FILTERING CTD DATA IN LOMBOK STRAIT TO KNOWING THE SOUND SPEED AND THERMOCLINE CHARACTERISTICS

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ABSTRACT

Lombok Strait is one of 9 chokepoints (narrow point) of the world. Lombok Strait is also one of the 3 lanes of the Indonesian Archipelagic Sea Lanes (IASL) contained in the IASL II which consists of the Makassar Strait and Lombok Strait. Lombok Strait has a depth of more than 150 meters and is a liaison between the Pacific Ocean and the Indian Ocean is very strategic for the submarine trajectory. So it is very important information about the water column in the Lombok Strait for military war operations needs. Therefore, the validity of accurate data is very important, by way of filtering CTD data. The goal is to know the thermocline characteristics and sound speed in the Lombok Strait. One of the methods used for CTD data filtering is by using Analysis Toolpak. Results from CTD data processing using Analysis Toolpak show that there is a difference between data profiles before and after filtering. It also can be seen that the characteristics of the thermocline of the Lombok Strait from North to South are increasingly tight or thin with a thickness of 146.094 meters to 87.694 meters. While the sound speed characteristics in the Lombok Strait from North to South direction also increasingly tight or thin with the difference in the value of sound speed from 34.547 m/s to 27.538 m/s. The seawater mass in the thermocline layer is thought to have originated from the North Pacific Intermediate Water (NPIW) which enters the Lombok Strait through the northern part of the Lombok Strait with an average salinity of 34,415 psu at an average depth of 42.504 meters. Based on the above data it is very important to filter the CTD data to produce valid and accurate data before further processing.

Keywords: *Filtering, Lombok Strait, Sound Speed, Thermocline.*

1. INTRODUCTION

In solving a problem, it is necessary to do an in-depth analysis, therefore it is necessary to support the data obtained from the field as a whole. The data should be quantitative. By using quantitative data the problem becomes clear because the assessment with assumptions that are still guessing, judgment with the words of circumstances or traits (good, bad, long, short, diligent, lazy, and others) can be avoided. Thus misconceptions, misunderstandings, misinterpretations, can be avoided. The analysis becomes directed and detailed, and decision-making will be more accurate.

Data and information as something resulting from data processing become easier to understand and meaningful that describes an event and facts that exist, so it is very useful for leaders in decision making and useful in determining the development of work programs in an institution.

Based on existing facts, conductivity, temperature, and depth (CTD) data from the survey area is directly processed as needed and presented using ocean data view (ODV) software. The results of the display describe the raw data obtained from the survey area conducted. If this is allowed continuously it will adversely affect the accuracy of the data for future surveys. Therefore, there needs to be further processing of CTD data, namely the implementation of filtering or smoothing. Because CTD data obtained from the survey area is still a lot of noise or random data that causes the quality of the data to be poor. With filtering or smoothing, the noise from CTD data obtained from the survey area can be reduced.

Therefore, research on thermocline characteristics and sound speed in the Lombok Strait based on CTD data filtering using Analysis Toolpak is one solution to solve the problem. Because the study discussed filtering or smoothing from CTD data obtained from the survey area. After that, the new filtering or smoothing result data is presented in ODV software and further data processing is carried out.

2. DATA PROCESSING TECHNIQUES

2.1. Interpolation

CTD data obtained from Pushidrosal is done data processing using Macro Excel with a basic visual programming language (VB) which is a script to interpolate lost data. After the CTD data is interpolated, the next step is to filter the CTD data using the Analysis Toolpak in the form of Exponential Smoothing. Inside Exponential Smoothing, there is a dumping factor value that must be filled as an exponential constant for the filtering process. The dumping factor is a correction factor that minimizes the instability of filtered data throughout the observation data. The formula for determining the dumping factor is 1- α (alpha).

2.2. RMSE and MAD Values

RMSE and MAD values are derived from the difference between CTD data and comparison data (WOD and INDESO) after filtering with a value of α 0.1 to 0.9 from downcasting, upcasting, and average CTD data from down-upcasting. After that sought the highest frequency of the smallest values of RMSE and MAD from each downcasting, upcasting, and down-upcasting station to determine the α value suitable for use in the next CTD data filtering process.

