Fisheries Journal, 14(4), 1828-1837 (2024)
http://doi.org/10.29303/jp.v14i4.1238

TEMPERATURE AND CHLOROPHYLL VARIABILITY DURING UPWELLING PHENOMENON IN THE SOUTHHERN WATERS OF BURU ISLAND TO SERAM ISLAND

Variabilitas Suhu Dan Klorofil Saat Terjadi Fenomena *Upwelling* di Perairan Selatan Pulau Buru Hingga Pulau Seram

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(Received October 3rd 2024; Accepted October 21st 2024)

ABSTRACT

Upwelling is the rise of water mass in the lower layer to the surface. The rise of water mass is due to wind moving above the waters so that this wind will push the water mass on the surface as a result of which water from below replaces the emptiness above. The variation in SST distribution is relatively lower and the abundance of chlorophyll as an indicator of the occurrence of the upwelling phenomenon and the effect of wind on the upwelling phenomenon. The purpose of this study was to determine the variability of SST and chlorophyll in the waters of South Buru Island to Seram Island and its effect on the upwelling phenomenon. The method used is a quantitative method with the aim of describing the state of SST and Chlorophyll in the Waters of South Buru Island to Seram Island. The results of the study showed that the analysis of the distribution of SST and chlorophyll from June to October was an upwelling phenomenon with SST in June 28,15°C and chlorophyll-a 0,44 mg/m^3 with an average wind speed of 4,58 m/s which was the beginning of the upwelling phenomenon. For July, the SST distribution was 27,21°C and chlorophyll-a 0.54 mg/m^3 with an average wind speed of 5,42 m/s. In August, the SST distribution was 26.95°C and chlorophyll-a 0,58 mg/m^3 with an average wind speed of 5,32 m/s. In September, the SST distribution was 27,73°C and chlorophyll-a 0,50 mg/m^3 with an average wind speed of 4.09 m/s, while in October, the distribution was 28,97°C and chlorophyll-a 0,29 mg/m^3 with an average wind speed of 2,65 m/s.

Keywords: Wind, Chlorophyll, SST, Ekman Transport, Upwelling

ABSTRAK

Upwelling merupakan naiknya massa air di lapisan bawah ke permukaan. Naiknya massa air dikarenakan adanya angin yang bergerak di atas perairan sehingga angin ini akan mendorong massa air di permukaan akibatnya air yang berasal dari bawah menggantikan kekosongan yang berada diatas. Variasi sebaran Suhu Permukaan Laut (SPL) relatif lebih rendah dan kelimpahan

klorofil sebagai indikator terjadinya fenomena *upwelling* serta pengaruh angin terhadap fenomena *upwelling*. Tujuan dari penelitian ini adalah untuk mengetahui variabilitas SPL dan klorofil pada perairan Selatan Pulau Buru hingga Pulau Seram dan pengaruhnya terhadap fenomena *upwelling*. Metode yang digunakan adalah metode kuantitatif dengan tujuan untuk menggambarkan keadaan SPL dan Klorofil di Perairan Selatan Pulau Buru hingga Pulau seram. Hasil penelitian menunjukan analisis sebaran Suhu Permukaan Laut (SPL) dan klorofil dari bulan Juni sampai bulan Okrober merupakan fenomena terjadinya *upwelling* dengan Suhu Permukaan Laut (SPL) bulan juni 28,15ºC dan klorofil-a 0,44 mg/m^3 dengan rata-rata kecepatan angin 5,32 m/s. Bulan September sebaran Suhu Permukaan Laut (SPL) 27,73 ºC dan klorofil-a 0,50 mg/m^3 dengan rata-rata kecepatan angin 4.09 m/s, sedangkan bulan Okrober sebesar 28,97ºC dan klorofil-a 0,29 mg/m^3 dengan rata-rata kecepatan angin 2,65 m/s.

Kata kunci: Angin, Klorofil, SPL, Transport Ekman, Upwelling

INTRODUCTION

The Banda Sea is a body of water that has a basin shape. This sea separates the Sunda display to the west and the sahul display to the east (Tapilatu et al., 2018). During the Eastern season, the phenomenon of upwelling in the Banda Sea occurs and is indicated through the distribution of very cold sea surface temperatures and the cause is Ekman Pumping (Gordon et al., 2001). Ekman pumping is an Ekman transport process caused by blowing wind. The sea has a very complex underwater topography. The complex topographic shape can affect the exchange of water masses that occur in the Banda Sea. The exchange of water masses moving from the bottom to the surface carrying rich nutrients can lead to lower temperatures from sea level and high chlorophyll-a. High chlorophyll-a and low SPL indicate the occurrence of an upwelling phenomenon (Nurafifah et al., 2022). According to Kämpf et al., (2016) Upwelling is the vertical movement of water masses from the lower layer to the upper layer.

