International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.
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Vol. 36 No. 2 January 2023, pp. 487-498

Temporary Shadow Zone Analysis Using Parabolic Equation Method In The Lifamatola Strait, North Maluku

Lily Harjanto Lily Harjanto ST, Laksma TNI Dr. Ir. Trismadi, M.Si, Letkol Laut (KH) Dr. Gentio Harsono, ST, M.Si

Republic of Indonesia Defense University, Faculty of Defense Technology, Jakarta Indonesia

*Corresponding author E-mail: lilyharjanto6@gmail.com

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Abstract – Indonesia has wide waters two thirds from mainland Thing this Becomes base for Indonesia to could utilise profusely potency existing sea _ good from riches bioavailability and mineral content _ in it , besides have riches Indonesia also has nature potency which need supervision specifically room still underwater _ not yet capable We master and control , p this raises vulnerability for Indonesian territorial security . Enhancement ability in utilise technology is something inevitability in maintain very area _ broad , broad determination of the Shadow zone in an area that is temporary will Becomes addition in do area security . Shadow Zone temporary analysis with method Parabolic Equation in the North Maluku Lifamatola Slat concluded that Profile the speed of sound in the waters of Lifamatola, North Maluku at high tide and low tide , indicates The attenuation coefficient will affect the TL value which is based on the simulation results of the TL value if the distance is farther (deep water), then the TL value will be even greater. The *Shadow Zone area* at a depth of 985 meters is wider than at a depth of 775.6 due to the longer sound wave distance , the distribution pattern of soundproof columns (*Shadow Zone*) during high tide and low tide conditions . There are many *shadow zone* patterns at Station 2 found compared at Station 1 . on location transducer 25 meters, visible medium that is not caught radiance more narrow compared with location transducer 110 meters so the *Shadow Zone area* with position transducer 110 meters more broad .

Keywords – Speed sound , Transducer , Shadow Zone, Parabolic Equation.

I. Introduction

Indonesian waters are the junction of two large seas and are also one of the most important distribution channels in the world. Indonesia's geographical position is an advantage compared to other countries, both in terms of geoeconomics, geopolitics, and geostrategy. Indonesia has three ALKI (Indonesian Archipelagic Sea Lanes) which regulate the right of passage for foreign ships and aircraft through Indonesian waters (Buntoro, 2012), and has 4 choke points out of 9 world choke points in Indonesian waters, namely the Malacca Strait, Sunda Strait, Lombok Strait and Makassar Strait (Marsetio, 2014).

According to King (1963), the mass of water as a body of water that is relatively homogeneous and can be described by its characteristics. The speed of sound in seawater is an oceanographic variable that determines the pattern of sound transmission in the medium (Kadarwati , 1999). The physical factors of seawater that most determine the speed of sound in seawater are temperature, salinity and pressure (Urick , 1983).

It is very ironic if Indonesia is a country whose ¾ is sea, the mapping of shadow zone profiles is still very rare. Even though the heart of the Republic of Indonesia's defense is in the sea. Water areas where the shadow zone is often sought by submarines to approach surface ship target contacts without being detected.

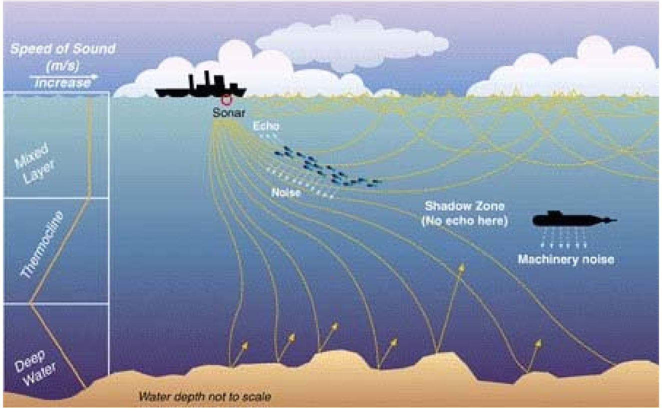


Figure 1. 1. The Shadow Zone Region Formed from Temperature Stratification on Ship Sonar on the Water (Source: University of Rhode Island, 2021)

One of the methods in determining the area of the shadow zone is the calculation using the parabolic equation which is a method used to overcome the problem of distance dependence in marine acoustics. This method was introduced by Hardi and Tappert in the 1970s. Since then this method has been able to solve sound propagation problems in the field of marine acoustics (Jensen et al, 1994).

This is interesting because in areas with high oceanographic dynamics, the possibility of detecting underwater objects such as submarines will be more difficult to do compared to other calmer waters. The area that is the focus of the research is Lifamatola Waters at 2 stations with coordinate positions 2°52'22.3" South Latitude -126°65'51.7" East Longitude and 2°54'21.6" South Latitude 126°68'17.7" East Longitude.

II. RESEARCH METHODS AND DESIGN

Research methods

The method used in this study is a quantitative method using a descriptive approach.