2.3. Alpha Value Determination

An α value is a value used to remove noise or random data from CTD data so that the filtering results can be close to the comparison data. The α value itself is between 0<α<1. The α value is used in Exponential Smoothing to determine the dumping factor value used. The formula for determining the α value is as follows.

$$\alpha=\sum freq[\min\{station,RMSE,MAD\}] \quad (1)$$

(Pranowo,W.S.2017,pers.comm)

Once the α value is specified, the dumping factor can be calculated and used for filtering CTD data using Exponential Smoothing. The filtering results are then converted into .txt data to be displayed using ODV software.

2.4 Determination of Thermocline Limits

Calculation of the upper and lower limit depths of the thermocline layer based on the characteristic temperature gradient that is the change in temperature to a depth of 0.1oC for each depth increase of one meter (Nontji, 1987). Bureau (1992) defines a thermocline layer as a depth or position where the temperature gradient is greater than or equal to 0.05oC/m. Based on these definitions, the depth of the upper and lower limits of the thermocline layer can be determined.

The upper limit is the minimum depth at which there has begun to occur a temperature difference greater than or equal to 0.05oC/m with a depth below it, while the lower limit is the final limit that there is still a difference greater than or equal to 0.05oC/m with a depth above it, but it has not occurred 0.05oC/m with a depth below it.

According to Luke and Lindstrom (1991), the depth of each layer in the water column can be known by looking at the change in temperature gradient from the surface to the inner layer. The mixed surface layer is a layer with a temperature gradient of no more than 0.03oC/m (Wyrtki,1961). While the depth of the thermocline layer in water is defined as a depth or position where the temperature gradient is more than 0.1oC depth of 1 meter (Ross,1970).

In this study, a way to determine the thermoclin layer using a temperature gradient of more than 0.1oC/m (Ross,1970). The formula for determining the thermocline layer is as follows.

$$dT=T2-T1 \quad (2)$$

$$dZ=Z2-Z1 \quad (3)$$

$$Thermocline=dT/dZ \quad (4)$$

2.5 T-S Diagram Processing

T-S diagram processing is done using Ocean Data View (ODV) software. The parameter added to create the T-S diagram is the temperature potential obtained from the Derived Variables tool. The next step is to create a diagram by setting Y-variable as potential temperature and X-variable as salinity. After that, the isopycnals function is added to the extras tool so that seawater mass figures are obtained on the diagram (Supangat, 2003).

3. RESEARCH FLOW CHART

The flow chart of the research is as follows.

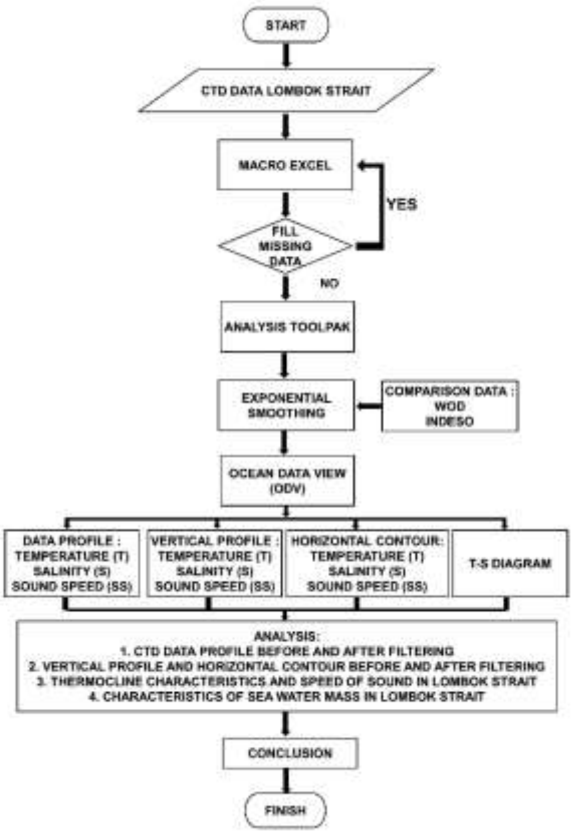

Figure 1. Research Flow Chart

4. RESULTS AND DISCUSSION

4.1. CTD Data Filtering Results

After the alpha value is determined in the dumping factor, then the result of filtering CTD data after it is converted into data .txt can be displayed in ODV software. Filtering CTD data in this study there were 13 CTD stations. The location and one of the profiles of CTD data filtering results are as follows.