According to Tubalawony et al., (2013) upwelling occurs in the Banda Sea in response to the blowing of the southeast monsoon wind. The upwelling process can be indicated by the distribution of chlorophyll-a concentrations and Sea Surface Temperature (SPL). According to Juliana et al., (2021), SPL is one of the oceanographic parameters that characterizes the mass of water in the ocean and is related to the state of the seawater layer underneath, so it can be used in analyzing phenomena that occur in the ocean. SPL has undergone variations from time to time, these changes can occur on a daily, seasonal or annual basis according to the natural conditions that affect it (Yuniarti et al., 2013). According to Kurnianingsih et al., (2017), SPL is an indicator of determining the location of upwelling because the location of the upwelling is an area with low temperatures, waters are said to have upwelling marked by an SPL value that is less than 27°C.

On the contrary, chlorophyll-a concentrations can be used as a reference in indicators of aquatic fertility (Sofarini D, 2012; Clinton et al., 2022). According to Swayati et al., (2015), if the intensity of sunlight and the concentration of nutrients in the waters are sufficiently available, the concentration of chlorophyll-a will increase and vice versa, if the intensity of sunlight and the concentration of nutrients in the waters are not available, the concentration of chlorophyll-a will decrease.

METHODS

Data and Research Location

This study was conducted in the waters south of Buru Island to Seram Island at the coordinates of 125.4 0 E – 131.5 0 E and 3.0 0 LS – 4.5 0LS and the location of this study is illustrated in Figure 1. The data used using secondary data include SPL data, chlorophyll data, and wind data. Sea Surface Temperature (SPL) or Sea surface temperature data and

chlorophyll-a data are obtained from http://oceancolor.gsfc.nasa.gov/ sites in NetCDF format (.nc). The data was then extracted using Ocean Data View (ODV) version 5.1.5. The data was then extracted using Surfer 12 and cropped according to the research location (Southern Waters of Buru Island to Seram Island) then stored in Microsoft Excel Open XML Spreadsheet (.xlsx) format, the average monthly wind speed data was then presented in the form of a wind distribution graph. From the wind distribution graph, analysis is then carried out to study the pattern of wind distribution spatially and temporally. Wind data was obtained through the ECMWF website in NetCDF (.nc) format. The data was then extracted using the Ocean Data View (ODV) version 5.1.5

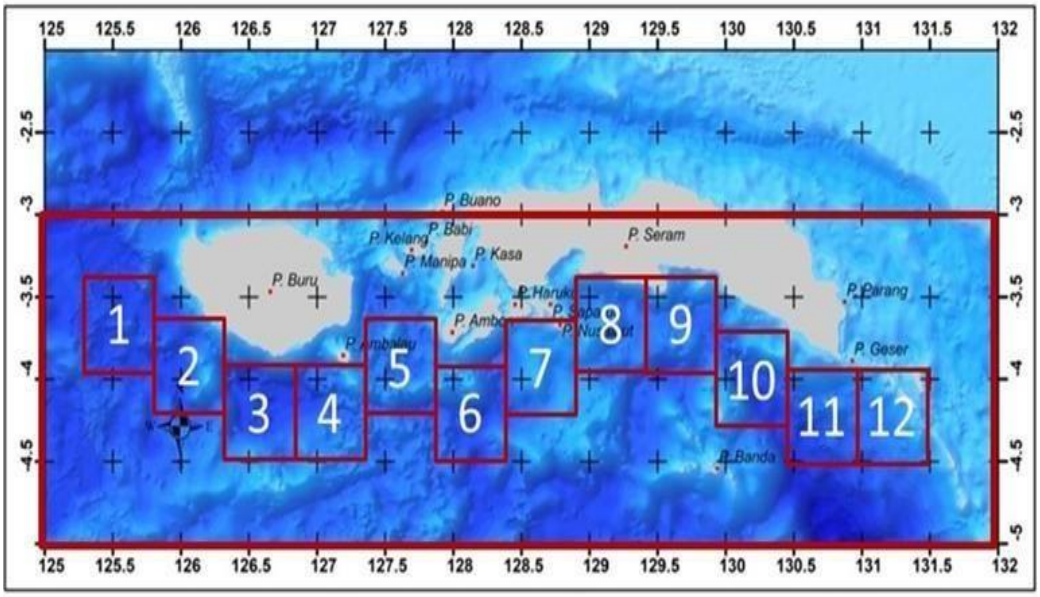

Fig 1. Research Location

RESULT

Sea Surface Temperature Variability (SPL)

The sea surface temperature can be seen to vary in value every month. The highest average sea surface temperature (SPL) value is 30.80ºC which occurred in December. The lowest average SPL was 26.95ºC in August.

