Advances in Theoretical & Computational Physics

Sound Velocity Properties due to Salinity, Temperature and Depth of The Whole Banda Sea: A Marvelous Thing of The ~318 Meter Surface of Deep Sea

Hendry I Elim[1,2,3,5,6,7,8*], Pieldrie Nanlohy[1,2,3,8], Nasrin Silawane[1,2], I Wayan Nurjaya[4] and Agus S Atmadipoera[4]

[1]*Physics Department, Faculty of Mathematics and Natural Sciences (FMIPA)*
[2]*Computational Oceanography and Weather Laboratory (CO&W Lab)*
[3]*Multidisciplinary Research Center of Excellence (MrCE)*
[4]*Department of Marine Science and Technology, FPIK*
[5]*Nanomaterials for Photonics Nanotechnology Laboratory (Lab. N4PN)*
[6]*Research Center of Nanotechnology and Innovative Creation (PPNRI-LEMLIT)*
[7]*Theoretical Physics Laboratory, Physics Department, FMIPA*
[8]*Maritime and Marine Science Center of Excellence, Jl. Dr. Leimena*

[*]Corresponding author
Hendry I Elim, Physics Department, Faculty of Mathematics and Natural Sciences (FMIPA), Pattimura University (UNPATTI), Jl. Martinus Putuhena, Poka, Ambon, Indonesia 97233; E-mail: hendryelim@gmail.com; elimheaven@outlook.com

Submitted: 07 June 2018; **Accepted**: 13 June 2018; **Published**: 18 June 2018

Abstract
A marvelous thing of the ~300 meter surface of a deep sea in an interesting area like Banda sea surrounding by 11 small islands in Banda prefecture of Maluku province was investigated based on sound velocity properties due to salinity, temperature and depth of the whole Banda sea using INDESO data from 3rd March 2007 to 18th March 2014 or about 7 years plus 15 days (715.t) with the depth of the whole data reaching as deep as 318 meter from the Banda sea surface. From 9 different areas that we devided based on the whole Banda sea area, the east part of Banda sea was very attractive areas called as areas of no. 3, no. 6 and no. 9 due to their economic potential exploration, respectively. According to our ongoing works during the 715.t, we discovered that the speed velocity of sound propagating (vs) in the sea was mainly temperature dependent in 3 different depths called as (1) Mixed layer (ML), (2) Thermocline layer (TL), and (3) Below Thermocline layer (BTL) on top 318 m surface of the deep Banda sea. The detail of the influences of North West Monsoon (NWM) and South East Monsoon (SEM) related to the v_s is discussed. Our results suggest that the east part of the whole Banda sea produced faster v_s than that in the others 6 areas. While when the NWM, there was a shift of the v_s especially in TL from the east to the center of Banda sea that made Seram and Buru sea islands warm. In addition, in the influence area due to NWM of BTL, the v_s is faster in the south area of Banda sea.

Keywords: Sound Velocity, Temperature, Salinity, Depth, Marvelous Banda sea.

Introduction
Ocean is an attractive area on earth due to its large area of about 70% that covers the earth. Therefore, by the dynamics of weather and the changing of earthly lands activities can cause few very dramatic desasters such as floods, landslides, fertility of agriculture lands, earthquakes, and many other hurricanes as well as vulcanoes activities [1-11]. Moreover, the dynamics life of creatures in the whole oceans will make typical movements from one position to another position, and from one area to another unpredictable and unique areas, for example the phenomena of cyclonic and anti-cyclonic in the various sea areas just like what has been observed in Banda sea [12,13]. In addition, there are in general 4 types of seasons consisted of (1) 1st Middle Season (1stMS), (2) 2nd Middle Season (2ndMS), (3) East Season (ES), and (4) West Season (WS) happended in the area that 2ndMS, and WS mainly caused by North West Monsoon (NWM), and 1stMS and ES affected by South East Monsoon (SEM), respectively [12].

