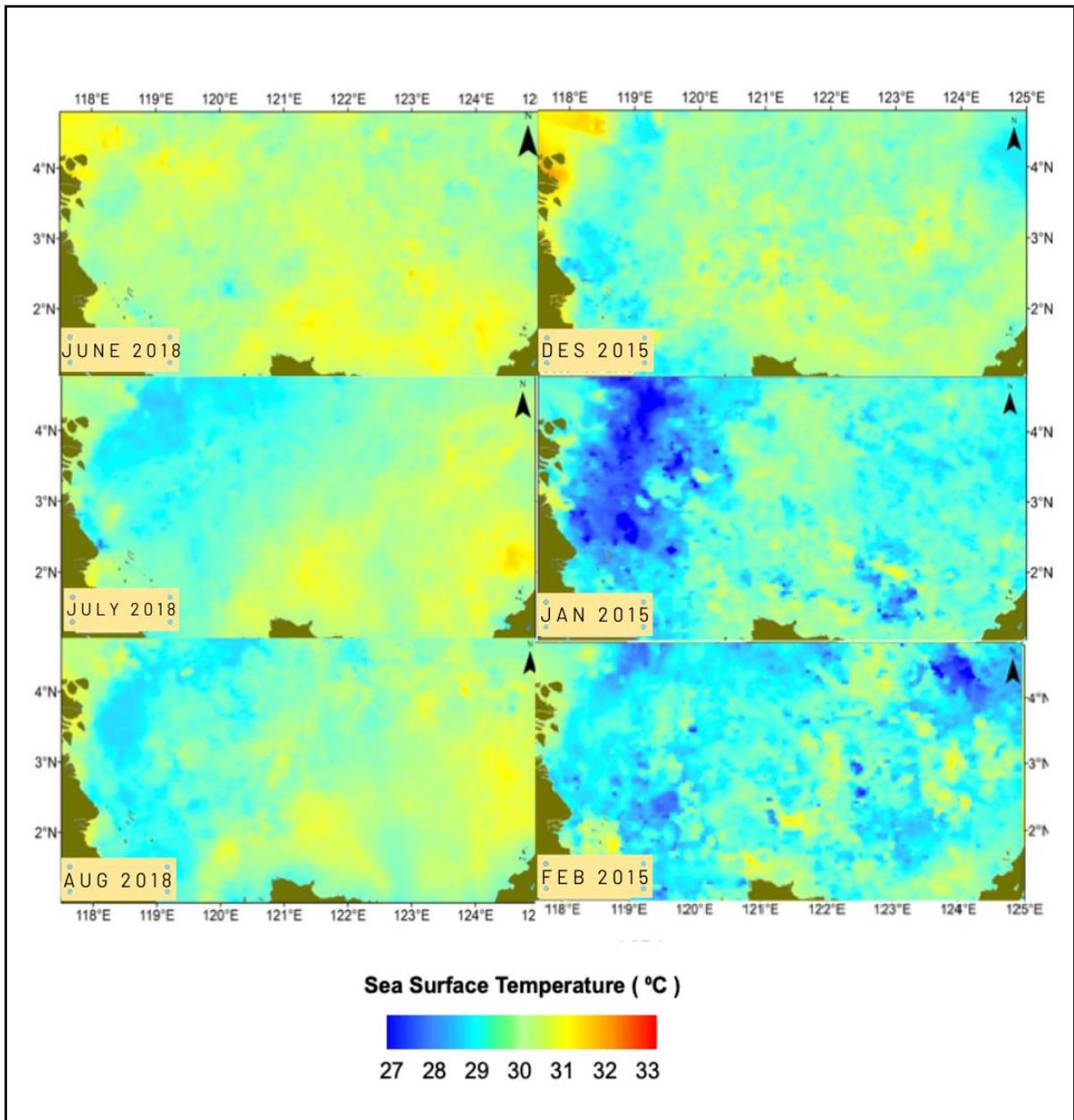


Figure 3. Spatial Map of Sea Surface Temperature in Eastern Season (JJA) and West Season (DJF)

The low SST value in the western season is due to the influence of the season which results in relatively higher rainfall. This is in accordance with the statement which states that, during the western season, the wind flows from the Asian Continent (winter) to the Australian Continent (summer) and contains a lot of water vapor because the wind passes through a wide

area, such as waters and ocean, this west monsoon that causes increased rainfall in Indonesia. Meanwhile, the high SST value in the east monsoon itself is thought to be due to the direction of the currents driven by the monsoon winds which are relatively opposite to the direction of the main stream (ITF).

So that the waters tend to have relatively low current velocities and the intensity of sunlight in the waters tends to increase. A spatial map of sea surface temperature in Celebes Sea waters is shown in (Figure 3).