1) Quantitative Method

It is a type of research whose specificity is systematic, planned and clearly structured from the start to the creation of the research design (Sugiyono, 2016).

2) Descriptive Research Approach

Descriptive method is a method used to find elements, functions, properties, or phenomena. The method begins with data collection, analysis and interpretation. How to write Implementation is done through research methodology, case studies (differentiated by case), comparative studies, behavioral analysis research and time and motion analysis (Suryana, 2010).

Research design

Research design is exploratory descriptive, according to Sugiyono (2016) exploratory descriptive research is Explorative descriptive research aims to describe the state of a phenomenon, in this study it is not intended to test certain hypotheses but by describing what a variable, symptom, or situation is.

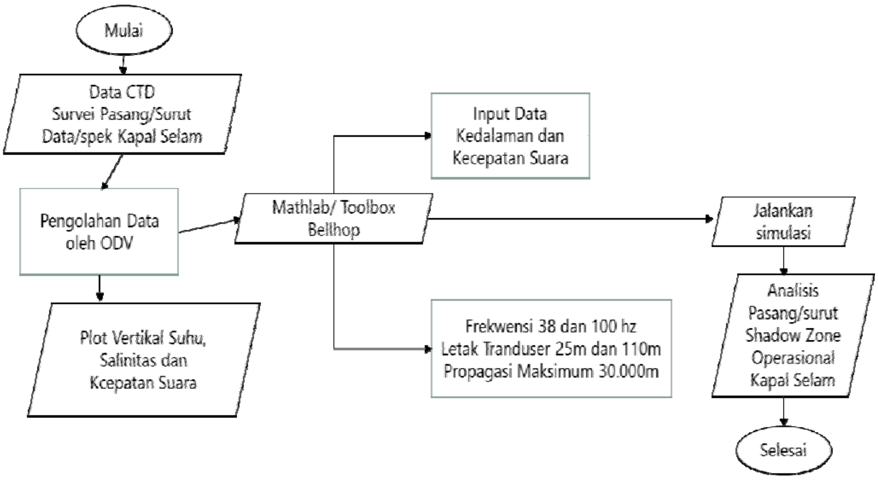
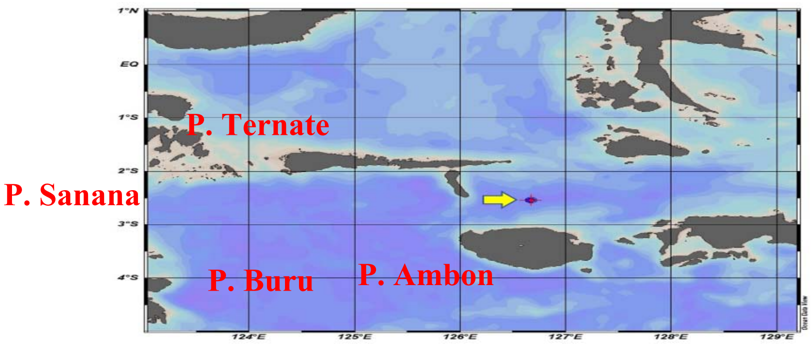


Figure **Error! No text of specified style in document.**. 1Research Design

III. Place And Time Of Research

Research Place

In this study, the locations that will become research areas are the northern and southern waters of Lifamatola Waterfront at 2 stations with coordinate positions 2°52'22.3" South Latitude -126°65'51.7" East Longitude and 2°54'21.6" South Latitude 126°68 '17.7" East.



Pictures of Research Stations in the Lifamatola Strait Waters

Research time

This research was conducted for approximately seven months, starting from August 2022 to January 2023. The research activities carried out can be divided into several stages, starting from the thesis planning stage, making proposals, collecting data, processing data, conducting simulation.

Data collection technique

The data collection table used in this study is shown in the table below.

Table **Error! No text of specified style in document.**. 1. Research data

No.	Data	Source
1	Survey Oceanography / Tides	Pushidrosal / Open source
2	*CTD Yo - yo _*	JAMSTEC TOCS Survey 2009
3	Temperature , Salinity , Depth	JAMSTEC TOCS Survey 2009

4	Transducer Parameters	JAMSTEC TOCS Survey 2009
5	Speed data entry Voice	JAMSTEC TOCS Survey 2009

Research Instruments

Tool

The tools to be used in this study consist of software and hardware with the following description:

- Personal Computer with specifications
- ODV software
- Microsoft Office software
- Mathlab Software (Belhhop Toolbox)
- Paint 3D

Ingredients

The data used as research material are:

- Survey Location Map Oceanography
- Tidal data waters Lifamatola
- Coordinate station position transducer
- location Depth transducer
- Defined parameters

Data Processing Techniques

Data on temperature , salinity , depth and tides for 31 days were taken from survey data field and saved in a file with the extension.cnv . the data then processed and converted be speed voice with ODV software so could used for simulation sound wave propagation . At the time before conducted conversion , data is done screening to eliminate error values and averaging for 31 days. The results of the data after correction and conversion are then made vertical profiles of temperature, salinity and speed of sound based on their depth using software *ODV* . To show the sound speed gradient that supports the *shadow zone simulation results, the Matlab* software is used with the *bellhop toolbox* .

