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VARIABILITY OF SEA SURFACE CHLOROPHYLL AND TEMPERATURE USING REMOTE SENSING TO SUPPORT MARINE AQUACULTURE IN INDONESIA

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ABSTRACT

The objective of this study is to examine the variability of sea surface chlorophyll (SSC) and sea surface temperatures (SST) to support marine aquaculture development within the Indonesian region. The study have been conducted by using remote sensing data of NOAA-AVHRR, SeaWiFs and Aqua MODIS for 10 year period (2007-2016). The result shows that monthly variation of SST and SSC climatologies are found to be affected by monsoonal climate system in this region. In deep water areas, the variability of SSC is very small in all year. Meanwhile, the highest SSC concentrations are observed in the Malacca Strait, around the coast of Kalimantan, Arafuru Seas and the eastern Banda Sea from January to December. Added, relatively large chlorophyll concentrations are encountered in the area of coastal regions.

Key words: chlorophyll; temperature; remote sensing; Indonesia Seas.

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1. INTRODUCTION

The rapid increase of population around the entire world has caused the large-scale exploitation of marine and inland fishery resources. Those facts have often resulted in severe degradation and declination of the quality of the marine environment. These pressures will certainly be more and more intensive in the future. The pressure on the environmental conditions affect the distribution and availability of fishery resources, Added, the state of global fishing stocks is in accelerating severe decline and the world's marine species may collapse by 2048 because of overfishing, environment pollution, habitat loss or even due to climate change (Worm, 2006).

However there is potential for increasing fish production from inland fisheries through intensified development of aquaculture. Against a background of increasing human population and an ever increasing demand for food, falling catches from capture fisheries and pollution, there is a major challenge to re-examine the nature and potential of the aquaculture sector (Muir, 1995). In addition, FAO (2004) stated that aquaculture production is increasing worldwide and it is expected that its activities will be expanding significantly in the near future as practices are further improved and diversified. Therefore, to ensure a sustainable development of the marine aquaculture industry, there is need to collect the entire range of information needed to assess changes in the marine environments, such as water quality, seawater temperature, marine productivity, ocean circulation and etc.

To understand marine environments, some research and observations by using the remote sensing data have been carried out by various researchers. Since 1970, remotely sensed imagery has been used to map coastal and ocean areas and their components such as water quality (Hensen et al., 2007), bottom features or bathymetry (Zikra et al, 2011), coastal dynamics (Crawford et al, 2007), terrestrial and marine habitat (Kim et al., 2000) and some coastal hazards. Since then, the remote sensed method has become more important for understanding the behaviour of marine environments because it can provide both spatial and temporal information. Moreover, the importance of time series of satellite imagery and derived products, for showing coastal and marine spatial-temporal trends on longer time scales is widely recognized, especially in relation to climatic variability.

However, in Indonesian Seas, the observation of marine environments was still limited. As one of the largest maritime continent in the tropical area, it is important to measure the entire range of information needed to assess changes in the marine environment conditions in Indonesian Seas. Therefore, the objective of this study is to examine the variability of seawater quality surround Indonesian Seas using remote sensing to support marine aquaculture development in Indonesia. The investigation focused in sea surface chlorophyll (SSC) and sea surface temperature (SST).

2. STUDY AREA

Indonesia has more than 17,500 islands and coastline in excess of 80,000 km. As the world's largest archipelago, Indonesia is positioned in a strategic location with respect to global ocean circulation patterns. Roughly, Indonesia stretch from 6ºN to 10ºS latitude and from 90ºE to 141ºE longitude. Geograpical location of Indonesian Seas are the only low latitude inter-ocean communication between the Pacific and Indian Oceans which known as Indonesian throughflow (ITF) as seen on Figure 1.

The dynamic nature of Indonesian seas shows the interaction with the Pacific and Indian Oceans and monsoonal climate (the southeast and northwest monsoon) and it may explain the high marine biodiversity of the region to a great extent. Besides influenced by the Asian-Australian monsoon system, Indonesia climate is also affected by global warming. Since then, information on wave climate variability (Zikra et al, 2016), water qualities, marine environments is having a significant role in the management and plan in coastal and marine sustainable development.