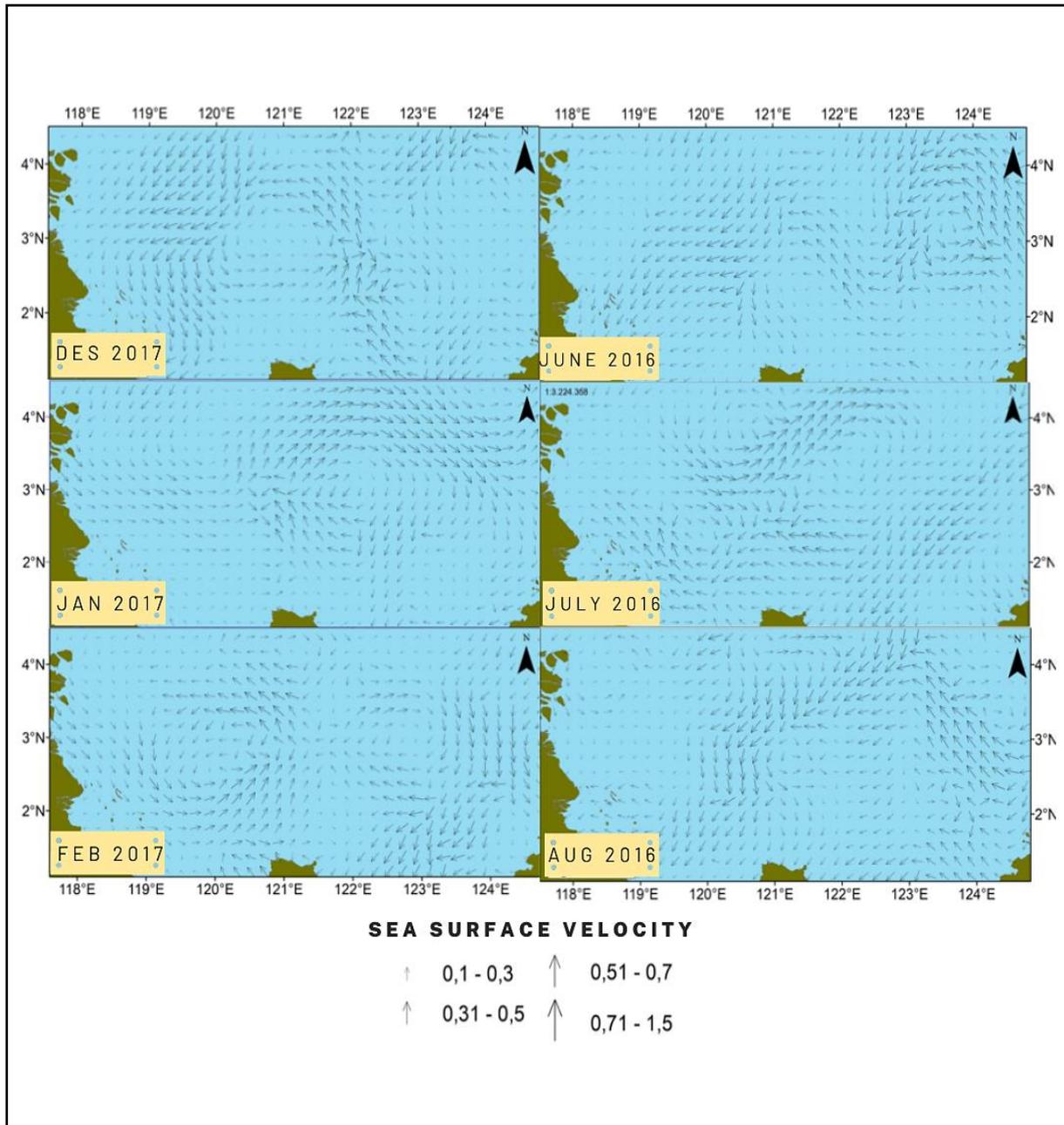


Figure 4. Spatial Map of Sea Current Velocity and Direction in West Season (DJF) and Eastern Season (JJA)

In this study the direction and velocity of sea surface currents occurring in the waters of the Celebes sea within 5 years has a distribution with the highest average ocean current velocity value in the west season (DJF) with a range of 0.73 m / s - 0.93 m / s, while in the east monsoon (JJA) in 2016 has the lowest average flow velocity in a period of 5 years with a value range of 0.33 m / s - 0.47 m / s.