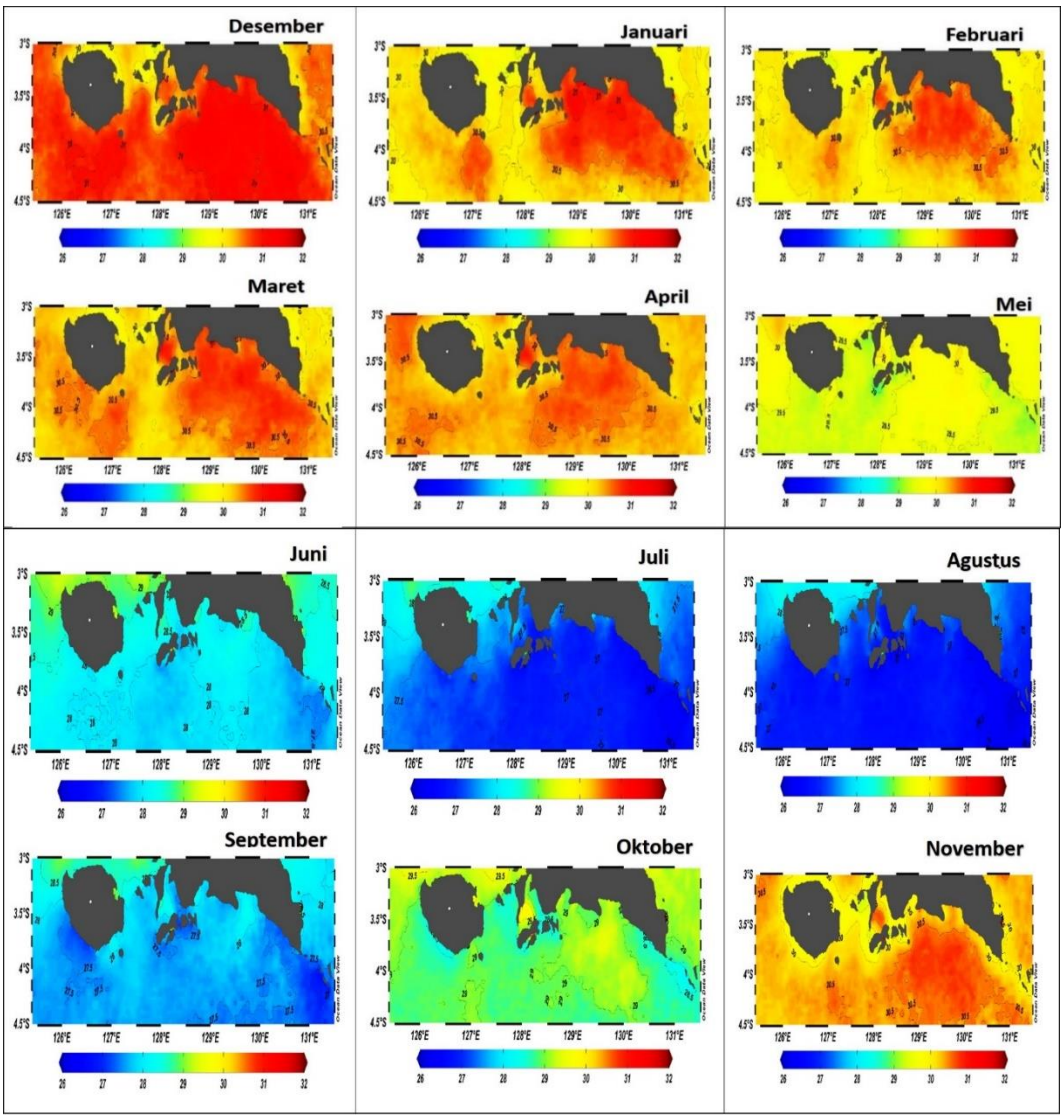

Fig 2. Monthly average distribution of SPL in the Southern Waters of Buru Island to Seram Island in 2003 – 2020

Chlorophyll-a Variability

The average value of chlorophyll-s is seen to vary, the highest chlorophyll-a occurs in August with a value of 0.58 mg/m3 in August, the lowest chlorophyll-a is 0.14 mg/m3 which occurs in March and April.