Figure 1 Map of Indonesian Seas

3. DATA USED

A series of monthly mean Sea Surface Chlorophyll-a (SSC) and Sea Surface Temperature (SST) data derived from the Aqua MODIS Level 3 Standard Map Image (SMI) obtained from NASA (http://oceancolor.gsfc.nasa.gov). The primary data used was collected during 10 year period from 2007 to 2016 in Indonesian region. The spatial resolution of this data is about 9 km and 1.1 km.

The data was downloaded in HDF format and then cropped by using SeaDAS 4.7 software. The ASCII data of SSC and SST was extracted from the similar source by using the same software and converted into Excel format. The monthly SSC and SST data are available from January 2007 to December 2016. The monthly climatological mean of SSC and SST are calculated on the basis monthly mean for 10 years period. To support this study, the meteorological data was also collected to understand the influence of monsoonal system on monthly variability of SSC and SST.

4. RESULTS AND DISCUSSION

In order to analyze the variability of SST and SSC surface chlorophyll, monthly mean of SST and SSC maps during 10 years period are presented on Fig. 2 and Fig. 3. Figure 2 and 3 show that the spatial variability of SST and SSC are strongly affected by the monsoonal climate. This is because the Indonesian Seas located between Australia and Asia and influenced by the Asia-Australia monsoon wind climate as shown in Fig.1. In Indonesia, the northwest monsoon or Asian Monsoon occurs during the months of December to February, Transition Monsoon Australia (March-April-May), while southeast monsoon or Australia Monsoon develops in the month of June to August and Transition Monsoon Asia (September- October-November). April and October are transition months.

Figure 2 shows the monthly climatologically mean of SSC (Sea Surface Chlorophyll) from January 2007 to December 2016. In general, from Figure 2, it is shown that there are areas in the Indonesian Seas that seem to exhibit little if any month-to-month variability in SSC surface chlorophyll. These are deep-water areas: in the western Pacific, the Indian Ocean, the Sulawesi Sea, the Halmahera Sea, and the Flores Sea (north of the Nusa Tenggara Island).

Throughout the year from January to December, the highest SSC surface chlorophyll concentrations are observed in the Malacca Strait, around the coast of Kalimantan and Arafuru Seas. During the southeast monsoon (June through September), high sea surface chlorophyll concentrations are observed in the area south of the Java-Nusa Tenggara Island, the Java Sea, the eastern Banda Sea and the Karimata Strait. Along the coasts south of the Java-Nusa Tenggara Island, the maximum in SSC surface chlorophyll appears to move to the west over the period of the southeast monsoon. This is consistent with westward movement of the upwelling center due to an alongshore wind shift and latitudinal changes in the Coriolis parameter [Susanto et al., 2001]. While in the northwest monsoon, sea surface chlorophyll concentrations declines in the eastern Banda Sea and south of the Java-Nusa Tenggara Island.

The monthly mean of Sea Surface Temperature (SST), based on monthly data from January 2007 to December 2016, is shown in Figure 3. Similar to SSC surface chlorophyll variability, the climatological mean SST patterns over the Indonesian Seas is clearly affected by the monsoon cycle system. During the northwest monsoon, colder temperatures are found in the South China Sea from December to March with SST values is between 27^o-28^o C. Entering southeast monsoon from June to August, temperature in the South China Sea is gradually increase to 29^o-30^o C. June and July is warmer temperature in the South China Sea. Warmer temperature is also found in Sulawesi Sea and Pacific Ocean during May to August with SST value is between 29^o-30^o C.

Conditions are reversed in the southern part of Indonesian Seas. During the southeast monsoon, from June–September, colder temperatures are observed in the southern part of the Java to Nusa Tenggara Island, the Arafuru Sea, Banda Sea and some part of Indian Ocean. These colder temperatures are due to upwelling generated by strong southeasterly winds along the coasts of the Java-Nusa Tenggara Island and within the Banda Sea (Gordon and Susanto, 2001). This SST variability in the southern part is larger and fluctuated within 24^o-28^o C. This colder temperature over the southern areas is not uniform during the southeast monsoon, especially in the Timor Sea. The Timor Sea is warmer than surrounding throughout the year. SST in Timor Sea is higher by 1^o-2^o C than areas to the west or east of Timor Sea.