The direction of the main flow in these waters is Indonesian throughflow (ITF). It can be seen that a path with a stronger current vector is clearly seen flowing from the inlet (inflow) in the southern part of Cape Mindanao to the southwest and across the central part of the Celebes Sea, then continuing to the northern entrance of the Celebes Sea. Makassar Strait, and part of it is undergoing recirculation. This main route is a representation of the

Indonesian throughflow (ITF) axis in the Celebes Sea. The distribution of velocity and direction of currents is found in the coastal area to the high seas (Figure 4).

The low current speed in the eastern monsoon is different from the prediction results which states that the winds during the west and east monsoons are stronger than the winds during the transitional season. This difference, presumably, is due to the influence of ITF meeting the east monsoon winds which have the opposite direction, causing a weakening of the intensity of current velocity in July– August. Meanwhile, the high current speed in the west monsoon is due to the direction of the wind in that season which tends to be in the same direction as the the main current flowing in the waters of the Celebes sea, thus increasing the intensity of the current speed in the region.

In the spatial distribution map of the velocity and current direction of the west and east monsoons in 2017 and 2016, it can be seen that the influence of the Coriolis force component that occurs in the circulation in the Celebes Sea, where the ITF is formed tends to be bent to the right from the direction of its flow due to the Celebes Sea is in the Northern Hemisphere. This can be seen in the spatial map of current velocity and direction in June where the main axis of ITF approaches the northern coast of Kalimantan, then moves south following the bathymetric contour along the slope of the northeast part of Kalimantan.

So it appears that ITF Celebes Sea is experiencing a strengthening (intensification) of currents along the western edge of the Celebes Sea. Although the main currents in the waters of the Celebes Sea are heavily influenced by ITF, variations in the direction and speed of currents are thought to be due to the influence of the Sulu Sea and changes in the monsoon winds based on seasons.

4. CONCLUSION

Based on the results and discussion above, it can be concluded that the seasonal variations in the spatial and temporal distribution of oceanographic parameters based on the results of statistical analysis have a value for each parameter, among them are ocean current velocity ranging from 0.34 m / s - 1.11 m / s; SST ranges from 27.45 °C - 32.83 °C; with an average maximum SST value for 5 years occurring in the eastern season and the second transitional season (May, June, July) with an average value range of 30.6 °C - 31.1 °C and the maximum mean sea current velocity for 5 years it occurs in the western season with a value range of 0.72 m / s - 0.77 m / s.

References

- [1] Moore, T. S., Marra, J., & Alkatiri, A. Response of the Banda Sea to the southeast monsoon. *Marine Ecology Progress Series*, 261, 41-49. 2003
- [2] Fine RA, Lukas R, Bingham FM, Warner MJ, Gammon RH. The western equatorial Pacific: a water mass crossroads. *J Geophys Res*. 99: 25, 063-25, 080.1994.
- [3] Fine R.A., Lukas R., Bingham F.M., Warner M.J., Gammon R.H. The western equatorial Pacific: a water mass crossroads. *Journal of Geophysical Research* 99 (C12) (1994) pp. 25, 063-25,080
- [4] Arnold L. Gordon. Oceanography of the Indonesian Seas and Their Throughflow. *Oceanography View* Volume 18, No. 4, Pages 14-27. <https://doi.org/10.5670/oceanog.2005.01>
- [5] Sudarto. Utilization and Development of Wind Energy Process for Production of Salt in Eastern Indonesia. *Jurnal TRITON* Volume 7, Nomor 2, Oktober 2011, hal. 61-70
- [6] Achmad Rizal. Implementation of Tourism Development Policies in Garut District, West Java Province, Indonesia. *The Institute of Biopaleogeography named under Charles R. Darwin* 5 (2021) 1-40. eBook ISBN 978-83-949342-4-8
- [7] Chun-Kit Lai, Xiao-Ping Xia, Robert Hall, Sebastien Meffre, Basilios Tsikouras, Maria Ines Rosana Balanguie-Tarriela, Arifudin Idrus, Elena Ifandi, Nur 'aqidah Norazme, Cenozoic Evolution of the Sulu Sea Arc-Basin System: An Overview. *Tectonics*, 10.1029/2020TC006630, 40, 2, (2020).
- [8] Abdu Elazeem Osman Adam Ali, Zhan Liu, Yongliang Bai, Abdalla Gumaa Farwa, Abboud Suliman Ahmed, Guomin Peng, A stable gravity downward continuation for structural delineation in Sulu Sea region. *Journal of Applied Geophysics*, 10.1016/j.jappgeo.2018.05.009, 155, (26-35), (2018).
- [9] Gary Nichols, Christian Betzler, Garrett Brass, Zehui Huang, Braddock Linsley, Dean Merrill, Carla Müller, Alexandra Nederbragt, Manuel Pubellier, Fernando Sajona, Reed Scherer, Hidetoshi Shibuya, Jih-Ping Shyu, Randall Smith, Renato Solidum, Piera Spadea, Depositional history of the Sulu Sea from ODP Sites 768, 769 AND 771. *Geophysical Research Letters*, 10.1029/GL017i011p02065, 17, 11, (2065-2068), (2012).
- [10] S. Murauchi, W. J. Ludwig, N. Den, H. Hotta, T. Asanuma, T. Yoshii, A. Kubotera, K. Hagiwara. Structure of the Sulu Sea and the Celebes Sea. *Journal of Geophysical Research* Volume 78, Issue 17, 10 June 1973, Pages 3437-3447. <https://doi.org/10.1029/JB078i017p03437>
- [11] Gary Nichols, Robert Hall. History of the Celebes Sea Basin based on its stratigraphic and sedimentological record. *Journal of Asian Earth Sciences* Volume 17, Issues 1–2, February–April 1999, Pages 47-59. [https://doi.org/10.1016/S0743-9547\(98\)00034-8](https://doi.org/10.1016/S0743-9547(98)00034-8)
- [12] Santiago Fraga, Francisco Rodríguez, Pilar Riobó, Isabel Bravo. *Gambierdiscus balechii* sp. nov. (Dinophyceae), a new benthic toxic dinoflagellate from the Celebes Sea

