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STUDY OF MIXED LAYER DEPTH VARIATION IN LIRAN ISLAND WATERS, SOUTHWEST MALUKU, APRIL 2016

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ABSTRACT

Liran Island waters are located between two seas, the Banda Sea and the Timor Sea. These waters are also the border between Republic of Indonesia and the Democratic Republic of Timor Leste (RDTL). The thickness of mixed layer depth in Liran Island waters are vary. This is assumed as a result of the influence of transition season I wind that blew in the area in April 2016. This study aims to determine the variation of the thickness layer mixed layer Liran Island waters, Southwest Maluku District on April 2016 caused by the transition season I wind. The methodology that used in this research is descriptive method with quantitative approach. The main data that used in this study is in situ sea temperature data, while the supporting data that used in this study is wind data which measured directly in the field for 9 days. The result of this research is based on determination of layer mixed layer using criterion $\Delta T = 1.0\ ^0C$. The west part of Liran Island had thinnest layer mixed layer depth that is about 20 - 38 m. The east part of Liran Island waters had the thickest mixed layer depth which up to 55 m. Meanwhile, the north part of Liran Island waters had a thickness of mixed layer between the eastern and western waters of 40 m. This related to the wind that blowing from the southwest to the northeast and causing a downwelling phenomenon in the east part of Liran Island waters and upwelling phenomenon in the west part of Liran Island waters while the north part of Liran Island waters did not get a great influence from the movement of the wind because of its location which protected by Liran Island itself.

Key words: mixed layer depth, the transitional monsoon I, Liran Island waters

INTRODUCTION

Southwest Maluku District is included in the National Strategic Area. The spatial planning on this area is prioritized and has a very important influence nationally on the sovereignty of the state, economy, social, culture and environment (Perpres, 2015). One of the islands belonging to the Southwest Maluku District, Maluku Province is Liran Island, which is a populated island and the outermost island of Indonesia. Liran Island is located between the Republic of Indonesia and the Democratic Republic of Timor Leste (RDTL). Liran Island waters has important role to the living of the people who lived there. Therefore, it is necessary to study oceanography, one of the aspects of oceanography is mixed layer depth of the Liran Island waters.

Mixed layer depth has an important role in the Liran Island waters. This layer plays a role in larval and pelagic fish eggs floatation (Kara *et al*., 2003). The Liran Island waters have abundant fishery resources. The density of pelagic fish especially in coral reef area at Lirang Island is 7 ind./m^2, where fish that can be consumed density is high (5 ind./m^2), while the density of fish that is not for consumtion is 2 ind./m^2 (BPOL, 2016).

Mixed layer depth is a surface layer that is affected by the wind (Talley *et al*., 2013). Liran Island is located in one of the waters that have active wind circulation the waters between Nusa Tenggara and Australia are often being the location of the tropical cyclones was born (Nontji, 1987). As a result, besides the seasonal winds The wind power from tropical cyclones that often occur, affecting the waters of Liran Island. The geographical location of Liran Island, which is flanked by Atauro Island (East Timor) in the southwest and Wetar Island in the east, is expected to have different impacts of wind movement on each side of Liran Island, which will affect the thickness of the mixed layer in Liran Island waters as well.

Because mixed layer depth is closely related to pelagic fish life, a good understanding of the depth of mixed layers can help conservation of pelagic ecosystems. In addition, the mixed layer depth is the surface layer that connects the ocean and the atmosphere, so the observation of mixed layers and the study of how the development of seasonal and on certain climate time scales of mixed layers are important for modeling and understanding the climate (Talley *et al*., 2013).

The purpose of this research is to know the variation of mixed layer depth in Liran Island waters, Southwest Maluku District on April 2016 and to know the influence of the transition season I on April 2016 with the variation of mixed layer depth in Liran Island waters. Data which had taken in the field was sea temperature depth of 0 m to maximum 100 m and the wind obtained from survey with BPOL in the waters of Liran Island. The temperature data obtained is then processed with ODV software and for the wind data is processed using Mike 21. Temperature data will be displayed in the form of vertical profile temperature and vertical profile distribution of ΔT, while the wind data will be shown in the form of windrose for direction and speed. The effect of wind on mixed layer depth can be seen from the results shown.

