Vertical Distribution of Temperature in Transitional Season II and West Monsoon in Western Pacific

Hikari A H Pranoto[1*], Kunarso[1], Endro Soeyanto[2]

[1] Department of Oceanography, Faculty of Fisheries and Marine Science Diponegoro University, Jl. Prof. H. Soedarto, SH, Tembalang, Semarang 50275, Indonesia
[2] Laboratory of Marine Survey, The Agency for Assessment and Application of Technology, Jl. MH. Thamrin 8, Central of Jakarta, Jakarta 10340, Indonesia

*Corresponding author Email: hikariazizah@gmail.com

Abstract. Western Pacific is the water mass intersection from both the Northern Pacific and Southern Pacific ocean. The Western Pacific ocean is warm pool area which formed by several warm surface currents. As a warm pool area and also the water mass intersection, western Pacific ocean becomes an interesting study area. The object of this study is to describe the temperature vertical distribution by mooring buoy and temporally in transitional season II (September – November 2014) and west monsoon (December 2014 – February 2015) in Western Pacific. Vertical temperature and wind speed data that was used in this study was recorded by INA-TRITON mooring instrument and obtained from Laboratory of Marine Survey, BPPT. Supporting data of this study was wind vector data from ECMWF to observe the relation between temperature distribution and monsoon. The quantitative approach was used in this study by processing temperature and wind data from INA-TRITON and interpreted graphically. In the area of study, it was found that in transitional season II the range of sea surface temperature to 500-meter depth was about 8.29 – 29.90 ºC while in west monsoon was 8.12 – 29.45 ºC. According to the research result, the sea SST of western Pacific ocean was related to monsoonal change with SST and wind speed correlation coefficient was 0.78. While the deep layer temperature was affected by water mass flow which passes through the western Pacific Ocean.

Keywords: *Temperature Vertical Distribution, Western Pacific Ocean, INA-TRITON*

1. Introduction

(*Triangle Trans Ocean Buoy Network*) is one of mooring instrument from JAMSTEC which has been deploying some buoys since 1998. This mooring system buoy sends real-time data to the satellite then received and stored in central data. This mechanism allows the observer to monitor time series data without physical presence in the area. One of the TRITON observation area is Western Pacific Ocean. In September 2014, JAMSTEC (Japan) together with BPPT (Indonesia) deploy INA-TRITON mooring buoy which was using m-TRITON as the buoy. INA-TRITON was made to continue the observation from the previous buoy in Western Pacific, specifically to monitor meteorology condition in Western Pacific. Meteorologists had been monitoring sea surface, especially Sea Surface Temperature (SST) as the main factor that affects low-frequency atmosphere change. The relation between sea and atmosphere is not only about climate system but also the prediction, thus from interdecadal climate variability system showed that sea and atmosphere are related [1]. Western Pacific Ocean as the intersection between North Pacific and South Pacific caused this water is passed by several water masses from both oceans. The mixing from both water masses always affect the salinity variability and especially in thermocline layer. The study area is also known as Indo-Pacific warm pool area which being interesting case to observe the vertical distribution of temperature, the warpool is formed by watermass mixing in the area. Oceanographically, water mass in Western Pacific affect Indonesia Water circulation, such as New Guinea Coastal Current, New Guinea Coastal Undercurrent, Mindanao Current and North Equator Counter Current [2]. Western Pacific also affected by seasonal change in Indonesia water which differs known as West Monsoon (December – March), Transitional Season I (April – May), East Monsoon (June – September) and Transitional Season II (October – November), the seasonal change itself related to the direction change of Monsoon [3]. In Western Tropical Pacific, local wind play important role in driving thermocline anomalies. The topic is accounted for by wind-induced Ekman Pumping anomalies [4]. INA-TRITON time series data was used to observe the needed information of research study. This research study had been aimed to vertical temperature distribution related to Transitional monsoon II and west monsoon condition.

2. Materials and Methods

2.1. Area of Study

The research study was determined by The Agency for Assessment and Application of Technology (BPPT) with purposive sampling method. The consideration of the study area was the Western Pacific has various water masses and also there was previous mooring buoy placed on research study location which is replaced with INA-TRITON. The buoy deployment was located on 1°48'15.87" N and 138°30'26.13" E. the study area was chosen assuming it represents the water variability of Western Pacific [5] and be the sequence of the previous study with TRITON buoy in location. Research Study Location had been described on Figure 1.