Although many world wide collaborative research efforts have been conducted in many different deep sea areas on earth, only few investigation was carried out in Banda deep sea of ~7000 meter depth due to many complicated issues both from Indonesia government regulations, and equipment limitations [14]. In this brief advanced computational and theoretical work presents how sound velocity (v_s) properties propagated under the influence of the 4 different seasons as deep as ~318 m surface of Banda deep Sea, and its relationship to salinity, temperature and depth of the the propagating areas. We obtained that few marvelous physical phenomena happened uniquely in those three devided areas located in 9 different areas in Banda sea with their parts of (1) Mixed layer (ML), (2) Thermocline layer (TL), and (3) Below thermocline layer (BTL). The detail findings will be discussed in the content of this paper.

Experimental and Computational Method
The advanced technique employed in this frontier physical oceanography was mainly based on the understanding physical system with a good mathematical physics supported by computational oceanography and weather data recorded using sophisticated both

satelites and argo flow in the ocean controlled from the satellite. By preparing a proper algoritm analysis connected to a smart model in the physical system. All the input data in this research were from INDESO (a collaboration project between France and Indonesia) collected from 3rd March 2007 to 18th March 2014 or about 7 years plus 15 days (715.t) with the depth of the whole data reaching as deep as 318 meter from the Banda sea surface. The row data had then been transformed into ordinary softwares such as Microsoft excel and origin to be analyzed and plotted. On the other hand, a software called as Ocean Data View 4 was used to produce the clear pictures of computational oceanography images which is capable in highlighting, and monitoring the original research data. In order to understand such marvelous scientific findings on the surface of a deep Banda sea, few parameters from the big pictures of Banda sea as well as all possibilities links with its vs properties due to salinity, temperature and depth 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 Discussion

Figure 1 shows that sound velocity properties due to salinity, temperature and depth characters in a normal season located in 9 different areas are closely connected with temperature. While its salinity is not only related to temperature, but also the environmental conditions such as in almost the east part of Banda sea (areas no. 3, 6 and 9), and area no. 7 as a result of a marvelous v_s propagation in those typical areas especially on the ML and TL layers as depicted in Figure. 1(a), and Figure. 1(b), respectively. Furthermore, it seems that vs in the other layer of BTL as shown in Figure. 1(c) has no effect with its salinity condition. From such 9 different areas, we can obtain that the areas of 3, 6 and 9 are very potential in economic exploration in terms of their fish production.

During NWM happened in the 9 areas in Banda sea as described in Figure. 2, a strong indicator of v_s was only observed in layers of TL and BTL of area no. 3. While in its ML, v_s was large in the area above area no. 1 fitted with its higher temperature in comparison to another areas. Such marvelous finding was purely due to season of NWM.

Figure 3 shows that in the whole investigated 3 layers area in Banda sea, the v_s was strongly contributed by the amount of salinity. The relationship of both parameters is that the larger the salinity, the faster the v_s. In addition, it is interesting to point out that on a particular areas of 3 and 5 in BTL, even the salinities were large, the v_s is faster in area no. 8 only. Such amazing finding was due solely to temperature contribution in the area.