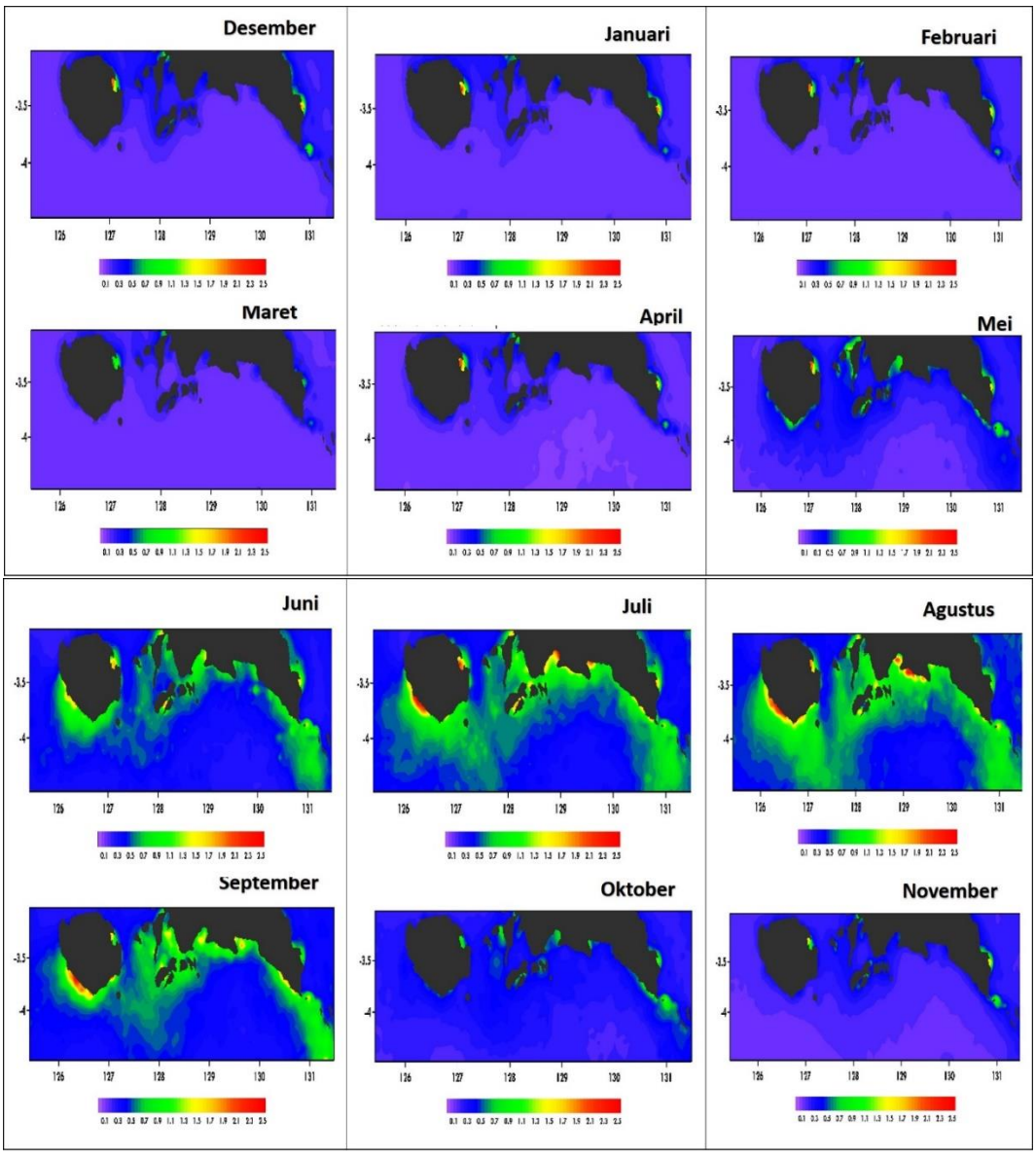

Fig 3. Monthly average concentration of chlorophyll-a in the Southern Waters of Buru Island to Seram Island in 2003 – 2020

Wind

The western monsoon winds occur in December, January and February which have different wind directions and speeds every month. In December, the average wind speed is 1.90 m/s, with the minimum speed occurring in the southern coastal part of the waters and the maximum in the northern part of the southern waters of Buru Island to Seram Island