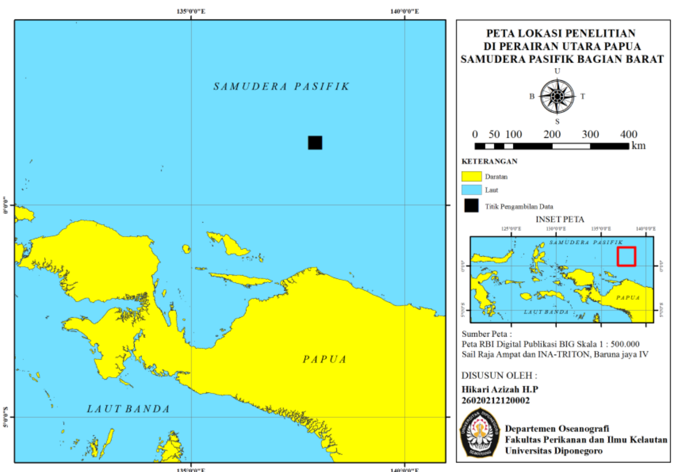

Figure 1. Buoy Deployment and Area of Study

2.2. Period of research

INA-TRITON was deployed in September 2014 in the study area recorded from early September 2014. The data that used in this study was in transitional season II (September – November 2014) and in west monsoon (December 2014 – February 2015).

2.3. Collecting Primary Data

The primary data was conducted by INA-TRITON mooring which recorded every 10 minutes and averaged by the hour. The first primary data was vertical temperature data which recorded by SBE-37-IM from Sea Bird Electronics as CTD (Conductivity, Temperature and

Depth) sensor. The data recorded on 1.5, 25, 50, 74, 100, 125, 150, 175, 200, 250, 300 and 500 meter depth. The second primary data that used was wind surface which recorded by 7050-a from WHOI (with R.M. Young Type 05103 addition). The data was recorded and obtained from Laboratory of Marine Survey, BPPT.

2.4. Collecting Supporting Data

The supporting data was wind surface data that obtained from European Centre for Medium-Range Weather Forecasts (ECMWF). The data was a model from the agency that downloaded in website http://ecmwf.int/ with spatial resolution 13.8 km with level IIIB and resolution $1/12^0x1/12^0$ which consist of component zonal wind (u) and meridional (v).

2.5. Analysis Method

Data from INA-TRITON was recorded every hour as mentioned before, and then it was filtered to sort data from invalid data and null data. Then, for vertical temperature data, every depth was averaged from hourly to daily by Microsoft Excel software, data was averaged again to monsoonal which was in transitional season II and west monsoon. After filtered and averaged, data proceeded by Surfer 10 to interpret vertical temperature distribution temporally in Western Pacific. While wind surface data was averaged per day by Microsoft Excel and interpret by the graphic to describe the windspeed, this data used to observe the correlation between windspeed and sea surface temperature as the monsoonal changes condition.

Wind surface data from ECMWF was obtained in NetCDF (Network Common Data Form) and extracted by ODV 3.4.2 software. The result of the extract was the component of zonal wind (east to west (u)) and meridional (north to south (v)) in altitude reference 10 meters. The data proceeded in Microsoft Excel to obtain wind speed and direction. Then, the data proceed by ArcGIS 10.0 to interpret wind distribution pattern in spatial.

The relation Between SST and wind data from INA-TRITON obtained by find the correlation between both data. The method which used to determine correlation coefficient was Pearson Correlation equation [6]. To interpret between two variables there are criteria according to correlation coefficient value.

Table 1. Coefficient of correlation value from Pearson Correlation

Correlation Coefficient	Relation Interpretation
0 – 0,2	Very Low
0,2 – 0,4	Low
0,4 – 0.7	High
0,7 – 1,0	Very High

3. Result and Discussion

As the result of temperature distribution, according to INA-TRITON data, it was found that temperature distribution pattern in Western Pacific was having colder from September 2014 to February 2015. Vertical temperature profile described the changes of temperature to the depth from surface column up to 500-meter depth. The decreasing of temperature value in the area of study can be seen as the temperature contour was crawling up since September 2014 to February 2015 in Figure 2.