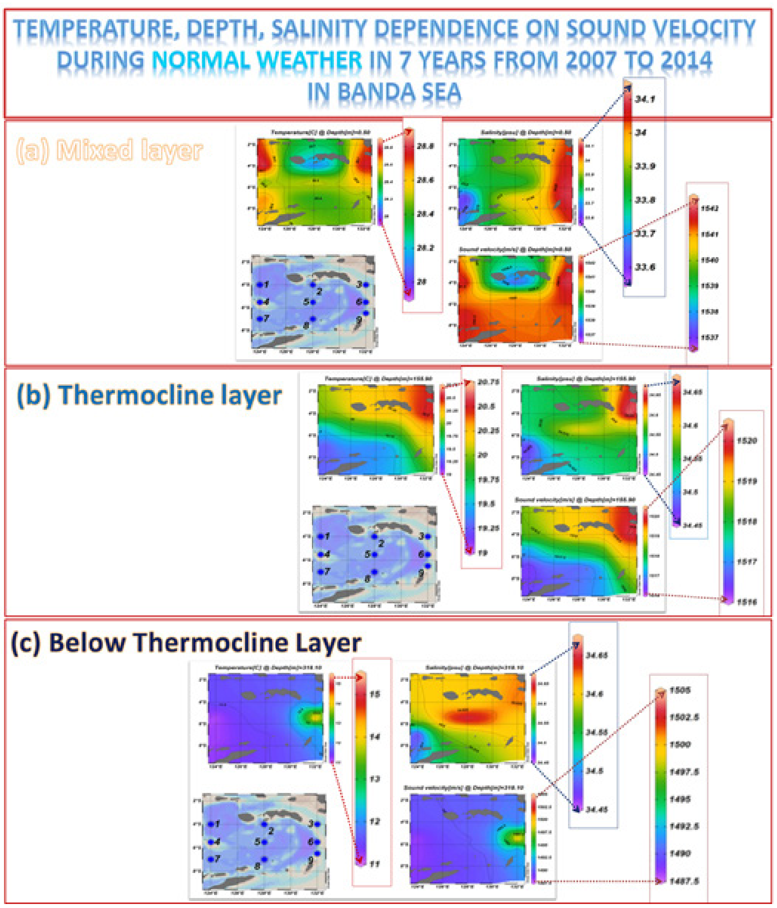

Figure 1: Sound velocity, v_s (*m/s*) dependence on temperature (°*C*), depth (*m*), and salinity (*psu*) in 3 different layers recorded from 007 to 2014 in Banda sea. In the figure, one chose the following depths of 0.50 *m*, 155.90 *m*, and 318.10 *m* in each layers as an example to describe the differences, respectively. The fastest marvelous v_s in BTL during normal season is ~1500 *m/s* located in area no. 6 associated with its temperature, and not depended on the highest salinity of ~34.65 *psu* in areas no. 2, and no. 5.

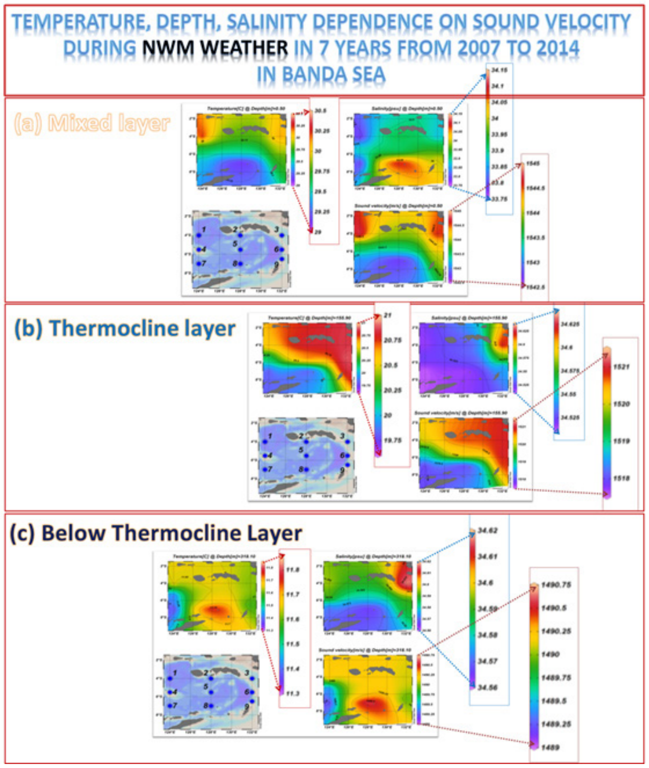

Figure 2: The influences of North West Monsoon (NWM) in 7 years associated with the v_s (*m/s*) due to temperature (*°C*), depth (*m*) and salinity (*psu*) in 3 different layers of mixed layer, thermocline layer, and below thermocline layer, respectively. The following depths in each layers of 0.50 *m*, 155.90 *m*, and 318.10 *m* were chosen as an example to describe the differences. The fastest splendid v_s in BTL is ~1490.75 *m/s* located in area no. 8 associated with its temperature, and not depended on the highest salinity of ~34.62 *psu* in area no. 3.