MATERIAL AND METHOD

This research was conducted on 14 - 30 April 2016 in Lirang Island waters, Southwest Maluku. In situ temperature data retrieval was conducted on April 16th - 17th, 2016 using WQC-24 at 11 points of temperature sampling station scattered around Liran Island. These stations are grouped into 3 main transects of western transects (stations 5, 6, 7, 8 and 9), northern transects (stations 1, 10, and 11) and eastern transects (stations 2, 3, and 4). Wind data retreival was conducted for 9 days on April 14 - April 23, 2016 using AWS (Figure 1).

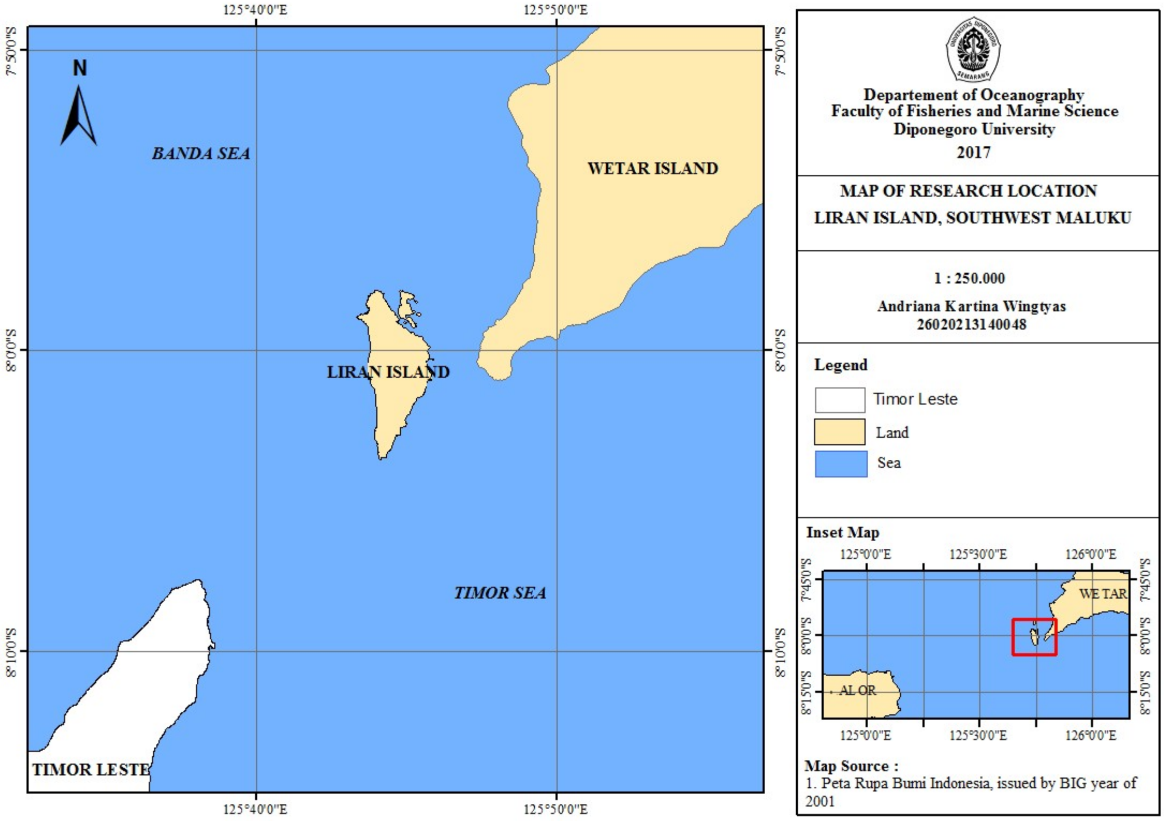


Figure 1. Location of Collecting Data Area

Sea temperature data processing conducted in January 2017. Data obtained from directly measurement using WQC-24 were sea temperature data with maximum depth about 100 m. Data were analyzed using ODV 4 to be shown vertical profile of sea temperature and variation of mixed layer depth in Liran Islan waters.