Table . Parameter Limits

No	Parameter	Information
1	Frequency used _	38 and 100 Hz
2	Depth transducer	25 and 110 meters
3	Depth location waters	775.6 and 985 meters
4	Speed Voice	gradient negative
5	Propagation Maximum	30,000 meters

Data analysis technique

Data analysis is a collection of learning activities Classifying, organizing, interpreting and validating data for Phenomena has social, academic and scientific value and must be an ongoing research process with analysis Inform the data first, then collect it .

Speed Analysis Voice

The speed of sound data is obtained through the conversion of temperature and salinity values and depth using the Mackenzie equation (1981):

$C = 1448.96 + 5.304 \times 10{-}2\ T\ 2 + 2.374 \times 10{-}4\ T\ 3 + 1.34(\ S - 35) +$

$1.630 \times 10{-}2\ Z + 1.675 \times 10{-}7\ Z\ 2 - 1.025 \times 10{-}2\ T\ (\ S - 35) -$

$7.139 \times 10{-}13\ TZ\ 3$……………………………………………(1)

where:

c : speed of sound (m/s)

T : temperature (degrees Celsius)

S : salinity (psu)

z : depth (m).

Use the Mackenzie equation is because using basic parameters as temperature , salinity and depth , while the difference with the equations of Leroy (1969) and Medwin (1975) are on the yield speed voice only the difference in error .

Analysis of Sound Wave Propagation Patterns

Sound wave propagation can experience attenuation caused by the absorption of acoustic energy by the environmental medium in the propagation area. This attenuation involves the process of converting acoustic energy into heat energy, resulting in a decrease in the intensity (attenuation) of the propagating sound wave energy (Pongoet 2008). In general, the equation for finding the attenuation coefficient according to Jensen *et al* . (1994) are :

$$\alpha - 0{,}033 + \frac{0{,}11 f^2}{1 + f^2} + \frac{44 f^2}{4100 + f^2} + 0{,}0003 f^2 \text{ ....(2)}$$

where :

α= coefficient attenuation (dB/km)

f = frequency (Hz)

Attenuation caused due to reflection or deflection happen when propagating sound waves pass two mediums with sufficient difference in refractive index big (Pongoet 2008).

Parabolic Equation Method

kindly mathematical , propagation models voice on theory equality parabolic could outlined in a manner short as following .

First , the equation wave voice transformed from *domain* time Becomes *domain* frequency . From Transformation this generated Bellhop equation as following (Jensen *et al.* 1994):

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial p}{\partial r}\right) + \rho(z)\frac{\partial}{\partial z}\left(\frac{1}{\rho(z)}\frac{\partial p}{\partial z}\right) + K_0^2 n^2 p = 0 \text{ ………………… … .. (3)}$$

where , acoustic pressure that is $p(r,z)$, seawater density that is $\rho(z)$, the reference wavenumber that is k_0 , index refraction that is$(k_0 = \omega / c_0)$,$n(r,z)$, corner frequency ie $(n = c_0 / c)$, ω, the speed of sound in water that is c and source to receiver distance that is r .

Shape settlement equality is function *Hankel* , as following :

$$p(r,z) = \psi(r,z) H_0^{(1)}(k_0 r) \quad \text{........... ....} (4)$$

This solution is substituted into the Helmholtz equation , so the resulting equation is as following :

$$\frac{\partial^2 \psi}{\partial r^2} + 2ik_0 \frac{\partial \psi}{\partial r} + \frac{\partial^2 \psi}{\partial z^2} + k_0^2 (n^2 - 1)\psi \quad \text{................ . ...} (5)$$

When defined an operator:

$$P = \frac{\partial}{\partial r} \qquad \text{dan} \qquad Q = \sqrt{n^2 + \frac{1}{k_0^2} \frac{\partial^2}{\partial z^2}} \quad \text{...... ....}(6)$$

more equations concise as following :

$$[P^2 + 2ik_0 P + k_0^2 (Q^2 - 1)]\psi = 0 \quad \text{........... ... .} (7)$$

Equations of the form parabolic this shared Becomes two part , that is for away waves _ source *(outgoing wave)* and approaching source *(incoming waves)* .

$$(P + ik_0 - ik_0 Q)(P + ik_0 + ik_0 Q)\psi - ik_0 [P, Q]\psi = 0 \quad \text{........... .} (8)$$