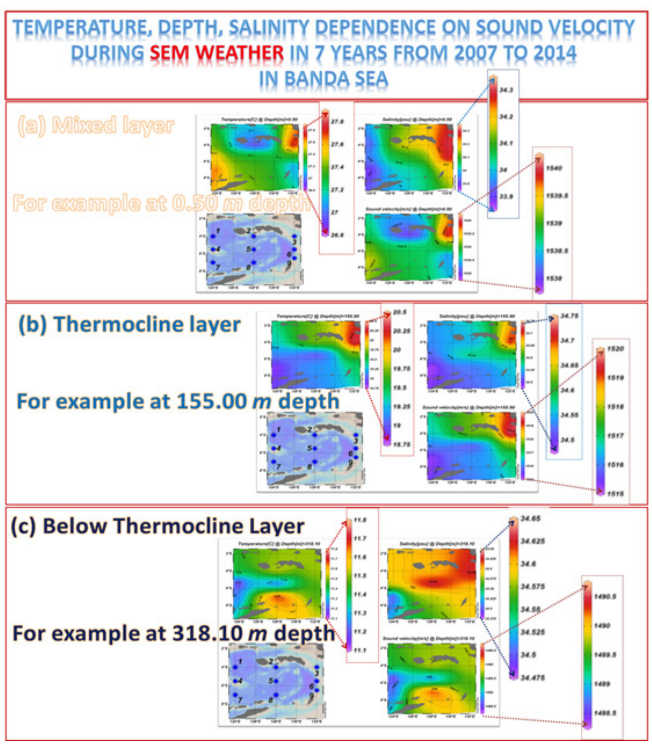

Figure 3: The effects of South East Monsoon (SEM) related to the v_s (*m/s*) related closely to 3 main parameters of temperature (*°C)*, depth (*m*), and salinity (*psu*) from 2007 to 2014 in Banda sea area. The fastest superb v_s in BTL during this unique SEM season is ~1490.25 *m/s* located between the area no. 5 and area no. 8 associated mainly with its temperature, as well as its highest salinity of ~34.625 *psu* in area no. 5.

Concluding discussion

Initial significant findings for further research as described in Figure. 4 in deeper sea beneath BTL of Banda will be based on the following findings in this work:

1. In BTL during normal and NWM moonsons, the fastest marvelous v_s as shown in Figure 1 and Figure 2 were associated with their temperature, not depended on their highest salinity areas.
2. During SEM in BTL as depicted in Figure 3, the fastest marvelous v_s is very closely associated with its temperature, as well as its highest salinity area.

Based on the detail influences of NWM and SEM in conjunction with the v_s, the fastest maevelous v_s in the three different layers were found to be 1544 m/s, and 1521 m/s in the layers of ML and TL during NWM, respectively. While during such moonson, the v_s was 1490.5 m/s or slightly decreased in BTL in comparison with that of normal weather.

It is interesting to point out that the temperature of ML during NWM was droped to be 20.25 °C from 28.8 °C during normal condition. While in the TL is still not much different, and in BTL of the NWM, the temperature decreased from 14 °C of normal moonson to be 11.8 °C similar with that in SEM. In addition, the largest salinity changes were observed during SEM in ML and TL as large as 34.3 psu, and 34.75 psu, respectively.

Our results imply that the east part of the whole Banda sea produced faster v_s than that in the others 6 areas. While when the NWM, there was a shift of the v_s especially in TL from the east to the center of Banda sea that made Seram and Buru sea islands warm. In addition, in the influence area due to NWM of BTL, the v_s is faster in the south area of Banda sea.

Based on Ref. [12], the significant change in Area 8 was due to WS caused by NWM. While a little bit change of Area 8 affected by 1st MS was due to SEM. On the other hand, during the NWM, there was a shift of the v_s especially in thermocline layer (TL) from the east to the center of Banda sea that made Seram and Buru sea islands warm. In addition, in the influence area due to NWM in below thermocline layer (BTL) of Banda sea, the v_s is faster in the south area of Banda sea.