Sea temperature data processing aims to produce 2 main outputs:

1. Vertical Profile of Sea Temperature

Sea temperature data processing used ODV 4 to produce vertical profile of sea temperature of each data retrieval station. The raw data from field measurements using WQC were processed into Ms. Excel to be seperated according to their transect. The first transect (representing western part of Liran Island waters), the second transect (representing northern part of Liran Island waters), and the third transect (representing eastern part of Liran Island waters). Analysis of sea temperature data using ODV 4 displaying data transversely while the position of data retrieval stations tend to be longitudinal. The divisions of transects into 3 parts aims to avoid overlap of data due to the position of stations were not completely transverse. The next step was processing data in ODV 4 in stational. This step displayed the distribution of sea temperature vertically. The result of this step was vertical profiles of sea temperature data which later can be seen visually the condition of mixed layer depth in Liran Island waters.

2. Criteria of Determining Mixed Layer Depth Using The Difference of Sea Temperature (ΔT)

A number of criteria has been used in the literature to determine mixed layer depth from observed salinity and in situ sea temperature. This criteria divided into 2 groups; first is criteria based on the difference of the characteristic of its ocean, where mixed layer depth is determined by the depth where the characteristic of its ocean changes from the surface value which we used as treshold value. In addition, determination of mixed layer depth can also be seen based on temperature gradient of the ocean sea temperature (Dong *et al*., 2008). In this study, determination of mixed layer depth using the first criterion.

The first criterion based on sea temperature difference (ΔT). The reference sea surface temperature value is used at a depth of 10 m, according to (Rao *et al*., 1989) that mixed layer depth characterized by the difference value of sea potential temperature ($\Delta T = |Ts - Td|$) ranged between 0.01 ^{0}C to 1.0 ^{0}C. After that, data were processed by ODV 4 to produce sectional figure of the distribution of ΔT in transverse view.

Wind data processing has been done by retrieving AWS recording data for 9 days in Liran Islan and processed into Ms. Excel to produce mean values of wind speed and direction.

Data which has been obtained from AWS were vector data ie vector of velocity **(u)** and vector of velocity **(v)** in m/s. To get the result of wind speed used the resultant vector equation:

$$v = \sqrt{u^2 + v^2}$$

V = total speed (m/s)
u = vector of velocity u (m/s)
v = vector of velocity v (m/s)

To get the direction of wind in degree unit then calculated based on **u** and **v** according to the following table.

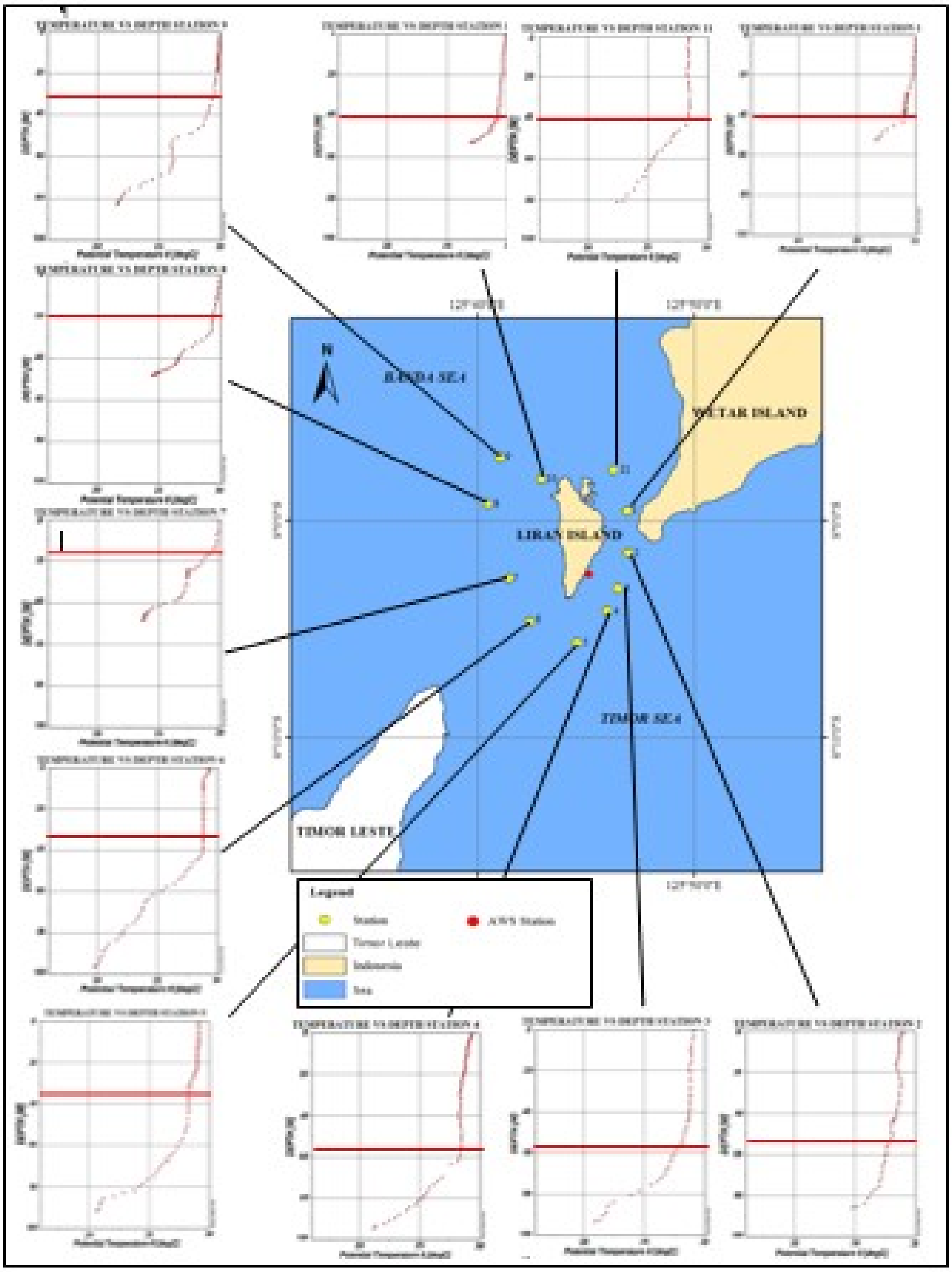
Table 1. Wind Direction Determination Using Quadrant.