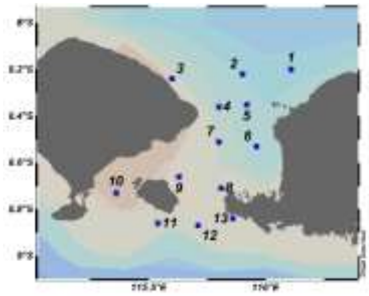

Figure 2. CTD Station Filtering Location

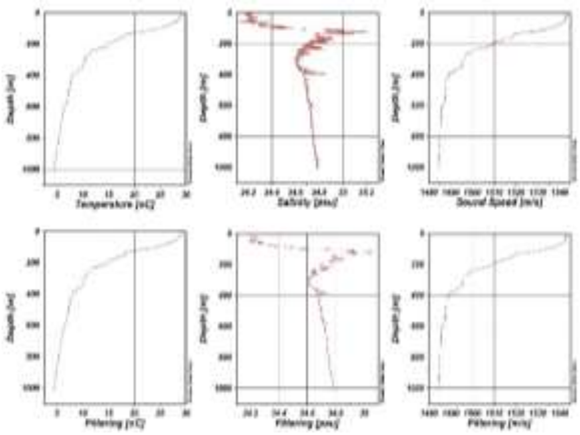

Figure 3. CTD Data Profile Station No.1

From The Picture can be seen the difference between CTD data profile station number 1 before and after filtering. Another CTD data profile can be seen in APPENDIX M. CTD data before filtering there is still noise or data is still rough on temperature, salinity, and sound speed. But after filtering using the Analysis Toolpak, CTD data looks smoother. Based on this research, it can be concluded that filtering CTD data is necessary to obtain valid and accurate data before further data processing.

4.2. Horizontal Plotting Results of CTD Data

The results of horizontal contour plotting in this study at depths of 0, 10, 20, 30, 54, 75, 100, 150, 196, 250, 500, 750 and 1000 meters. The location and one of the results of plotting horizontal contour depth of 54 meters are as follows.

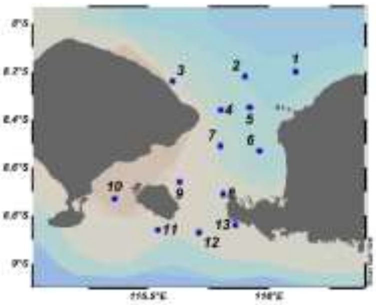

Figure 4. Location of CTD Station Horizontal Contour Depth 54 Meters

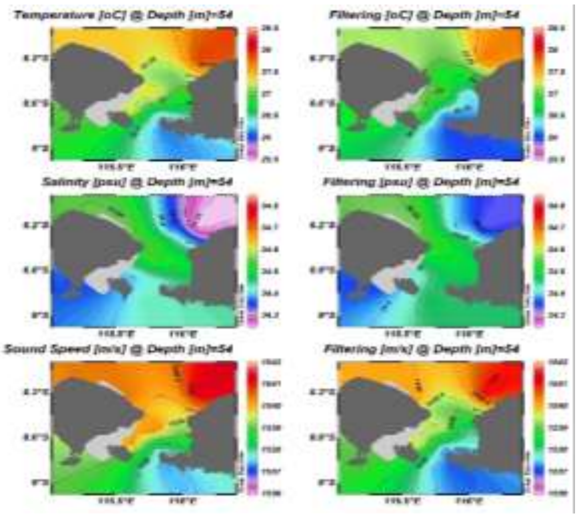

Figure 5. Horizontal Contour Depth 54 Meters

The image above is an image of the horizontal contour of the average upper limit of the 13 CTD station data. In the picture, it can be seen that there is a color difference between CTD data before and after filtering. The color difference is found in temperature, salinity, and sound speed. Based on this research, it can be concluded that filtering CTD data is necessary to obtain valid and accurate data before further data processing.