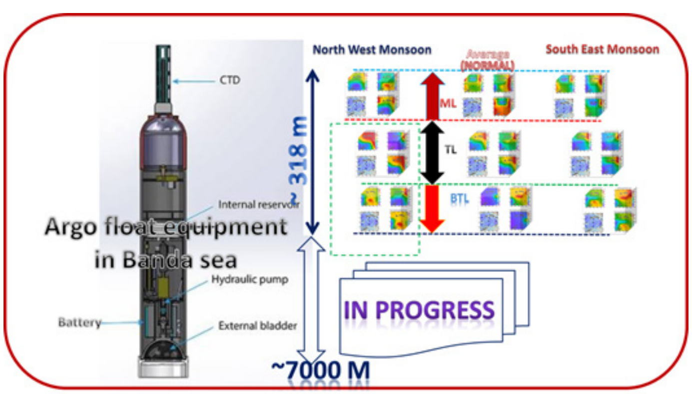

Figure 4: Deep sea research in Banda area is in preparation

Further advanced deep sea research with argo float sophisticated equipment that can dive as deep as 7000 m will uncover many mysteries of physical discovery in deep Banda sea according to our surface findings of it in 9 different areas that the east part of Banda sea (areas of no. 3, no. 6 and no. 9) was very attractive areas due to their economic potential exploration.

Acknowledgements

The authors would like to thank the Department of Marine Science and Technology, FPIK, Institut Pertanian Bogor (IPB), Bogor, Jawa Barat, Indonesia for their financial supports in this research. Furthermore, P.N. and H.I.E. are grateful to the chairman, Dr. G.V. Limmon of Maritime and Marine Science Center of Excellence (MMSCE) for his cooperation work. Part of this work was also supported by Prof. Dr. M.J. Saptenno, the president of Pattimura university who not only encouraged us, but also provided research grant of *Riset Unggulan Daerah* No. 741/UN13/SK/2017 about energy research funded by Pattimura university, Ambon, Indonesia in order to develop maritime and marine advanced research and technology.

References

1. Gupta A K, Anderson, DM, Overpeck JT (2003) Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean, Nature 421: 354-357.
2. Wang B, Ding QH (2006) Changes in global monsoon precipitation over the past 56 years, Geophysical Research Letters 33. DOI: 10.1029/2005GL025347.
3. Shukla, J., 2007, Monsoon mysteries, Science Vol. 318, pg. 204-205.
4. Cook ER, Anchukaitis KJ, Buckley BM, D'Arrigo RD, Jacoby GC, et al. (2010) Asian Monsoon Failure and Megadrought During the Last Millennium, Science 328: 486-489.
5. da Silva AE, Véspoli de Carvalho LM (2007) Large-scale index for South America Monsoon (LISAM), Atmospheric Science Letters 8: 51-57.
6. Fleitmann D, Burns SJ, Mangini A, Mudelsee M, Kramers J, et al. (2007) Holocene ITCZ and Indian monsoon dynamics recorded in stalagmites from Oman and Yemen (Socotra), Quaternary Science Reviews 26: 170-188.
7. Cole, J. E., 2000, Tropical Pacific Forcing of Decadal SST Variability in the Western Indian Ocean over the Past Two Centuries, Science Vol. 287(5453), pg. 617-619.
8. Hakkinen S, Rhines PB, Worthen DL (2011) Atmospheric Blocking and Atlantic Multi-decadal Ocean Variability, Science 334: 655-659.
9. Deutsch C, Brix H, Ito T, Frenzel H, Thompson LA (2011) Climate-Forced Variability of Ocean Hypoxia, Science 333: 336-339.
10. Abram NJ, Gagan MK, Cole JE, Hantoro WS, Mudelsee M (2008) Recent intensification of tropical climate variability in the Indian Ocean, Nature Geoscience 01: 849-853.
11. Friedrich T, Timmermann A, Abe-Ouchi A, Bates NR, Chikamoto MO, et al. (2012) Detecting regional anthropogenic trends in ocean acidification against natural variability, Nature Climate Change 02: 167-171.
12. HI Elim, P Nanlohy, R Lalita, N Sahartira, H Silawane, et al. (2017) 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, International Journal of Health Medicine and Current Research 02: 641-645.
13. P Nanlohy, NS Hehanussa, AS Atmadipoera, IW Nurjaya, HI Elim (2017) A unique cyclonic and anti-cyclonic eddies current

character in Banda sea, International Journal of Health Medicine and Current Research 02: 600-604.
14. Mizobata K, Saitoh SI, Shiomoto A, Miyamura T, Shiga N, et al. (2002) Bering Sea cyclonic and anticyclonic eddies observed during summer 2000 and 2001, Progress in Oceanography 55: 65-75.