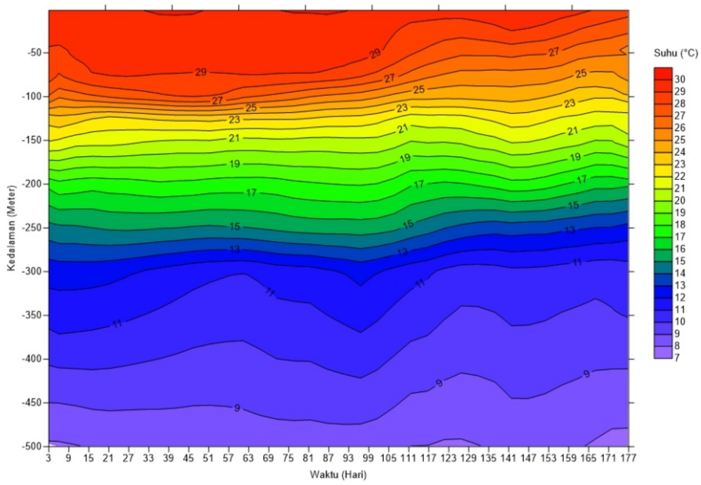

Figure 2. Vertical Temperature Distribution From September 2014-February 2015

According to Figure 2 is represented the averaged temperature was decreasing, in case the temperature average of the surface column was 29.9 °C in transitional season II and become 29.45 °C in west monsoon. The warm temperature is the character of Pacific warmpool, which is warmer than 28 - 29 °C [7] The lowering temperature that exists in sea surface might have a correlation to the monsoonal wind in area of study. The windspeed was stronger in west monsoon than in transitional season II which presented in Figure 3. The increasing of windspeed also might increase the mixing process in the water column. The mixing process will bring the colder water mass from deeper water column to the surface and the sea surface temperature is colder as the result [8]. The decreasing of sea surface temperature in west monsoon was assumed related to upwelling process, that from isotherm line as the indicator which shallowing to the surface in west monsoon (Figure 2). Upwelling process trigger colder water mass from the deeper column to surface water column, this event caused the temperature in the surface water column colder than before due to the entrance of deeper water mass[9].

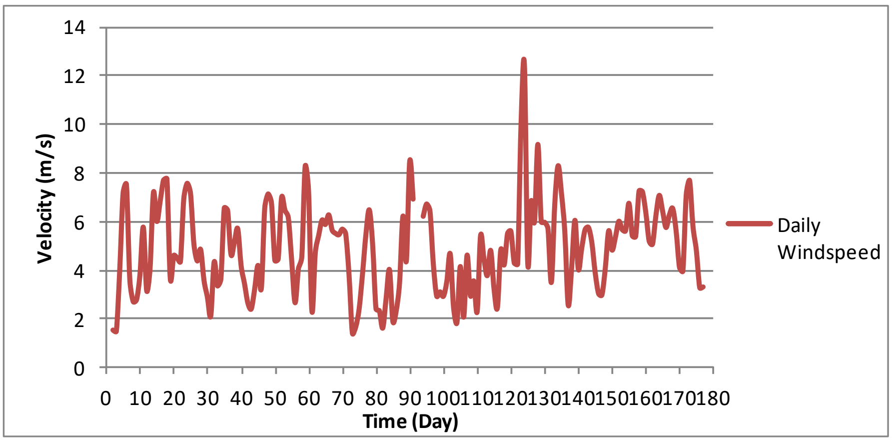

Figure 3. Daily averaged windspeed from September 2014 – February 2015

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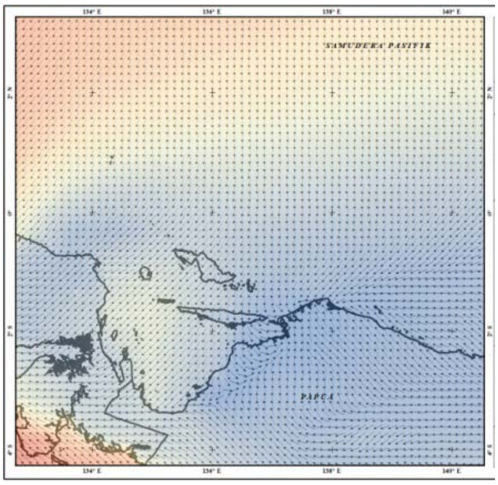