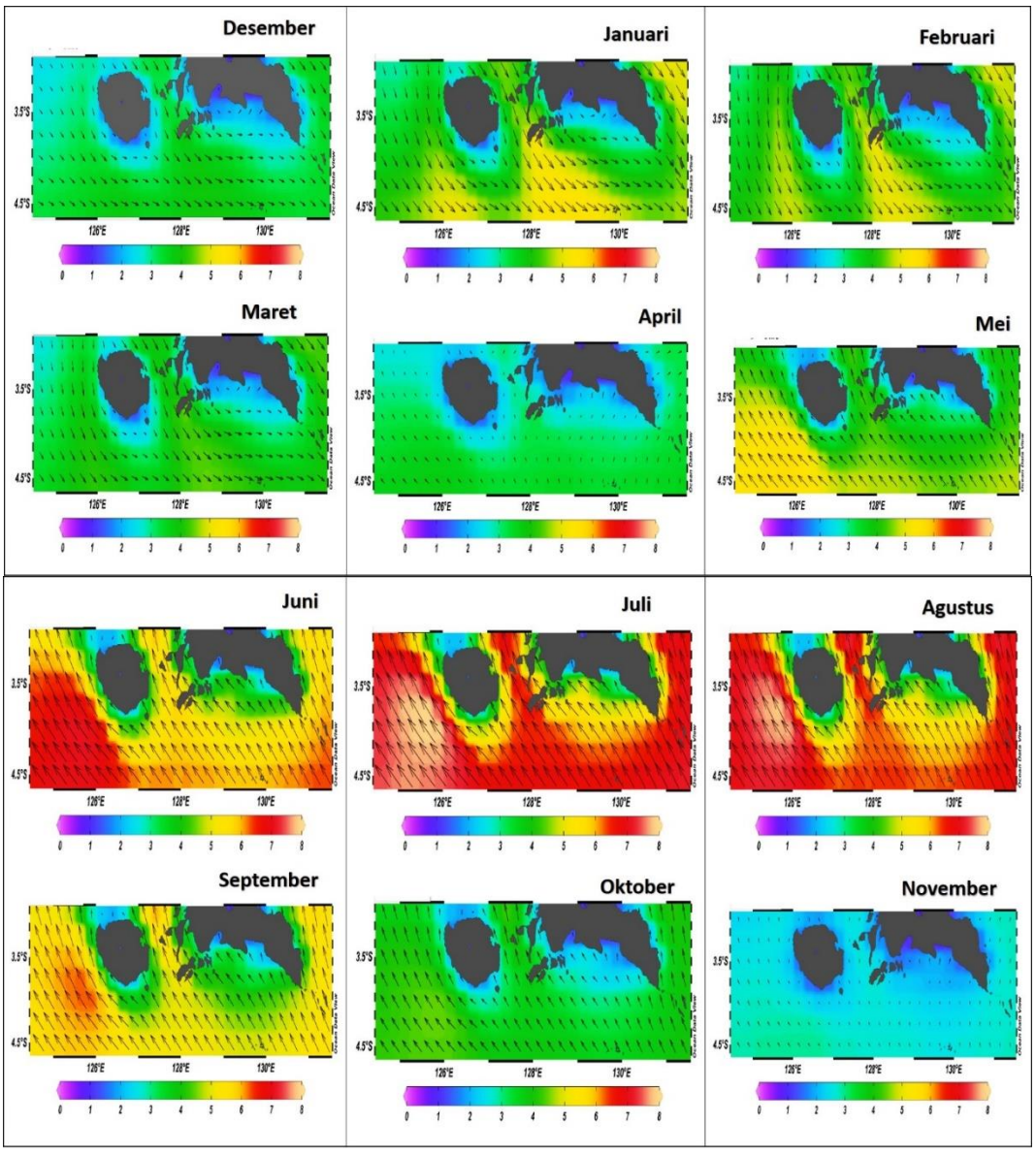

Fig 4. Average monthly Wind Distribution at sea level from 2003-2020

DISCUSSION

The average SPL distribution in December is 30.80°C with high sea surface temperature spreading almost to all waters around the South of Buru Island to Seram Island, while the lower SPL is detected in the northern part of the waters, so in December there is a tendency for a higher SPL to be in the waters South of Buru Island to Seram Island. The average SPL distribution in January was 30.29°C. Low sea surface temperatures in January are north of the coast of the waters around Buru Island to Seram Island while high temperatures are detected on the south coast of Buru Island to Seram Island. The final period of the western season, namely in February, has an average SPL distribution of 30.19°C with low temperatures on the north coast of the waters of Buru Island to Seram Island and higher temperatures on the south coast of Buru Island to Seram Island. During the western season, the distribution of sea surface temperature increases in December and the distribution of sea surface temperature decreases in January (Kurnianingsih et al., 2017).

Monthly SPL decreased compared to the western season. This is due to the transition from the western to the eastern season, where the sun experiences a shift towards the northern part of the earth and the SPL will gradually be low (Rahman et al., 2019). The average SPL

distribution in March was 30.40°C with higher temperatures occurring in the waters south of Buru Island to Seram Island and lower temperatures in the north of the waters of Buru Island to Seram Island. In April, the average distribution of SPL decreased slightly compared to March, which was 30.39°C. The average SPL distribution in May decreased to 29.54°C with low temperatures in the south of the temperature waters and high temperatures in the north of the waters.

This is in accordance with the opinion of Amri et al., (2013) who stated that the lowest SPL occurred in the eastern season and the 2nd transition due to the strong southeast monsoon wind and reached its peak from August to September. The speed and components of the wind blowing perpendicular to the coastline cause upwelling in the eastern season and the turn 2, thus reducing the SPL (Syafik et al., 2013).

The average distribution of SPL in June is 28.15°C with low temperatures in the southern waters of Buru Island to Seram Island and high temperatures occur in the north of the waters. In July, the temperature decreased which resulted in an average SPL distribution of 27.21°C, high temperatures occurred in the north of the waters and low temperatures were detected in the southern waters of Buru Island to Seram Island. Then, there was a decrease in temperature in August with an average SPL distribution of 26.95°C. The highest SPL in August occurred in the north of the waters, while the southern waters of Buru Island to Seram Island dominated the colder temperatures. In August, the SPL decreases during the period of the eastern season in the waters around the South of Buru Island to Seram Island. Overall, during the eastern season period, there is a tendency for a low SPL distribution in the southern part of Buru Island to Seram Island. This indicates that during the eastern season around July-September in the waters of these waters there is a lift of cold water masses from the bottom to the surface, which is physically characterized by colder surface temperatures and higher salinity (Siwi et al., 2017).