If assumed energy from approaching wave _ source more small compared with away waves _ source so that only away waves _ source just dominant _ so will obtained shape equality following :

$$P\psi = ik_0 (Q \; 1)\psi \quad \text{...... ....}(9)$$

Or

$$\frac{\partial \psi}{\partial r} = ik_0 \left(\sqrt{n^2 + \frac{1}{k_0^2} \frac{\partial^2}{\partial z^2}} - 1 \right) \psi \quad \text{... . ...}(10)$$

after that , defined :

$$\varepsilon = n^2 - 1, \qquad \mu = \frac{1}{k_0^2} \frac{\partial^2}{\partial z^2} \qquad \text{dan} \qquad q = \varepsilon \mu \quad \text{.......................} (11)$$

Then the operator Qcan be expressed as $= \sqrt{1 + q}$it is written the equation as following :

$$\frac{\partial \psi}{\partial r} \; ik_0 (\sqrt{1 - q} \; 1)\psi \quad \text{... ... .}(12)$$

Then continued to equality hereinafter referred to equality parabolic (PP). In the equation , expansion ethnic group could conducted among others with utilise row pade .

$$\sqrt{1 + q} = 1 + \sum_{j=1}^{m} \frac{a_{j,m} q}{1 + b_{j,m} q} \; O(q^{2m+1}) \quad \text{... ....}(13)$$

Where m is the number of terms used in the expansion

$$a_{j,m} = \frac{2}{2m+1} \sin^2 \left(\frac{j\pi}{2m+1} \right),$$

$$b_{j,m} = \cos^2 \left(\frac{j\pi}{2m+1} \right) \quad \text{...... ... .}(14)$$

Expansion results with row Pade this used in complete equation (13) separately numeric .

IV. Research Results And Discussion

Data Decryption

Study this has held in month November 2022 at Pushidrosal TNI AL and the Defense University Campus road Salemba Jakarta highway . Ingredients research used _ is in the form of data -based processing software programs, that is Matlab R2018a and ODV, meanwhile tools used _ Personal Computer (PC) or Laptop .

Results of Data Collection

Simulation *Shadow Zone* at Station 1

Simulation propagation wave sound at Station 1 depth 775.6 meters conducted with limitation frequency 38 Hz and 100 Hz and location depth transducers 25 meters and 110 meters. this limitation intended so that could is known pattern propagation wave sound in shallow waters _ where point coordinates are taken on the part south Waters Lifamatola with depth about 775.6 m.

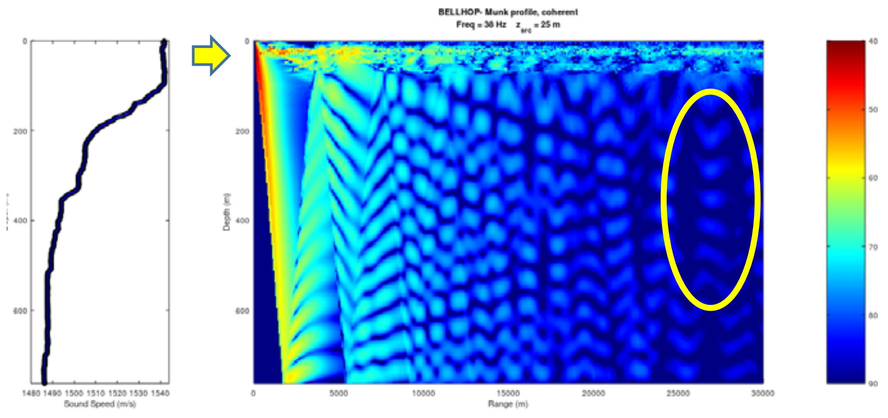


Figure 4 . 7 Simulation Results Propagation Sound Waves at Station 1, Frequency 38 Hz and Depth Transducer 25 meters (Circle yellow is area *Shadow Zone*) in the Waters Lifamatola .

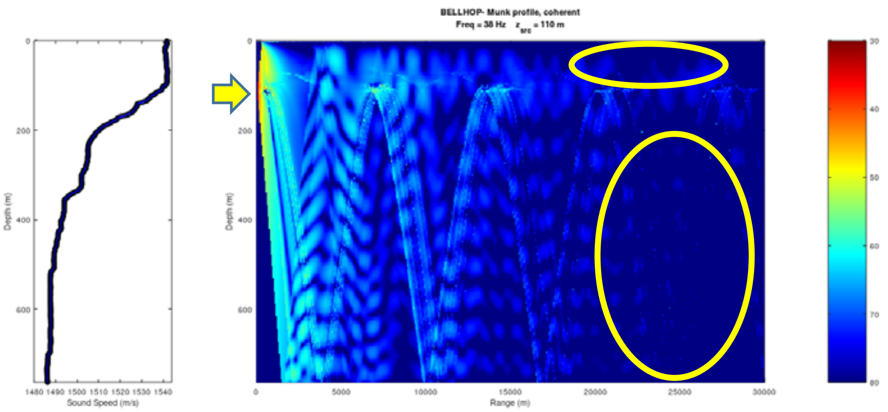


Figure 4 . 8 Simulation Results Propagation Sound Waves at Station 1, Frequency 38 Hz and Depth Transducer 110 meters (Circle yellow is area *Shadow Zone*) in the Waters Lifamatola .

