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ORIGINAL ARTICLE

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TYPICAL CHARACTER IN THE SOUTH OF BANDA SEA BASED ON THICKNESS AND VARIABILITY IN THE UPPER LIMIT THERMOCLINE AREA AND ITS RELATIONSHIP WITH SOUND VELOCITY

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ABSTRACT

Typical character of south Banda Sea based on thickness and variability in the upper limit thermocline area has been identified by studying the whole area of Banda sea using the ~7 years INDESO data recorded from 3rd March 2007 to 18th March 2014. We found from such investigation of 4 types of seasons: (1) 2nd Middle Season (**2ndMS**), (2) West Season (**WS**), (3) 1st Middle Season (**1stMS**), and (4) East Season (**ES**) happended in the area that (1) **2ndMS**, and (2) **WS** caused by North West Monsoon (**NWM**), and (3) **1stMS** and (4) **ES** affected by South East Monsoon (**SEM**) contributed to the understanding of the upper layer of thermocline depth closely associated with the change of season. **The detail discussion of such finding especially related to sound velocity in each three different layers of mixed layer, thermocline, and below thermocline is provided in this present paper.**

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INTRODUCTION

Ocean is the most attractive field on earth due to its complex physical environmental system as well as its largest food contributions on earth which is about 70% in the total amount in comparison with that from the land area of the earth [**1-4, 8-11**]. Therefore, the environmental problem in the sea area can directly influence the life of human being on earth, of cource with various complicated causes including its links with natural disasters [**5-7, 12**].

Banda sea is one of the earth deepest sea with its deep about 7000 m. Because of its deepest uniqueness, there was a lot of misteries beneath it particularly associated with various unique varieties of the ocean animals and plants living there. Banda area itself consisted of at least 11 islands. Based on the history of the islands, Maluku first official government was started there by Dutch due to spicies treasures in the islands. In order to understand the physical character in the Benda sea, there were many efforts conducted by a various multidisciplinary scientists such as biologists, geophysicists, marine scientists, and physicists. The contributions of such interdisciplinary scientists make the sea areas are interesting to be fully uncovered not only from foreigner scientists, but also from their tourists.

In this brief study, the authors present their research findings based on ~7 years data recorded from 2007 to 2014 of Infrastructure Development for Space Oceanography (**INDESO**) especially related to the typical character of south Banda Sea based on thickness and variability in the upper limit thermocline area as well as its connections with sound velocity in each three different layers of (1) Mixed layer (**ML**), (2) Thermocline layer (**TL**), and (3) Below Thermocline layer (**BTL**) as deep as ~318 m from the sea surface.

I. Computational Physics Method

The investigation method used in this current research was based on computational physics method particularly based on computational oceanography and weather in conjuction with computational and numerical algoritm analysis of a principal model in physical system. The input data in this work was collected by **INDESO** in 7 years from 2007 to 2014. **INDESO** was a collaborative program between France and Indonesia. The row data had then been transformed into ordinary softwares such as Microsoft excel and origin to be analyzed and plotted. While by using Ocean Data View 4, the clear pictures of computational oceanography images can be highlighted, and monitored. In order to understand the scientific findings, ones needed to investigate the big pictures of Banda sea as well as all possibilities links with its thickness and variability influenced by the seasons with their typical weather as well as the sound velocity propagated in the 3 diferent upper layers of the sea such as (1) **ML**, (2) **TL**, and (3) **BTL**, respectively.

RESULTS AND DISCUSION

Figure 1 shows **4 types of seasons**: (**1**) 2nd Middle Season (**2ndMS**), (**2**) West Season (**WS**), (**3**) 1st Middle Season (**1stMS**), and (**4**) East Season (**ES**) happended in the area that (**1**) **2ndMS,** and (**2**) **WS** caused by North West Monsoon (**NWM**), and (**3**) **1stMS** and (**4**) **ES** affected by South East Monsoon (**SEM**), respectively. **The significant change in Area 8 was due to WS** caused by North West Monsoon (**NWM**). While **a little bit change of Area 8 affected by 1st MS** was due to South East Monsoon (**SEM**).