The variability of monthly SPL in the upwelling area from June to August tends to decrease, which is strongly suspected to be influenced by the Southeast Monsoon winds which are increasing in intensity. This phenomenon is in accordance with the statement of Susanto et al., (2006) which stated that an increase in the intensity of the Southeast Monsoon wind speed will result in an increase in the intensity of upwelling. The increase in the intensity of upwelling from June to August increases the flow of cold water from the sublayer to the surface, so there is a decrease in SPL from June to August. The tendency of declining SPL in upwelling areas is also due to the strengthening of the advection process (Wyrtki, 1961). This advection process is a process of transferring heat from water to the atmosphere through wind media. The advection process will strengthen along with the strengthening of the intensity of the Southeast Monsoon winds. The strengthening of the advection process has an impact on the increasing amount of heat energy transferred from the waters to the atmosphere, as a result of which the water temperature tends to decrease, as happened in the upwelling area of the South of Buru Island to Seram Island from June to August.

From the results of the analysis above, it can be identified that the upwelling event is based on the decrease in the distribution of SPL in the waters around the South of Buru Island to Seram Island. This is also strengthened by a study conducted by Kurnianingsih et al., (2017) which explains that spatially the distribution pattern of SPL is different every month, the increase in SPL which decreases every month can indicate an upwelling in the area. Low SPL distribution and high chlorophyll indicate the occurrence of upwelling.

Monthly chlorophyll-a concentrations in the waters south of Buru Island to Seram Island are presented in Figure 3 which shows that in general the concentration of chlorophyll-a is low for most waters and high concentration in the southern coastal part of the waters. According to Prianto et al., (2013), the concentration of chlorophyll-a in coastal and coastal waters is relatively high compared to the high sea area, due to the supply of nutrients through

river run-off from the mainland. According to Tubalawony et al., (2015), in the Western season (December-February) in the waters of the Banda Sea, northwest munson winds blow which results in weak uplift of water masses from the thermocline layer which has an impact on low chlorophyll concentrations. Chlorophyll-a concentrations during the western monsoon period in the waters south of Buru Island to Seram Island occurred in December, January and February. The average concentration of chlorophyll-a in December was 0.16 mg/m3, the minimum concentration of chlorophyll-a occurred in the southern part of the waters while the maximum concentration occurred in the northern waters. In January, the maximum concentration of chlorophyll-a was shown in the northern part of the waters from Buru Island to Seram Island and the minimum concentration occurred in the south of the waters with an average concentration of chlorophyll-a in January of 0.15 mg/m3. The average concentration of chlorophyll-a in February was 0.15 mg/m3 with the minimum concentration in the south and the maximum in the northern coastal part of the waters around Buru Island to Seram Island. In general, in the western season period, the distribution of very low concentrations of chlorophyll-a predominantly occurs in the southern part of the waters.

Monthly chlorophyll-a variability in the region from June to August tends to increase (Figure 3), presumably due to the increase in the intensity of water mass transport from the deeper layers that carry nutrients to the sea level as the month changes occur through the upwelling mechanism. The increase in chlorophyll-A is caused by the existence of an upwelling mechanism that is more intensive with increasing nutrient levels and will result in high chlorophyll-a levels (Hendiarti et al., 2004). In addition, the high value of chlorophyll-a is suspected to be due to the high intake of nutrients from the mainland which carries high nutrients (Clinton et al., 2022). Marlian et al., (2015) added that nutrient inputs from land have a very strong relationship with chlorophyll-a from phytoplankton as a determinant of productivity levels from aquatic.

CONCLUSSION

The upwelling phenomenon occurs in the southern waters of Buru Island to Seram Island and takes place in June, July, August, September and October due to a decrease in the distribution of SPL, an increase in chlorophyll-a and an increase in wind speed.

ACKNOWLEDGEMENT

The author would like to thank the two supervisors, Dr. Ir. Simon Tubalawony, M.Si and Dr. Ir. D. D. P. Matrutty, M.Si who have guided me well so that this research can be completed, Thank you also to the team who have helped a lot in the research.

REFERENCES

Amri, K., Manurung, D., Gaol, J. L., & Baskoro, M. S., (2013). Karakteristik Suhu Permukaan Laut dan Kejadian Upwelling Fase Indian Ocean Dipole Mode Positif di Barat Sumatera dan Selatan Jawa Barat. *Jurnal Segara, 9*(1), 13.

Boussidi, B., Cornillon, P., Puggioni, G., & Gentemann, C. (2019). Determining the AMSR-E SST Footprint from Co-Located MODIS SSTs. *Remote Sensing*, *11*(6), 715.

Fadika, U., Rifai, A., & Rochaddi, B. (2014). Arah dan Kecepatan Angin Musiman serta Kaitannya dengan Sebaran Suhu Permukaan Laut di Selatan Pangandaran Jawa Barat. *Journal of Oceanography*, *3*(3), 429-437.