In this study, remote sensing technique was able to show the ability to provide SST and chlorophyll-a data in wider perspective. The synoptic view of the broader area and multi-temporal which is captured spatially enable the user to observe environmental aspects that are not possibly seen in terrestrial survey. This adequate information will provide more valid management and plan in coastal and marine sustainable development.

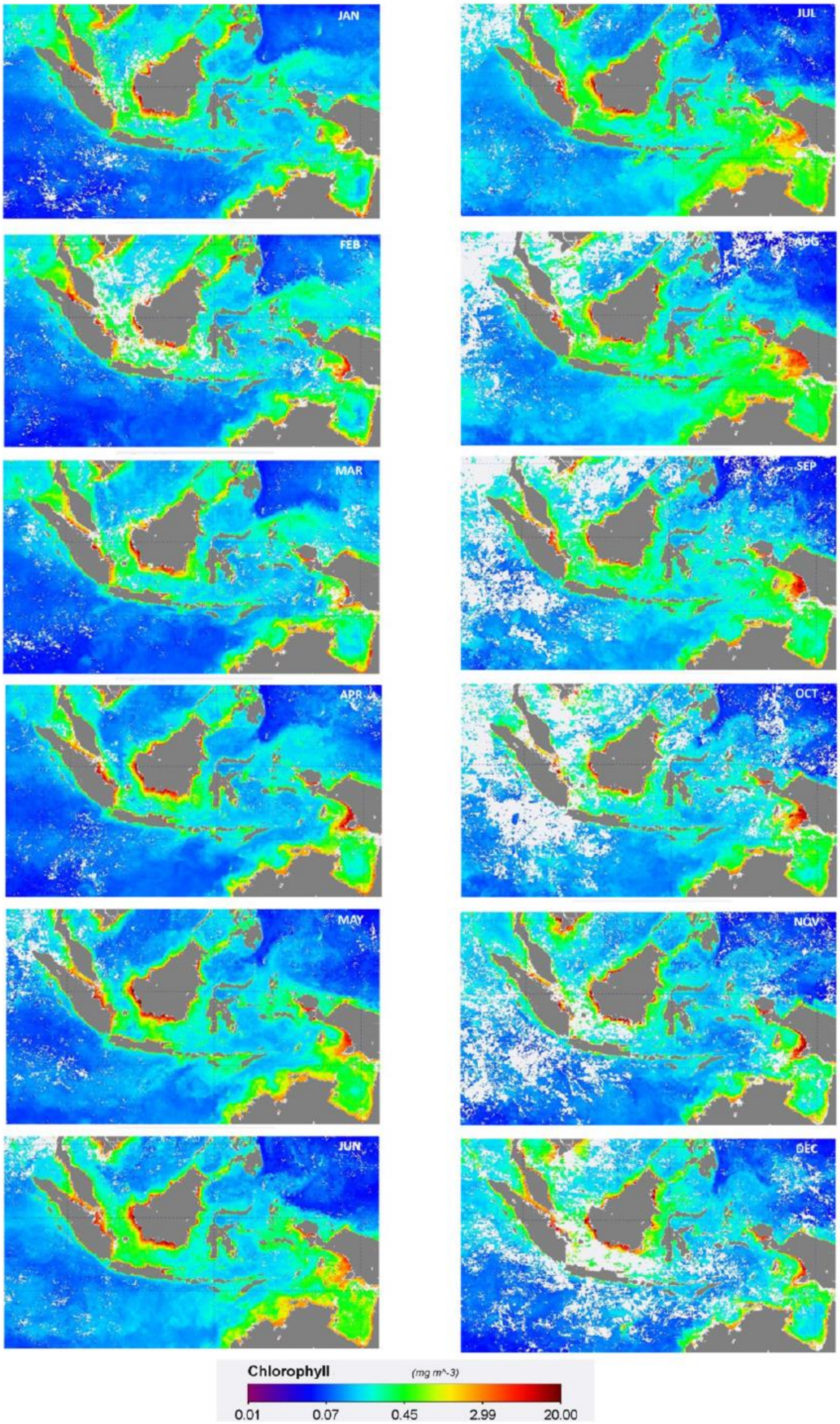

Figure 2 Results of monthly climatological mean of SSC from 2007 to 2016.