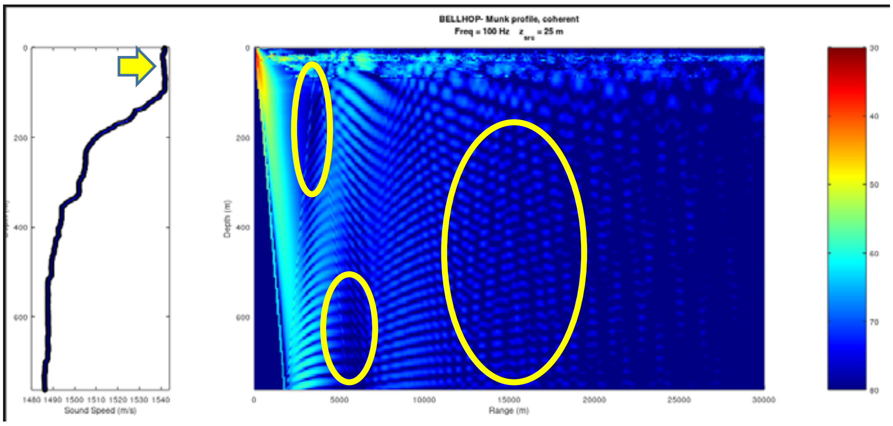


Figure 4 . 9 Simulation Results Propagation Sound Waves at Station1, Frequency 100 Hz and Depth Transducer 25 meters (Circle yellow is area *Shadow Zone*) in the Waters Lifamatola .

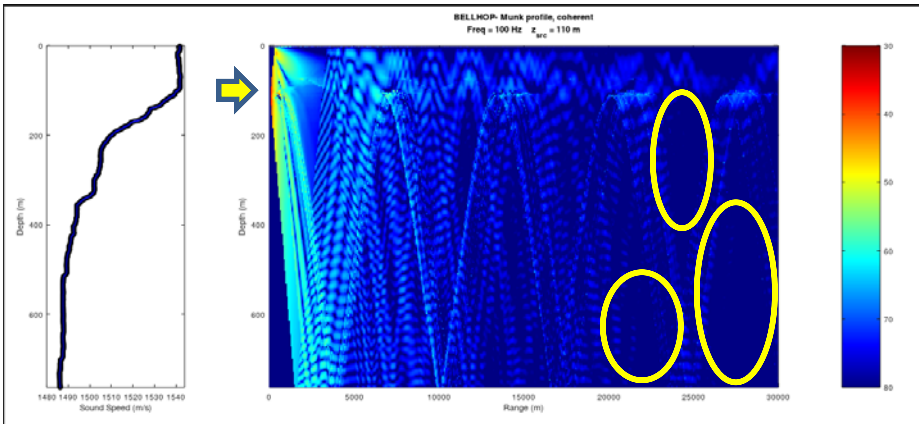


Figure 4 . 10 Simulation Results Propagation Sound Waves at Station1, Frequency 100 Hz and Depth Transducer 110 meters (Circle yellow is area *Shadow Zone*) in the Waters Lifamatola .

On results simulation (Figs. 4.7 – 4.10), is shown that along with increase distance vines wave sound , then will the more experience lost transmission or also called _ *Transmission Loss* (TL) so that value the more increase along with increase distance propagation . On simulation pattern propagation wave voice with frequency 38 Hz and distance transducer 25 meters (Fig. 4.7), pattern propagation his voice seen enough fluctuating . at the moment wave voice emitted , pattern its propagation experience decline until base waters then reflected return to surface only reach distance 25,000 meters although voice capable propagated up to 30,000 meters. On propagation wave his voice , experiencing score lost transmission that is not too big . At a distance of 1500m propagation wave sound , weakened , p this seen from increasing TL values close to 70-73 dB. Wave starting sound _ weakened . *Shadow Zone* voice where radiance wave sound already _ reach limit will turned return to the Middle good when propagation voice up or down . Wave penetrating sound _ lower layer , will turned toward lower so that causing deviation above and below layers (Defrianti and Primary 2019). *Shadow Zone* area in the simulation this have more area small compared with simulation with different parameters other . *Shadow Zone* formed at a distance of 25,000 - 30,000 meters in depth close with surface , a distance of 20,000 - 22,500 meters at a depth of 90 - 600 meters, with score close to 80 dB.