4.3. Thermocline Layer

Table 1. Upper And Lower Limit Values of Lombok Strait Thermocline Layer

Termoklin	Batas Atas				Batas Bawah				Ketebalan			
	Depth	°C	m/s	psu	Depth	°C	m/s	psu	Depth	°C	m/s	psu
Utara	73.810	25.948	1537.568	34.539	219.905	12.766	1503.021	34.699	146.094	13.181	34.547	0.159
Selatan	51.407	26.363	1537.992	34.430	139.101	15.744	1510.454	34.724	87.694	10.619	27.538	0.294
Barat	57.135	27.074	1539.742	34.530	259.550	11.329	1498.504	34.684	202.415	15.744	41.238	0.154
Timur	41.897	27.043	1539.413	34.397	163.006	16.894	1514.312	34.645	121.109	10.150	25.101	0.249

From the table above can be concluded that the characteristics of the thermocline layer of the Lombok Strait from north to south are getting tighter or thinner with a thickness from 146,094 meters to 87,694 meters or from 202,415 meters to 121,109 meters. While the characteristics of sound speed in the Lombok Strait from North to South are also getting tighter or thinner with the difference in sound speed value from 34,547 m/s to 27,538 m/s or from 41,238 m/s to 25,101 m/s. Similarly, the difference in temperature value is also increasing
Meeting. Different for the difference in salinity value becomes increasing or thicker.

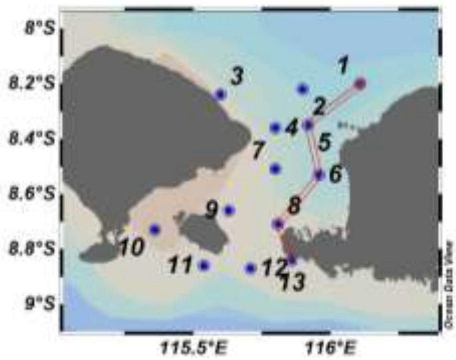

Figure 6. East Cross Section of Lombok Strait

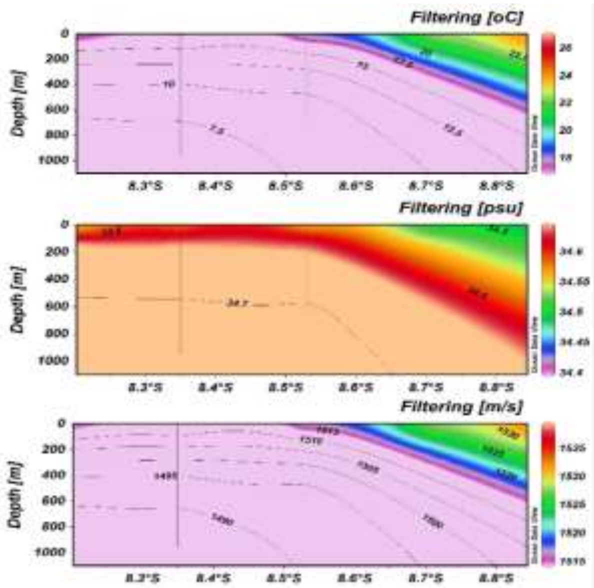

Figure 7. Vertical Profile of The Eastern Thermocline Layer of the Lombok Strait

4.4. Temperature-Salinity Diagram

The plotting results of the temperature-salinity diagram of the five CTD stations are as follows.