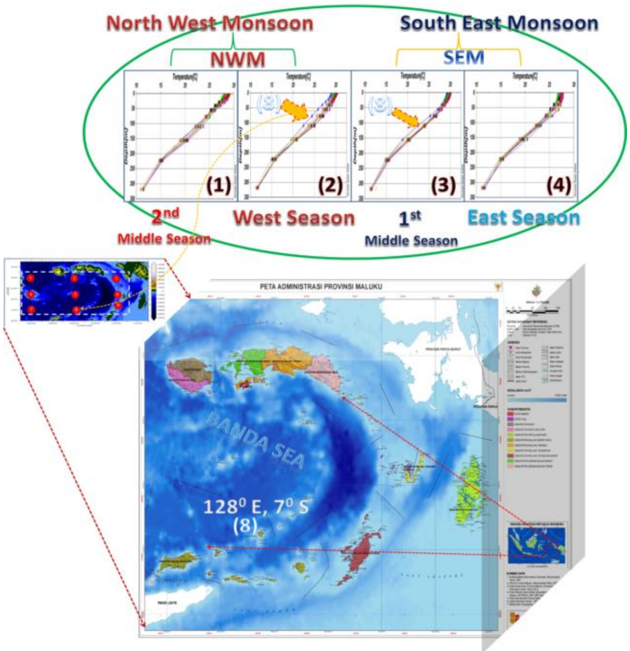

Figure 1. 4 types of seasons: (**1**) 2nd Middle Season (**2ndMS**), (**2**) West Season (**WS**), (**3**) 1st Middle Season (**1stMS**), and (**4**) East Season (**ES**) happended in the area that (**1**) **2ndMS,** and (**2**) **WS** caused by North West Monsoon (**NWM**), and (**3**) **1stMS** and (**4**) **ES** affected by South East Monsoon (**SEM**), respectively.

Figure 2 depicts cyclonic Eddies effect of the improvement of the upper limit in the thermocline layer mainly happened because of **WS** happened in December to February located in the south part of Banda sea. The finding suggests that the upper limit of the thermocline layer in area (8) was the thinnest among other Banda sea areas.

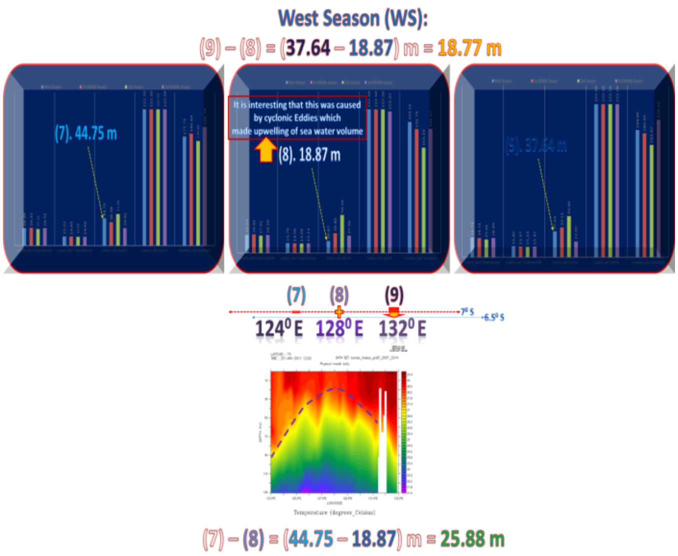

Figure 2. Cyclonic Eddies effect of the improvement of the upper limit in the thermocline layer mainly happened because of West season (December to February) in the south part of Banda sea.

Figure 3 shows that November and January special behavior of sound velocity related to Monsoon and ENSO in Banda Sea have been identified using the data model from **INDESO** recorded **from July 2008 to May 2011**, when **ENSO** phase was happened. From 9 areas of the whole Banda deep sea marked in the inset of Figure 1, we obtained such special physical phenomena **in area no 3 called as North East of Banda area**. Based on 3 types of sea vertical layers such as (1) **ML**, (2) **TL**, and (3) **BTL** on top of the deep Banda sea in such area, we observed that the **~4.54% top layers (≤ 318 m) of ~7000 m Banda deep sea shown a special character in November and January**. It is interesting to note that only layers **TL** and **BTL** have a similar behavior. For example, in layer **BTL**, the El Nino phase changed the sound velocity to be weaker than the normal phase in July to May within 3 years from 2008 to 2011. **On the other hand, the La Nina phase moved the sound velocity faster than the normal phase in July to April within the 3 observed years**. Such phenomena was based on the observation data in this research. In our investigation significant finding as described well in Figure 3, the sound velocity is faster in the mixed layer than that in thermocline layer. While the below thermocline layer, we found that the sound velocity had the lowest speed.