Frequency simulation results 38 Hz with distance transducer 110 meters (Figure 4.8) also shows fluctuating propagation patterns as well . P no moment wave voice emitted , the installation of the transducer at a position of 110 meters causes a pattern its propagation experience decline until base water n then able reflected return to surface , although sound is capable of traveling up to 2 0,000 meters , The sound wave propagation in this simulation experienced a significant sound loss compared to the previous simulation (Figure 4.7). Propagation wave voice start weakening where the TL is getting approach 60 - 7 0 dB at a distance of 100 00 meters . The *Shadow Zone area* (yellow circle) looks wider than the previous simulation (Figure 4.7). This is because the position of the transducer at a distance of 110 meters causes sound waves to propagate towards the bottom of the waters and then towards the surface so that they experience a lot of lack of acoustic energy. According to Urick (1983), the farther the sound wave propagates, the higher the attenuation value, so the transmission loss value is greater . In this simulation, the *Shadow Zone* (circle yellow) formed at a distance 20,000 – 30,000 meters at a depth of 200 – 800 meters close to the surface, a distance of 17,000 meters at a depth of 0 – 55 meters, each of which has TL values close to 80 dB.

Next, the simulation is carried out with frequency 100 Hz and distance transducer 25 meters (Figure 4.9). Sound propagation patterns also fluctuate where experience decline until base waters then reflected return to surface only it reaches a distance of 20 000 meters although sound is capable of propagating up to 24 000 meters. This is very different from before with the same transducer position. In addition, Propagation wave his voice experience lost transmission which is quite large of in the previous simulation (Figures 4.7 and 4.8), especially at a depth of 3 5 – 30 0 meters and 500 - 800 meters at a distance of 3,000 – 8,000 meters . This is a result of differences in the value of the frequency used. According to Urick (1983), the greater the frequency used, the higher the attenuation value so that it affects wave propagation in the water column. Increasing TL values _ approach 60 - 70 dB at 21000 indicates a weakening of sound propagation . The existence of the *Shadow Zone* (circle yellow) seen at a distance of 21,000 – 30,000 at a depth close to the surface, a distance of 3,000 – 4,000 at a depth of 35 – 300 meters, a distance of 4,000 – 8,000 meters at a depth of 500 – 800 meters, where is the value TL are close to 60-70 dB each.

Simulation last at Station 1 's that is with use frequency 100 Hz and installation transducer at a distance of 110 meters, (Figure 4.10). With installation transducer at a distance of 110 meters, pattern its propagation experience decline until base waters then reflected return to surface , though voice capable propagate until 25,500 meters so that seen fluctuating . Lost transmission in the simulation this is more big compared simulation previously with different frequencies (Figure 4.10) . Quite a difference significant this caused by value frequency used _ i.e. 100 Hz. The distance of 10,000 meters shows weakening propagation voice with increasing TL values close to 60 - 80 dB. Formation area *Shadow Zone* visible at a distance of 23,500 – 26,500 in depth close with surface , a distance of 20,500 – 24,000 at a depth of 500-800 m, a distance of 25,000 – 30,000 meters at a depth of 300 – 800 meters, where the TL values are close to 80 dB each.

***Shadow Zone* Simulation at Station 2**

Simulation next conducted at Station 2 section north Waters Lifamatola with depth reaches 985 meters with a frequency limit of 38 Hz and 100 Hz and location depth transducers 25 meters and 110 meters. This limit is also carried out with purpose know pattern propagation wave voice waters Lifamatola with depth of 985 meters.

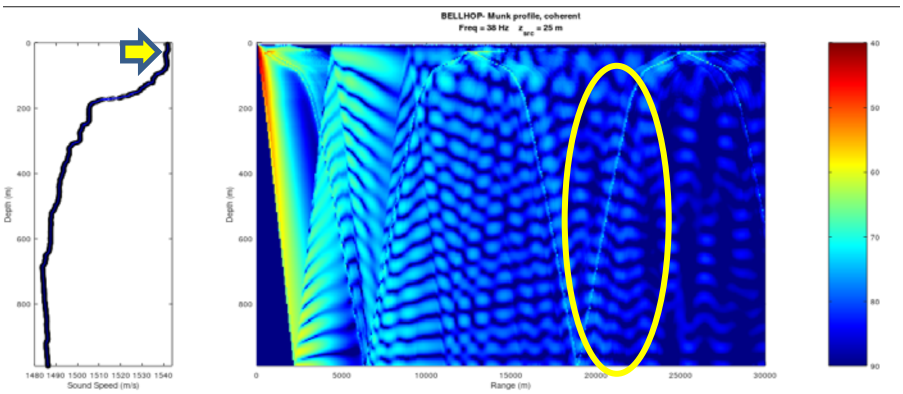


Figure 4 . 11 Simulation Results Propagation Sound Waves at Station2, Frequency 38 Hz and Depth Transducer 25 meters (Circle Yellow is area *Shadow Zone*) in the Waters Lifamatola .