Fahrezi, A. A., Wulandari, E. P., Arrafi, M., Ridwana, R., & Himayah, S. (2022). Analisis Sebaran Suhu Permukaan Laut di Laut Banda Tahun 2017–2019 Menggunakan Data dari Sensor Amsr-2. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, *15*(1), 81-90.

Imran, A., Patanda, M., & Ernaningsih, D. (2023). Pengaruh Suhu Permukaan Laut dan Klorofil–A terhadap Hasil Tangkapan Ikan Teri (*Stolephorus* sp.) di Teluk Banten. *Jurnal Ilmiah Satya Minabahari*, *9*(1), 8-28.

Kämpf, J., & Chapman, P. (2016). *Upwelling systems of the world* (31-42). Springer International Publishing Switzerland.

Kunarso, A. S., Ningsih, N. S., & Hadi, S. (2009). Upwelling dan Fishing Ground Tuna di Laut Nusantara. *Badan Penerbit Universitas Diponegoro, Semarang*, *211*.

Kurnianingsih, T. N., Sasmito, B., Prasetyo, Y., & Wirasatriya, A. (2017). Analisis Sebaran Suhu Permukaan Laut, Klorofil-A, dan Angin terhadap Fenomena Upwelling di Perairan Pulau Buru dan Seram.

Kuswardani, A. R. T. D. (2012). The Development of a Wave-Tide-Circulation Couple Model and Its Upwelling Simulation Application in the Indonesian Seas [*Disertation*]. *Ocean University of China, China*.

Mahagnyana, M., Limaran, G. D., & Fadlan, A. (2017). Pengaruh Monsun terhadap Kesuburan Perairan Utara Jawa dengan Menggunakan Satelit Aqua Modis. *Unnes Physics Journal*, *6*(1), 37-40.

Marlian, N., Damar, A., & Effendi, H. (2015). Distribusi Horizontal Klorofil-a Fitoplankton sebagai Indikator Tingkat Kesuburan Perairan di Teluk Meulaboh Aceh Barat. *Jurnal Ilmu Pertanian Indonesia*, *20*(3), 272-279.

Marpaung, S., Prayogo, T., Yati, E., Purwanto, A. D., Nandika, M. R., Domiri, D. D., & Kushardono, D. (2022). Analisis Karakteristik Net Primary Productivity dan Klorofil-a di Laut Banda dan Sekitarnya. *Jurnal ilmu dan teknologi kelautan tropis*, *14*(1), 31-46.

Mustikasari, E., Dewi, L. C., Heriati, A., & Pranowo, W. S. (2015). Pemodelan Pola Arus Barotropik Musiman 3 Dimensi (3D) untuk Mensimulasikan Fenomena Upwelling di Perairan Indonesia. *Jurnal Segara*, *11*(1).

Nurafifah, U. O., Zainuri, M., & Wirasatriya, A. (2022). Pengaruh ENSO dan IOD terhadap Distribusi Suhu Permukaan Laut dan Klorofil-a pada Periode Upwelling di Laut Banda. *Indonesian Journal of Oceanography*, *4*(3), 74-85.

Pond, S. (1983). *Introductory Dynamical Oceanography*. New York: Pergamon Press Ltd.

Putra, I. I., Sukmono, A., & Wijaya, A. P. (2017). Analisis Pola Sebaran Area Upwelling Menggunakan Parameter Suhu Permukaan Laut, Klorofil-A, Angin dan Arus Secara Temporal Tahun 2003-2016 (Studi Kasus: Laut Banda). *Jurnal Geodesi Undip*, *6*(4), 157-168.

Rahman, M. A., Syamsudin, M. L., Agung, M. U. K., & Sunarto, S. Pengaruh Musim terhadap Kondisi Oseanografi dalam Penentuan Daerah Penangkapan Ikan Cakalang (*Katsuwonus pelamis*) di Perairan Selatan Jawa Barat. *Jurnal Perikanan dan Kelautan Unpad*, *10*(1), 485019.

Ratnawati, H. I., Hidayat, R., Bey, A., & June, T. (2017). Upwelling di Laut Banda dan Pesisir Selatan Jawa serta Hubungannya dengan ENSO dan IOD. *Omni-Akuatika*, *12*(3).

Riupassa, Y., & Wattimury, J. J. (2022). Variabilitas Musiman Suhu Permukaan Laut dan Angin di Laut Arafura. *Jurnal Laut Pulau: Hasil Penelitian Kelautan*, *1*(2), 71-84.

Setiadi, N. L., Schaduw, J. N. W., Luasunaung, A., Tilaar, F. F., Manoppo, L., Tumbol, R. A., & Sumilat, D. A. (2020). Analysis of Upwelling Event Based on Satellite Imagery in Fishery Management Area (FMA) 716. *Jurnal Ilmiah Platax*, *8*(2), 242-250.

Simbolon, C. D. L., Ruhiat, Y., & Saefullah, A. (2022). Analysis of Wind Direction and Speed of Rainfall Distribution in Tangerang Regency. *Jurnal Teori dan Aplikasi Fisika*, 113-120.