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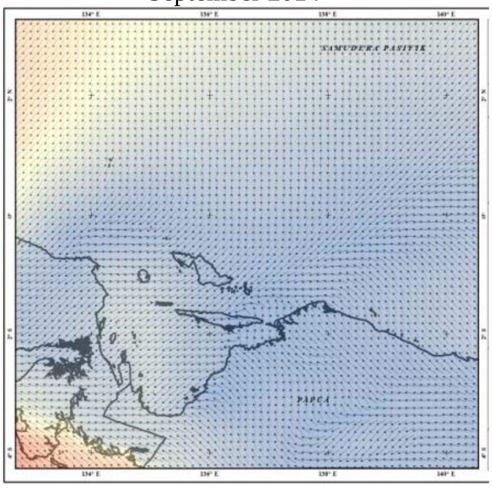

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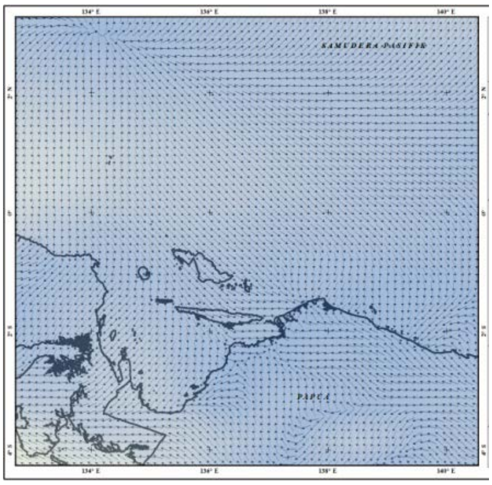
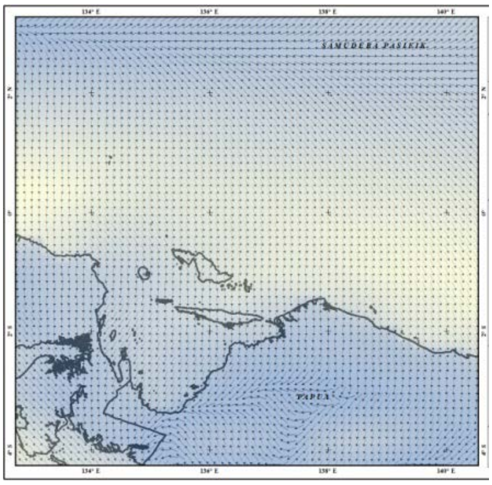


November 2014



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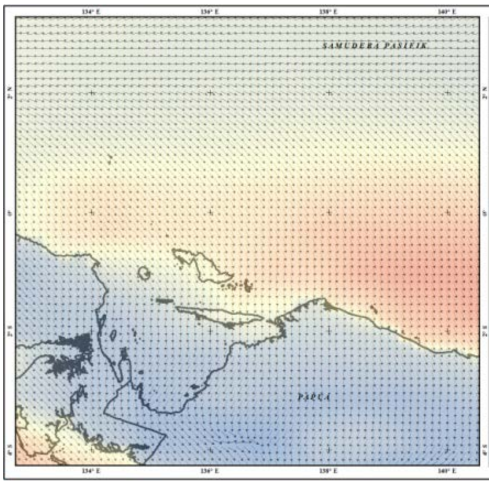
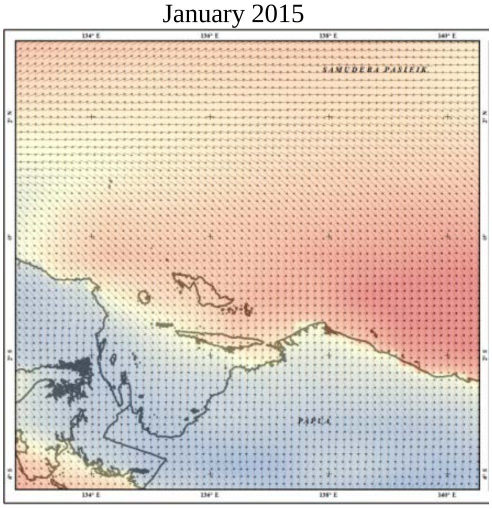