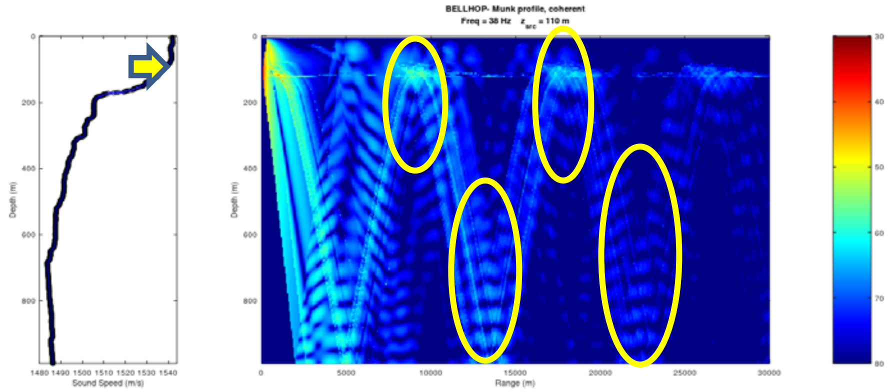


Figure 4 . 12 Simulation Results Propagation Sound Waves at Station2, Frequency 38 Hz and Depth Transducer 110 meters (Circle Yellow is area *Shadow Zone*) in the Waters Lifamatola .

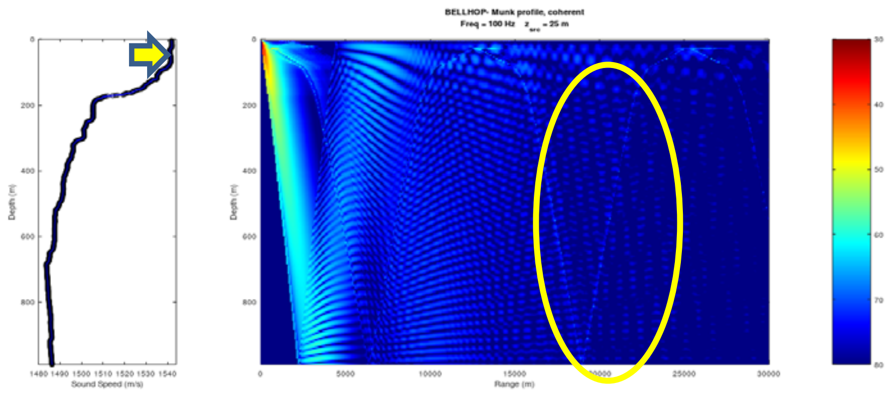


Figure 4 . 13 Simulation Results Propagation Sound Waves at Station2, Frequency 100 Hz and Depth Transducer 25 meters (Circle Yellow is area *Shadow Zone*) in the Waters Lifamatola .

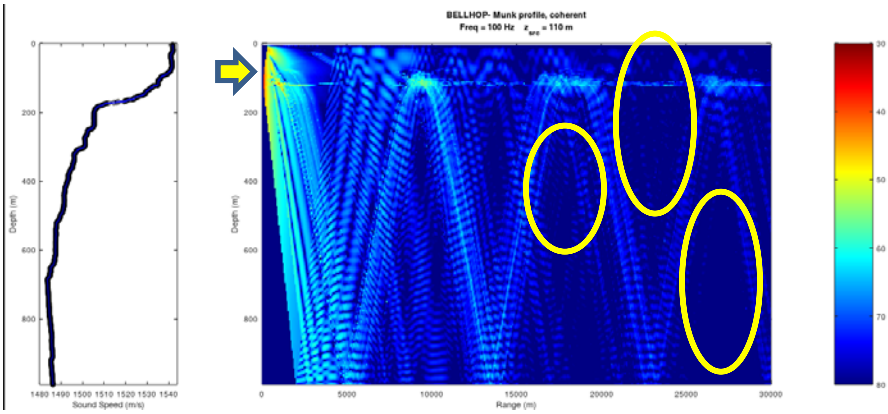


Figure 4 . 14 Simulation Results Propagation Sound Waves at Station2, Frequency 100 Hz and Depth Transducer 110 meters (Circle Yellow is area *Shadow Zone*) in the Waters Lifamatola .

Seen in the simulation results obtained (Fig. 4.11 – 4.14), simulation of frequency and depth parameter limits given transducer , concurrently with increase distance vines wave sound , then will the more experience lost transmission *(Transmission Loss)* . In the results obtained, the *Shadow Zone pattern* is more complex than the simulation in the northern part of the waters Lifamatola

On simulation pattern propagation wave voice with frequency 38 Hz and distance transducer 25 meters (Fig. 4.11), shows pattern fluctuating emission . _ it _ can seen from decline until base waters then reflected return to surface until distance of 30,000 meters. Propagation pattern perfect from base waters until surface this more far if compared with simulation with the same parameter limits at Station 1 (Figure 4.7 - 4.10). Reason difference the lies in the frequency used , where frequency low this more effective if used in more water areas in (Jansen et al. 1994). Besides it's on deceleration wave voice he also experienced score lost propagation more transmission _ bigger and more shdow zone area wide if compared with pattern propagation wave sound on frequency and depth same transducer _ station 1 with frequency and position the same transducer Figure 4.7. weakening propagation occurs in a distance of 2000 meters where the range of TL values is getting closer to the 65-70 dB area reed propagation wave pretty good sound looks until could pass distance up to 30,000 meters. The area showing the *Shadow Zone area* (circle yellow) formed at a distance 2 5,000 – 28,500 meters at a depth of 120 – 838 .3 meters, with respective TL values close to 80 dB.