Sofarini, D. (2012). Keberadaan dan Kelimpahan Fitoplankton Sebagai Salah Satu Indikator Kesuburan Lingkungan Perairan di Waduk Riam Kanan. *EnviroScienteae*, *8*(1), 30-34.

Swayati, D. P., Muskananfola, M. R., & Rudiyanti, S. (2015). Konsentrasi Klorofil-a, Nitrat dan Fosfat untuk Menilai Kesuburan Muara Sungai Wakak, Kendal. *Management of Aquatic Resources Journal (MAQUARES)*, *4*(4), 71-79.

Syah, A. F., & Sholehah, S. (2021). Thermal Front Variability during the El Nino Southern Oscillation (ENSO) in the Banda Sea Using Remotely Sensed Data. *Journal of Marine Science*, *3*(2).

Syafik, A., Kunarso, K., & Hariadi, H. (2013). Pengaruh Sebaran dan Gesekan Angin terhadap Sebaran Suhu Permukaan Laut di Samudera Hindia (Wilayah pengelolaan perikanan Republik Indonesia 573). *Journal of Oceanography*, *2*(3), 318-328.

Tapilatu, Y. H. (2016). Profil Oseanografi Biologi Laut Banda: Sebuah Tinjauan Kritis. *Omni-Akuatika*, *12*(2).

Tarigan, S., & Wouthuyzen, S. (2017). Mapping and Monitoring the Sea Surface Temperature in Weda Bay Using Terra and Aqua-Modis Satellites. J Remote Sensing & GIS 6: 217. doi: 10.4172/2469-4134.1000217 Page 2 of 6 J Remote Sensing & GIS, an open access journal ISSN: 2469-4134, *6*(4), 1000217. *Date Julian date Satellites Station No. In-situ Temp. Digital Number Values*, *30*, 3.

Tomczak, M., & Godfrey, J. S. (2003). *Regional oceanography: an introduction*. Daya Books.

Tubalawony, S. (2007). Kajian Klorofil-a dan Nutrien Serta Interelasinya dengan Dinamika Massa Air di Perairan Barat Sumatera dan Selatan Jawa–Sumbawa.

Tubalawony, S., Kusmanto, E., & Muhadjirin, M. (2012). Suhu dan Salinitas Permukaan Merupakan Indikator Upwelling sebagai Respon terhadap Angin Muson Tenggara di Perairan Bagian Utara Laut Sawu. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*, *17*(4), 226-239.

Tubalawony, S., Purnama, R., & Ferdinandus, J. (2015). Penentuan Daerah Potensial Upwelling dan kaitannya dengan Pengolaan Laut Banda. In *Seminar Nasional-Pembangunan Kelautan dan Perikanan Berbasis Laut Banda. Ambon*.

Tristianto, G., Wulandari, S. Y., Suryoputro, A. A. D., Handoyo, G., & Zainuri, M. (2021). Studi Variabilitas Upwelling di Laut Banda. *Indonesian Journal of Oceanography*, *3*(1), 25-35.

Ulqodry, T. Z., & Aryawaty, R. (2013). Pola Sebaran Konsentrasi Klorofil-a di Selat Bangka dengan Menggunakan Citra Aqua-Modis. *Maspari Journal: Marine Science Research*, *5*(1), 22-33.

Uneputty, B. A. S., Tubalawony, S., & Noya, Y. A. (2022). Klorofil-a dan Kaitannya terhadap Produktifitas Primer Perairan Laut Banda pada Fenomena La Nina. *Nekton*, *2*(1), 57-65.

Vallina, S. M., Cermeno, P., Dutkiewicz, S., Loreau, M., & Montoya, J. M. (2017). Phytoplankton Functional Diversity Increases Ecosystem Productivity and Stability. *Ecological Modelling*, *361*, 184-196.

Waters, V. I. I. (2012). Pengaruh Durasi dan Intensitas Upwelling Berdasarkan Anomali Suhu Permukaan Laut terhadap Variabilitas Produktivitas Primer di Perairan Indonesia Influences of Upwelling Duration and Intensity Based on Sea Surface Temperature Anomaly Toward Primary Productivity. *Jurnal ilmu dan teknologi kelautan tropis*, *4*(1), 67.

Wijaya, A., Priyono, B., & Mahdalena, N. C. (2018). Karakteristik Spasial Temporal Kondisi Oseanografi Laut Banda dan hubungannya dengan Potensi Sumberdaya Perikanan. *JFMR (Journal of Fisheries and Marine Research)*, *2*(2), 75-85.

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

Yuniarti, A., Maslukah, L., & Helmi, M. (2013). Studi Variabilitas Suhu Permukaan Laut Berdasarkan Citra Satelit Aqua MODIS Tahun 2007-2011 di Perairan Selat Bali. *Journal of Oceanography*, *2*(4), 416-421.