	u (m/s)	**v** (m/s)	Θ
Quadrant I	+	+	90 – arcTAN |**v**/**u**|
Quadrant II	+	-	90 + arcTAN |**v**/**u**|
Quadrant III	-	-	270 – arcTAN |**v**/**u**|
Quadrant IV	-	+	270 + arcTAN |**v**/**u**|

RESULT AND DISCUSSION

Distribution of mixed layer thickness

Based on the result of Figure 2 can be known that there are variation of mixed layer depth in Liran Island waters. The research stations in the eastern transect of the island have the thickest mixed layer depth compared to the research stations in the western transect of the northern transect of the island. Station 5, 6, 7, 8, and 9 in the western part of Liran Island have mixed layer depth of 20 – 38 m. The northern transect which consisting of station 1, 10, and 11 have mixed layer depth of 40 m. Meanwhile, station 2, 3 and 4 which located in the eastern transect Liran Island waters have mixed layer depth of 51 - 55 m.



Fugure 2. Vertical Profile of Sea Temperature in Liran Island Waters, April 2016. (The red line indicates the lower bound of mixed layer depth based on the difference of sea temperature ΔT = 1.0 °C)

Wind factor

One of the factors which affect the thickness of mixed layer depth is wind. Wind data processing in the form of windrose is to know the speed and direction of the wind blowing on April 2016. The result of windrose that presented in Figure 3 which was taken using AWS for 9 days from April 14^{th} – April 23^{rd}, 2016 shows that the wind dominantly blowing from southwest and other small parts blowing from the west and northwest. The maximum speed of the wind is 7.3 m/s blowing from southwest and and the minimum speed of the wind is 1.6 m/s blowing from southwest, west, and northwest. The average speed of the wind is ranged from 3.2 m/s to 4.8 m/s.