At a frequency of 38 Hz and distance transducer 110 meters (Fig. 4.12), pattern propagation is also visible fluctuating . Position installation transducer 110 meters causing pattern voice experience decline until base waters , then reflected return to surface only reach distance of 2000 meters, though voice capable propagate up to 30,000 meters. Besides Therefore , different results were also obtained where propagation wave his voice experience score lost more transmission _ big and more complex if compared with pattern propagation wave sound at Station 1 (Figure 4.8) with the same parameter constraints . the descent energy acoustic consequence scattering voice caused by conditions waters in parts north Waters Lifamatola this own depth more in with environmental parameters more varied, so causing decline energy acoustics (Syirajjudin 2016). Variation layer depth causing change in speed voice (can increase can reduced). Change speed voice this causing current bias sound propagation move between different areas speed sound , bending or biased towards the area with speed more sound _ low . If gradient speed voice between regions _ big , getting big amount too refraction (Defianto and Primary 2019). at a distance 700 meters propagation wave voice start weakened . H al this seen from increasing TL values approach 60 - 70 dB. Area *Shadow Zone* (circle yellow) in this simulation is formed at a distance of 1 2 100 – 1 6 200 meters at a depth close to the surface, a distance of 164 00 - 200 00 meters at a depth of 4 00 – 9 63.3 meters, distance 2 2 . 5 00 – 24 500 meters in depth 00 – 4 63.3 meters, distance 22,000 – 25,000 at a depth of 3 00 – 975 ,3 meters where each has TL values close to 80 dB.

Subsequent simulations were carried out with different frequencies viz 100 Hz and distance transducer 25 meters (Figure 4.13). The results obtained where the pattern of sound propagation fluctuates . When you transmit sound waves , you can see a pattern sound barrier experience decline until base waters then bounce to surface until it reaches distance of 30,000 meters . wave _ voice already experiencing attenuation of propagation at a distance of 2 500 meters , where the value of Transmission Loss (TL) is increasing approach 60 - 7.0 dB . The *Shadow Zone* area found in this simulation (Figure 4.13) is smaller but more diverse than the simulation conducted at Station 1 (Figure 4.9) with the same parameter constraints. This is because the frequency value used (100 Hz) is not suitable for deep waters. Deep waters are more suitable for transducers with lower frequency values (Jensen *et al* . 1994). The existence of the *Shadow Zone* (circle yellow) in this simulation can be found at a distance of 23.300 – 30.0 00 at a depth close to the surface up to 950 meters, with a TL value close to 80 dB.

Simulation with frequency 100 Hz and distance transducer 110 meters (Figure 4.14) also shows a fluctuating pattern. Due to the limitation of the position of the transducer installed at a distance of 110 meters causes the propagation pattern experience decline until base waters then bounce return to surface , although sound is capable of propagating up to 30,000 meters. The *Shadow Zone area* in this simulation looks smaller but more diverse compared to the simulation in Station 1 (Figure 4.10) with the same parameter limits. At a distance of 2000 meters, propagation wave voice seems to have started weakened , where increasing TL values approach 60 - 7.0 dB . The area that forms the *Shadow Zone* (circle yellow) can be seen at a distance of 15 000 at a depth of 220 - 600 .3 meters, a distance of 20 000 at a depth of near surface until depth of 400 meters, a distance of 2 4,000 at a depth of 4 00 - 95 0 meters, where the TL values are close to 80 dB each.

V. Conclusions And Recommendations

Conclusion

A. Profile the speed of sound in the waters of Lifamatola, North Maluku at high tide and low tide , indicates The attenuation coefficient will affect the TL value which is based on the simulation results of the TL value if the distance is farther (deep water), then the TL value will be even greater. The *Shadow Zone area* at a depth of 985 meters is wider than at a depth of 775.6 because the sound wave distance is farther away , so it will affect the increase in attenuation value which results in a greater decrease in acoustic energy

B. Distribution pattern of soundproof columns (*Shadow Zone*) during high tide and low tide conditions . There are many *shadow zone* patterns at Station 2 found compared at Station 1 . on location transducer 25 meters, visible medium that is not caught radiance more narrow compared with location transducer 110 meters so the *Shadow Zone area* with position transducer 110 meters more broad . The *Shadow zone area* at Station 1 is effective detected if use frequency of 100 Hz while at Station 2 effective detected at a frequency of 38 Hz, with position each transducer used are 25 and 110 meters.

Suggestion

It is necessary to add other parameters that can support the simulation results such as the addition of bathymetry data, wind, currents, and oceanographic phenomena such as *internal waves* so that they can approximate actual water conditions

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