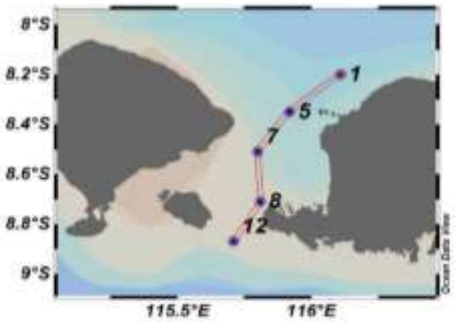

Figure 8. Fifth Cross Section of CTD Station in Lombok Strait

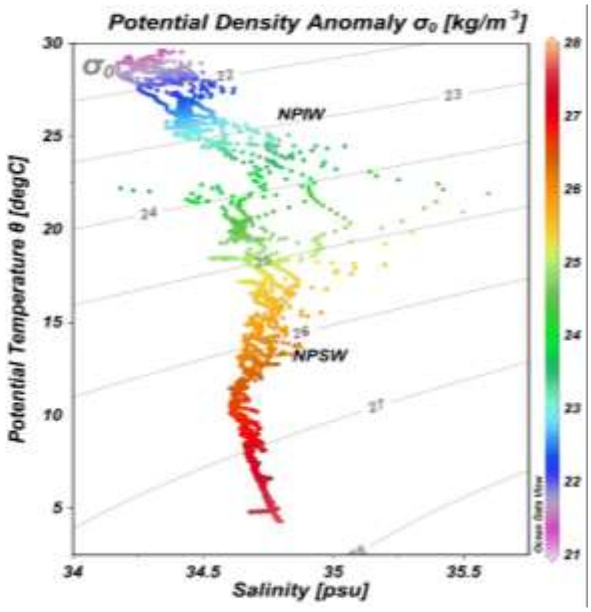

Figure 9. Cross Section Result T-S Diagram

Table 2. T-S Chart Upper and Lower Border Values

Stasiun	Batas Atas				Batas Bawah				Ketebalan
	Depth	°C	m/s	psu	Depth	°C	m/s	psu	m
1	80.410	26.281	1538.407	34.376	235.522	11.916	1500.450	34.698	155.112
5	44.707	27.379	1540.254	34.362	239.432	12.367	1501.933	34.658	194.725
7	51.697	27.914	1541.477	34.542	301.079	9.741	1493.548	34.685	249.382
8	20.807	27.659	1540.377	34.464	129.365	19.293	1521.236	34.569	108.558
12	14.900	28.190	1541.284	34.332	126.236	13.940	1505.189	34.806	111.336
Mean	42.504	27.485	1540.360	34.415	206.327	13.451	1504.471	34.683	163.823

The results of the T-S diagram of the five CTD research stations in the Lombok Strait can be seen in the figure above. From the diagram, it can be known that the Lombok strait from north to south has the following characteristics of seawater mass; Seawater mass in the upper layer of thermocline based on the T-S diagram is to have a σ0 in the range of 21-22.6. Then, the mass of seawater in the thermocline layer, has the characteristic value of seawater mass σ0 in the range of 22.6-23.2, while in the lower layer the thermocline has the characteristic value of seawater mass σ0 in the range of 23.2-27.7. The mass of seawater in the thermocline layer is thought to have originated in the North Pacific Intermediate Water (NPIW) entering the Lombok Strait through the northern part of the Lombok Strait is evidenced by the average salinity value of 34,415 psu at an average depth of 42,504 meters by the range of salinity value measurements taken by Wijffels et al,2002 and You,2003 of 34.4 psu. While the mass of seawater in the lower layer of the thermocline is thought to come from North Pacific Subtropical Water (NPSW) at an average depth of 206,327 meters with an average salinity value of 34,683 psu while the reference salinity value is 34.65 psu (Wijffels et al.2002 and You.2003).

5. CONCLUSIONS

Based on the results of CTD data processing and the results of discussions that have been carried out in this study, it can be drawn some conclusions as follows:

- CTD Data Profile Lombok Strait before and after filtering there are some differences, therefore the need to filter data CTD before further data processing using Analysis Toolpak.
- Vertical profile display and horizontal contour of Lombok Strait CTD data before and after filtering there are several differences, so it will affect the results in the analysis process of determining the thermocline layer.
- The characteristic of the thermocline in the Lombok Strait from North to South is that it is getting tighter or thinner which was originally 146,094 meters thick to 87,694 meters, as well as the speed of sound that is decreasing

with the difference in sound speed value from 34,547 m/s to 27,538 m/s.

- In the Lombok Strait, there are two different seawater masses from the surface to a depth of about 200 meters. The mass of NPIW seawater originating from the Okhotsk Sea and the Gulf of Alaska was detected at an average depth of 42,504 meters and the mass of NPSW seawater coming from the shallow subtropical in the North Pacific was detected at an average depth of 206,327 meters.

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