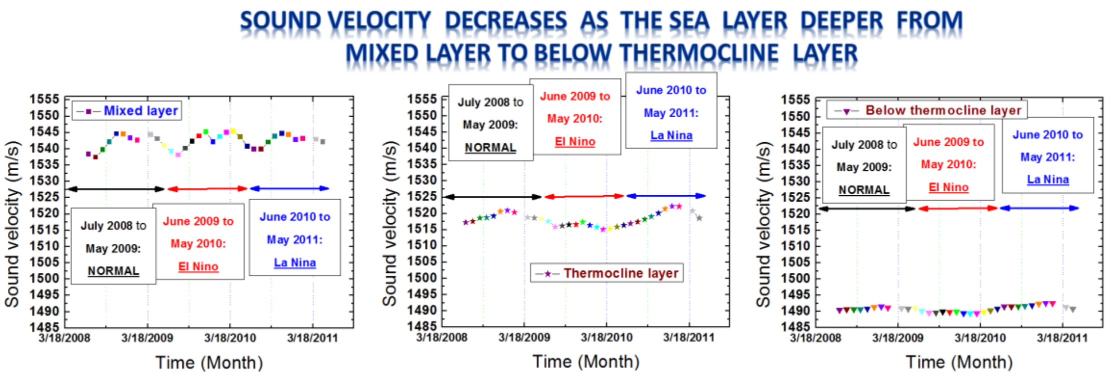

Figure 3. Sound velocity propagation in 3 types of Banda sea layers such as mixed layers, thermocline layer, and below thermocline layer during 3 types of weather processes of **Normal condition**, **El Nino** and **La Nina** **from July 2008 to May 2011**, respectively.

Figure 4 describes that sound velocity was closely related with **ASPL Nino 3.4.** and **wind velocity** in which the speed of such sound decreases progressively from mixed layer to below thermocline layer. In the mixed layer of Banda sea, the sound velocity has a significant fluctuation influenced by **ASPL Nino 3.4.** While in the thermocline layer of Banda sea, the wind velocity has a clear fluctuation due to a significant influence of such wind. **As the speed of wind increses particularly from 6 to 8 m/s, the sound**

velocity in the mixed layer slightly decreases from 1545 m/s to 1540 m/s.

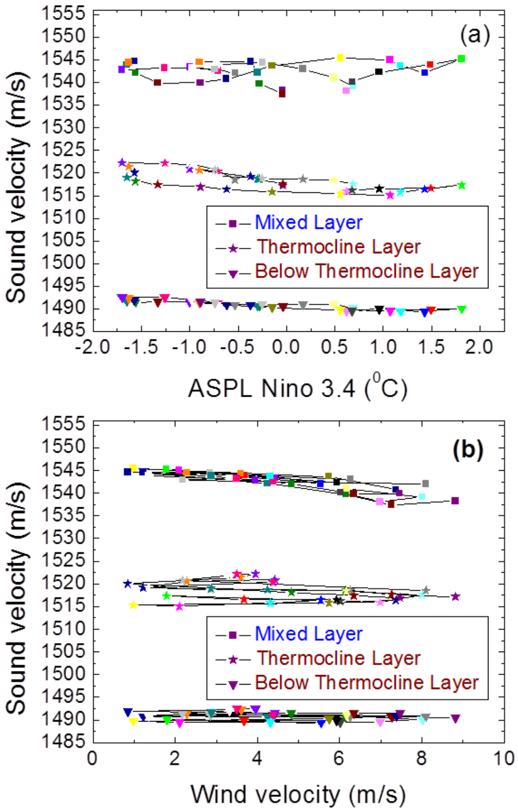

Figure 4. (**a**) Sound velocity versus ASPL Nino 3.4, and (**b**) Sound velocity versus wind velocity in three layers (Mixed, Thermocline and Below Thermocline layers) of Banda Sea identified using the data model from Infrastructure Development for Space Oceanography (**INDESO**) recorded from July 2008 to May 2011, when **ENSO** phase was happened.

CONCLUSION

In conclusion, from 9 areas in the whole Banda deep sea, we obtained a unique physical phenomena in area no 3 called as North East of Banda area. Based on 3 types of sea vertical layers such as (1) **ML**, (2) **TL**, and (3) **BTL** on top of the deep Banda sea in such area, we observed that the **~4.54% top layers (≤ 318 m) of ~7000 m** Banda deep sea shown a special character in November and January. **This research suggests that such area no 3 of Banda sea may have a big source of many types of fish in the location**. In addition, the sound velocity in the mixed layer has an obvious fluctuation due to the speed of wind in the surface of the Banda sea. **While in the thermocline layer, the sound velocity was observed to have a great fluctuation in the low speed of wind of 1 to 5 m/s**.

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