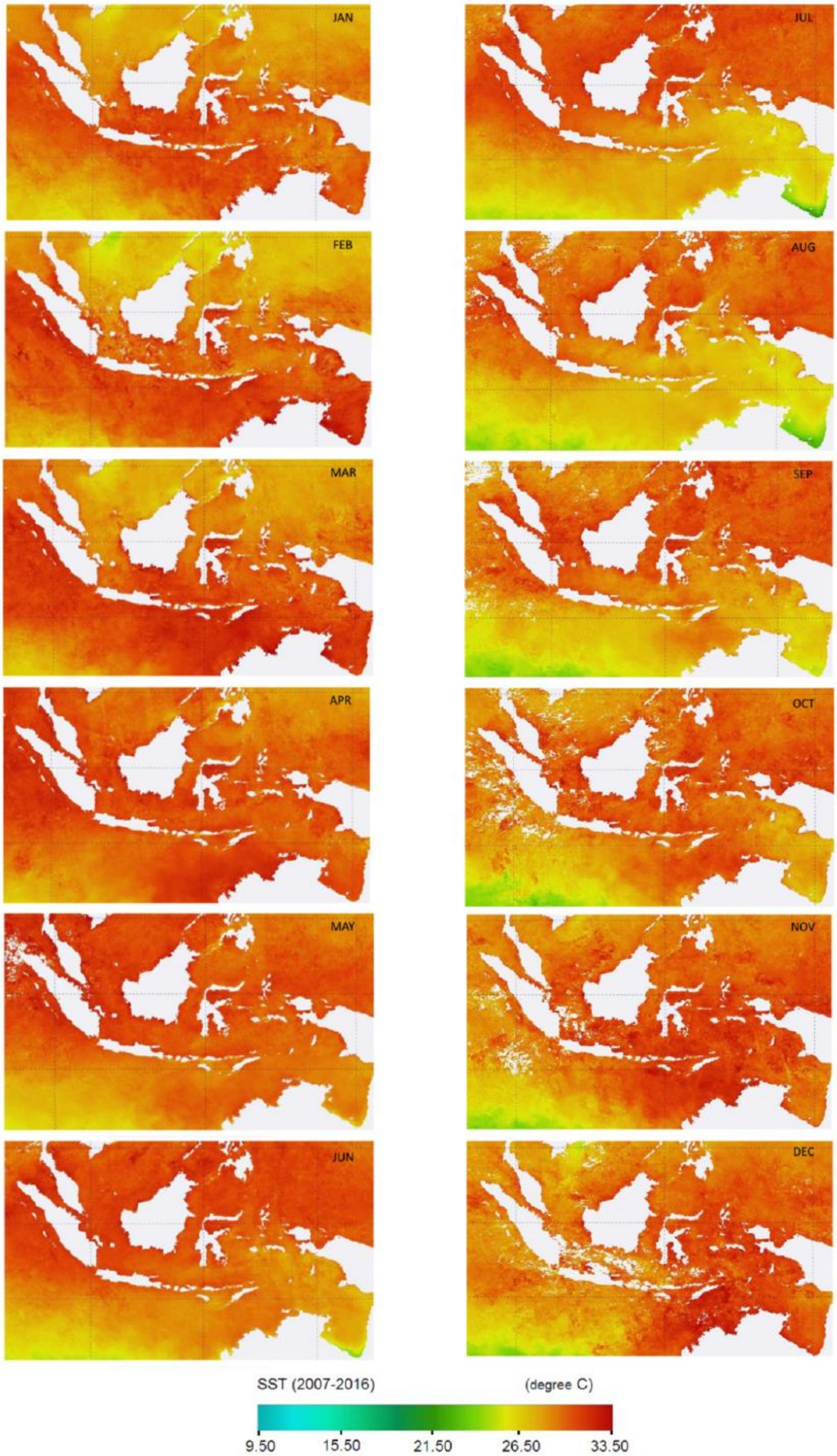

Figure 3 Results of monthly climatological mean of SST from 2007 to 2016.