January 2015



February 2015

Figure 4. Windspeed and direction on September 2014 – February 2015

Upwelling process in Western Pacific was assumed due to current divergent process. As depicted in Figure 4, wind as an indicator had divergent. Wind that was burst from west to east through Western Pacific was having divergent process where some of wind burst turned to the northeast and some of them to the southeast. Wind which burst to the northeast was trigger Ekman current to South. Thus current divergent were formed to east and south, this process allows empty column on water surface which would be filled by its deeper water mass, this event is known as upwelling [10]. This event also mentioned by [5] as the existence of New Guinea Eddy (NGE) that advected by New Guinea Coastal Undercurrent, North Pacific and North Equator Counter Current. Upwelling itself in general terms is vertical displacement of deep waters toward the surface. In reality, upwelling is never takes place deeper than few hundred meters [11].

Table 2. Averaged temperature for depth in transitional season II and west monsoon

Time	Depth (meter)										
	-1.5	-25	-50	-75	-100	-125	-150	-200	-250	-300	-500
Transitional Season II	29.90	29.54	29.26	29.02	27.25	22.96	21.16	17.53	15.06	11.80	8.29
West Monsoon	29.45	28.82	27.64	26.33	24.38	21.89	20.54	17.21	13.95	10.92	8.12

Besides sea surface temperature which had increased contour, the temperature on deeper water column was also increased. This kind of situation present in Table 2, which showed temperature for every sensor depth and averaged in transitional season II and west monsoon. From the table above obtained that The temperature on every recorded depth in west monsoon was colder than transitional season II. This event can be seen in Figure 2, it also showed phenomenon on isotherm 11^{o}C which has wavy pattern that head to the upper water column.the wavy isotherm pattern was showed on ±300-400 meter depth. This wavy pattern was assumed that it indicated the internal wave existence in depth and study area. The internal wave will interfere the boundary layer (the bottom thermocline boundary layer). In the tropical Pacific, the main currents, westward flowing over the upper ocean are forced by the easterly trade winds. In the first 10 meters water depth immediately away from the equator, deflection by the rotation of the earth occurs to the right in the northern hemisphere and the left in the southern hemisphere. This coriolis causes ekman transport [12].The internal wave could be exist due to density difference between thermocline layer and deep water layer. Nontji [13], that internal wave could be identified with the existence of wavy pattern on isotherm profile in deep water. Internal wave that occurs was assumed caused by water mass mixing right below the 12 ^{o}C isotherm. Thurman [7], mentioned that surface column of Western Pacific was affected by Subtropical Lower Water which occur on 120 – 200 meter depth, in deeper column was affected by Northern Intermediate Water on 250 – 400 meter depth and also Northern Intermediate Water on 600 – 800 meter depth. Nuriyanto[3], the water masses that exist in area of study was Southern Pacific Tropical Water, Northern Pacific Tropical Water, Northern Pacific Intermediate Water and Antartic Intermediate Water. The influence of water mass mixing to isotherm pattern, that water mass mixing possibly affect the isotherm pattern into wavy pattern [14]. The water mass mixing identified by temperature and/or salinity graphically change from pointed line into slope line [15].

4. Conclusion

Study of vertical temperature distribution in Western Pacific water found that the temperature was related to monsoon change which in this research was during transitional season II and west monsoon. Averaged temperature in every depth was having difference while in transitional season II was higher than west monsoon. The decreased of SST has been founded that in transitional season II was 29.9 ^{o}C on the other hand sea surface temperature in west monsoon was 29.45 ^{o}C. Mixing on surface water column due to wind divergention which triggered divergent ekman current occurred on the sea surface. On the deep water, the wind burst is not affected the water dynamic, but due to the wavy pattern toward the upper column below 12 ^{o}C isotherm, it assumed that internal wave exists caused by water mass mixing on the study area.

5. Acknowledgments

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