- (SW Pacific Ocean). *Harmful Algae* Volume 58, September 2016, Pages 93-105.
<https://doi.org/10.1016/j.hal.2016.06.004>
- [13] Taniguchi, A. Distribution of microzooplankton in the Philippine Sea and the Celebes Sea in summer, 1972. *Journal of the Oceanographical Society of Japan* 33, 82-89 (1977). <https://doi.org/10.1007/BF02110013>
- [14] Mega Syamsuddin, Spatial and temporal patterns of ocean variability using empirical orthogonal functions (EOF) in the Southern Java Waters. Diversity of Sea Cucumber Based on the Characteristics of Habitat Sikakap Strait Water Area, Mentawai Island District, Indonesia. *World Scientific News* 142 (2020) 76-87
- [15] Achmad Rizal, Isni Nurruhwati, Diversity of Sea Cucumber Based on the Characteristics of Habitat Sikakap Strait Water Area, Mentawai Island District, Indonesia. *World Scientific News* 145 (2020) 379-396
- [16] Achmad Rizal, Zuzy Anna, The Effect on Mangrove Density with Sediment Transport Rate in Sikakap Coastal Area of Mentawai Island District, West Sumatera Province, Indonesia. *World Scientific News* 146 (2020) 202-214
- [17] Rifki A. Mustaqim, Sunarto, Mega L. Syamsuddin, Ibnu Faizal, Abrasion impact towards green turtle *Chelonia mydas* (Linnaeus, 1758) nesting areas in Sindangkerta, Tasikmalaya Regency, West Java, Indonesia. *World Scientific News* 147 (2020) 124-139
- [18] Syawaludin A. Harahap, Lintang P. S. Yuliadi, John N. Sinulingga, Surficial Sedimentary at the Bottom in Waters Surrounding the Arisen Land of Putri Island, Karawang – Indonesia. *World Scientific News* 151 (2021) 95-109
- [19] Igor G. Zurbenko, Amy L. Potrzeba-Macrina, Numerical Predictions for Rising Water Levels in the Oceans. *World Scientific News* 152 (2021) 1-14
- [20] M. Boy Adiluhung, Indah Riyantini, Sunarto, Ibnu Faizal, The Influence of Tidal on the Nesting Activity of Green Turtle (*Chelonia mydas* (Linnaeus, 1758)) at Pangumbahan Beach, Sukabumi Regency, West Java, Indonesia. *World Scientific News* 154 (2021) 48-65
- [21] Noir P. Purba, Ibnu Faizal, Finri S. Damanik, Fadliyan R. Rachim, Putri G. Mulyani, Overview of Oceanic Eddies in Indonesia Seas Based on the Sea Surface Temperature and Sea Surface Height. *World Scientific News* 147 (2020) 166-178
- [22] Chengcheng Yang, Xiao Chen, Xuhua Cheng, Bo Qiu, Annual versus semi-annual eddy kinetic energy variability in the Celebes Sea. *Journal of Oceanography*, 10.1007/s10872-020-00553-7, (2020)
- [23] Xiao Chen, Bo Qiu, Shuiming Chen, Xuhua Cheng, Yiquan Qi. Interannual Modulations of the 50-Day Oscillations in the Celebes Sea: Dynamics and Impact. *JGR Oceans* Volume123, Issue7, July 2018, Pages 4666-4679.
<https://doi.org/10.1029/2018JC013960>