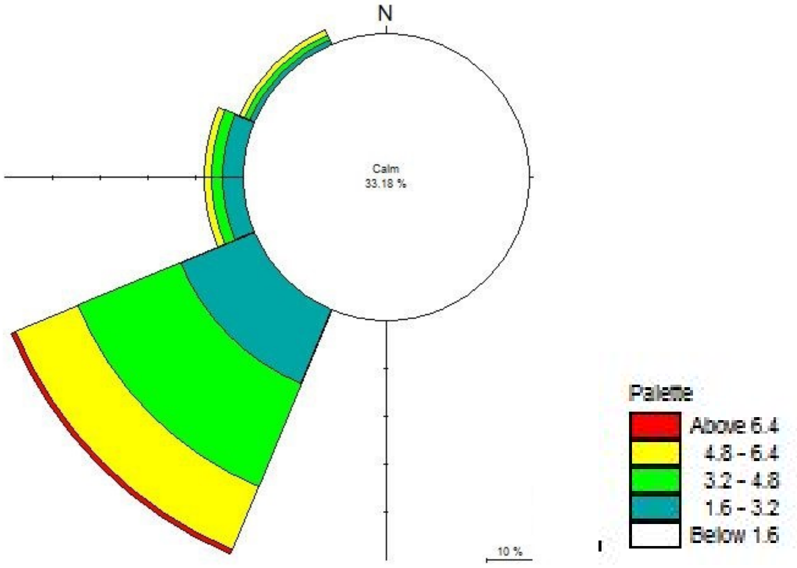


Figure 2. Windrose of Liran Island on April 14^{th} – April 23^{rd}, 2016.

Based on Figure 2, the thickness of mixed layer depth in Liran Island is vary. The westerns transect has the thinnest mixed layer depth compared to the other transects. This is due to the wind blowing from the southwest (Figure 3) with maximum speed of 7.3 m/s and striking the Liran Island and turning to the western part of the island. The wind can affect the water column until 60 – 100 m (Wyrtki, 1961).. In addition, if the wind blows above sea surface it will cause ekman transport. Ekman transport is closely related to coriolis effect. The latitude of Liran Island which located south of the equatorial line causes the wind to be turned leftward by the coriolis effect. This resulted ekman transport which occuring in the water column tending to turn leftward away from the shoreline. In the water column, shape of ekman transport is spiral so it ekman spiral. It makes the water mass of mixed layer carried away from the shore. Thus, the lower water mass rises (upwelling) and the mixed layer depth in western transect of Liran island has the thinnest layer which ranged from 20 to 38 m in the result.

The eastern transect of Liran Island also get the effect of the dominant wind blowing which from the southwest with the maximum speed of 7.3 m/s. The mechanism of wind affection to the mixed layer depth in the eastern transect of the island as well as what occured in the western transect of the island. The wind blows above the sea surface results the ekman transport in the water column. The direction of ekman transport affected by the direction of the wind, the direction of the wind affected by the coriolis effect. . The latitude of Liran Island which located south of the equatorial line causes the wind to be turned leftward by the coriolis effect, which is carried closer to the shoreline. The upper water mass from offshore towards the coast so that mixed layer depth thickened and the thermocline layer pressed to the bottom. The result is the water mass of mixed layer in the eastern transect of Liran Island decreasing (downwelling) and has the thickest layer which ranged from 51 to 55 m (Figure 2). The wind plays significant role in the decrease of the upper layer of thermocline (Kunarso *et al*., 2012).

Meanwhile, the northern transect of Liran Island has a steady thickness of mixed layer which the bottom line of the layer is 40 m. This is due to the position of this transect protected by Liran Island from the influence of the southwest wind. As a result, mixed layer depth in northern transect not thickening or thinning.

CONCLUSION

The waters of Liran Island, Southwest Maluku District have variation of mixed layer depth on April 2016. Based on the determination of mixed layer depth with $\Delta T = 1.0\ ^{\circ}C$ method, the western transect of Liran Island waters has the thinnest layer of mixed layer depth which ranged from 20 to 38 m. The eastern transect of Liran Island waters has the thickest layer of mixed layer depth which ranged from 51 to 55 m. Meanwhile, the northern transect of Liran Island waters has the mixed layer depth thickness between the eastern transect and western transect which is 40 m.

The wind has the significant role in the variation of mixed layer depth in Liran Island waters. This is due to the dominance of wind direction that blew in April 2016 from the southwest to the northeast with the maximum speed of 7.3 m/s, so that mixed layer depth in the eastern transect of Liran Island experienced downwelling that thickening the mixed layer, while mixed layer depth in the western transect of Liran Island experienced upwelling so that the mixed layer in this transect thinned, and the northern transect of Liran Island have a steady and homogenous mixed layer due to the influence of the wind is weak because the position of this transect protected by the island.

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