5. CONCLUSIONS

In this paper, sea surface temperature and chlorophyll climatologies of the Indonesian Seas are computed using satellite-derived data of NOAA-AVHRR, SeaWifs and Aqua MODIS for 10 year period (2007-2016). Variability of SST and SSC climatologies are found to be affected by monsoonal climate system in this region. In deep water areas, the variability of SSC is very small in all year. Meanwhile, the highest SSC surface chlorophyll concentrations are observed in the Malacca Strait, around the coast of Kalimantan, Arafuru Sea and the eastern Banda Sea from January to December. Added, relatively large chlorophyll concentrations are encountered in the area of coastal regions. This marine environment condition in Indonesian Seas is suitable to support marine aquaculture and various marine conservations.

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REFERENCES

[1] Worm, B. 2006. “Impacts of biodiversity loss on ocean ecosystem services”, *Science*, 314(3): 787-790.

[2] Muir, J. 1995. “Aquaculture Development Trends: Perspectives for Food Security”, International Conference on Sustainable Contribution of Fisheries to Food Security. Kyoto, 4-9 December 1995. KC/FI/95/Tech/4. FAO, Rome.

[3] FAO. 2004. “Fishery Statistics. Aquaculture Production 2002”. *FAO Yearbook*. Vol. 94/2. Rome. 193p.

[4] Henson, S.A. and A.C. Thomas. 2007. “Interannual variability in timing of seasonal chlorophyll increases in the California Current”. *J. Geophys.Res*. In Press.

[5] Zikra, M., Hashimoto, N., Yamashiro, M. & Suzuki, K. 2011. “Spectral analysis of pixel brightness on video images to study wave analysis at Hasaki beach in Japan,” Proc. 21st Int. Offshore and Polar Engineering Conference (ISOPE), Vol. 3, Hawaii, USA, 19–24 June 2011, pp. 974–979 (CD-ROM).

[6] Zikra M., A. Putika and Mukhtasor. 2016. "Analysis of wave climate variations based on ERA-Interim Reanalysis data from 1980 to 2014 to support wave energy assessment in Indonesia". *ARPN Journal of Engineering and Applied Sciences*, Vol. 11, No. 2, pp. 879-884.

[7] Crawford, W.R., P.J. Brickley, and A.C. Thomas, 2007. “Eddy Transport into a Cyclonic Gyre: An Example in the Gulf of Alaska”. *Prog. in Oceanogr*. In Press.

[8] Kim, S.-W., Saitoh, S.-I., Ishizaka, J., Isoda, Y., and Kishino, M. 2000. Temporal and spatial variability of phytoplankton pigment concentrations in the Japan Sea derived from CZCS images. *J. Oceanogr.*,56: 527−538.

[9] Anonim. 2007. SeaWiFs Project. Available from http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/ EAWIFS_BACKGROUND.html

[10] Anonim.2007. MODIS. design concept. Available from http:// modis. gsfc. nasa. gov/ about/ design.php Banse, K., and English, D.C. (2000). “Geographical differences in seasonality of CZCS-derived phytoplankton pigment in the Arabian Sea for 1978–1986”, Deep-Sea Res. II,47: 1623−1677.

[11] NASA HOMEPAGE, “MODIS Design Concept.2007.

[12] Susanto, R. D., A. L. Gordon, and Q. Zheng. 2001. "Upwelling along the coasts of Java and Sumatra and its relation to ENSO", *Geophys. Res. Lett*., 28(8), 1599–1602.

[13] Gordon, A. L., and R. D. Susanto. 2001. "Banda Sea surface layer divergence", *Ocean Dyn*., 52(1), 2–10, doi:10.1007/ s10236-001-8172-6.

[14] B. Ramyaa Sree and SS. Asadi A Remote Sensing and G IS Based Critical Evaluation of Change Detection Study in Thimmaipally Watershed for Land Resources Management, International Journal of Civil Engineering and Technology , 8(4), 2017, pp. 2110-2124.

[15] P.Lakshmi, SS. Asadi, P.Polu Raju, and D.Sathish Chandra, An Integrated Approach For Site Selection By Using Remote Sensing And Design Of Group Houses In And Around Vijayawada: A Model Stud y. International Journal of Civil Engineering and Technology , 8(3), 2017, pp. 806–815.

[16] M. Satish Kumar ,SS. Asadi , S.S. Vutukuru , Assessment of Heavy Metal Concentration in Ground Water by Using Remote Sensing and GIS , International Journal of Civil Engineering and Technology , 8(4), 2017, pp. 1562-1573