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Spectrum Analysis of Sound Wave Recordings with Dolphinear type DE200 Based on Distance and Frequency Variations in Mahakam River Using Audacity Software

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Abstract
Dolphinear is an instrument for monitoring sound wave signals underwater. This study aims to see how the results of sound recording by Dolphinear type DE200 based on variations in distance and frequency of the sound source using the Audacity Software. In this study, the sound source will be generated through a waterproof speaker with a frequency variation of 100 Hz to 20 kHz. The distance between the sound source and the dolphinear is also varied from 1 to 5 meters. Audacity software is used to generate, record, and obtain the spectrum of the recorded audio sound signal. Based on the spectrum of the sound recorded by the DE200 dolphinear, frequency peaks close to the source frequency can be detected in recording using a 500 Hz sound source, but the main frequency peaks in the spectrum are difficult to detect in recording using sound sources above 500 Hz. In this study, it was also found that there is a limit to the recording ability of the dolphinear DE200 for frequencies above 18 kHz which is indicated by a decrease in intensity at that frequency.
Keywords: Dolphinear DE200, Spectrum, Frequency, Underwater, Sound Wave

1. Introduction

Dolphinear is an instrument that serves to record and monitor the sound movements of dolphins, whales, submarines, and the sound of people on board for a long period to a depth of 100 meters underwater, where sound pressure is recorded in a hydrophone [1]. Dolphinear with type DE200 does not use a condenser microphone, but uses a mic with an omnidirectional sound capture pattern. Figure 1 shows the DE200 dolphinear instrument. Based on its specifications, this tool can capture sound in the frequency range of 200 Hz-20 kHz [2]. The sound capture from the dolphinear can be connected to software (PC) to record audio and sound wave spectra under the water surface in real-time [3]. Dolphinear DE200 has been used in several studies including the detection of noise pollution under the water surface [4] [5], the study of animal habits in aquatic habitats [6], and Autonomous Underwater Vehicles (AUV) detection and monitoring systems underwater [7][8][9].

Detection technology under the water surface using soundwave is called hydroacoustic, which has several advantages including in terms of obtaining detection information directly without disturbing the object under study at a certain frequency because the detection is carried out remotely using soundwave. This is an effective solution for objects that located below the water surface [10]. Hydroacoustics is commonly used in the detection of fish or marine mammals [11][12]. In hydroacoustics, the ability of the instrument to detect and distinguish a unique frequency is very important. This study will characterize the response of the DE200 dolphinear instrument based on its ability to detect certain frequencies with varying distances. In addition, this research will also test the comparison of the recording results obtained on in the air and underwater. The software used as a tool for acquisition and analysis of recorded data in this study is Audacity® as has been done by several previous studies [13][14]. Audacity® is used because it provides many features such as real-time recording, audio signal generation, and various kinds of spectral analysis [15][16][17].

Figure 1. Dolphinear DE200

This research was conducted at the confluence of the Mahakam River with Semayang Lake, Pela Village, Kutai Kartanegara Regency, Kalimantan Timur Province. This location was chosen because the water area is one of the Mahakam River Dolphin (Pesut Mahakam) habitats [18][19], where this research is expected to be the initial information about the ability of the DE200 dolphinear instrument for monitoring and detection applications of Mahakan River Dolphin (Pesut Mahakam).

2. Method

This research was conducted from June to September 2023. The research location was carried out in the Mahakam River, Pela Village, Kota Bangun District, Kutai Kartanegara Regency. The tools used were 2 laptops connected to Audacity software, dolphinear DE200, waterproof speakers (sound source), and connectors. On the first laptop, Audacity software is used as a sound generator connected to the speaker, while the other laptop acts as a sound recorder connected to the dolphinear DE200. Data acquisition was carried out with a distance variation of 1 to 5 meters, with a variation of the source frequency of 200 Hz-20 kHz at each distance. The data acquisition scheme is shown in Figure 2. In addition, the dolphinear DE200 response was also tested in the air with the same set of frequency and distance variations as in the data acquisition underwater.

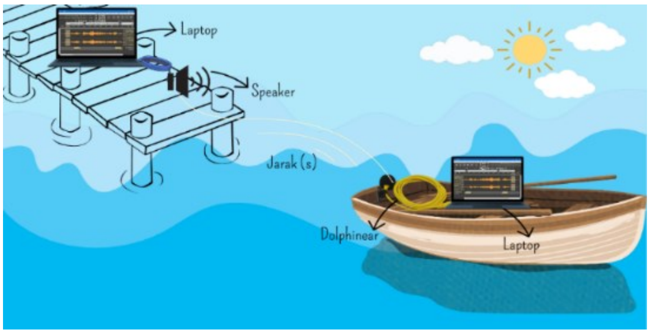


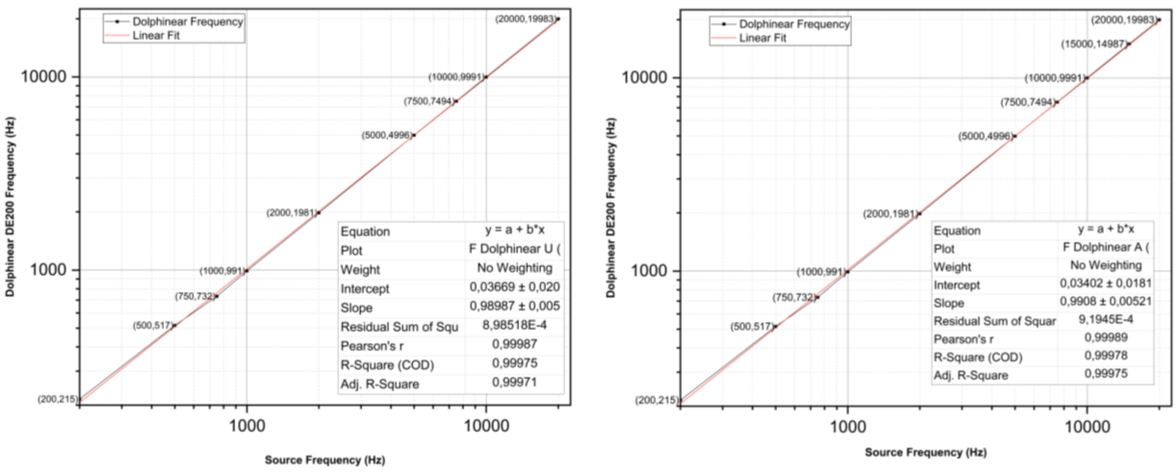
Figure 2. Data Acquisition Scheme

The recordings obtained are sound signals as a function of time. The signal is then transformed using the Fast Fourier Transform (FFT) feature available in Audacity to obtain the signal spectrum (sound signal in function of frequency) [20][21]. This signal spectrum is used to analyze the dolphinear response for each distance and frequency variation.

4. Result and Discussion

4.1. Relationship Between Source Frequency and Frequency Received by Dolphinear for Sound Waves in Air and Sound Waves Underwater

Figure 3 shows the graph of the relationship between the frequency of the sound source and the frequency received by the dolphinear DE200 for measurements in the air (a) and measurements under the water surface (b).



(a) (b)

Figure 3. Graph of the Relationship Between Source Frequency and Frequency Received by Dolphinear on Sound Waves in (a) Air and (b) Underwater

Based on Figure 3, it appears that in air and underwater measurements, there is a good linear relationship between the frequency of the sound source and the frequency detected by the dolphinear. This is indicated by the R-Square values of 0.99975 (in the air) and 0.99978 (underwater), indicating minimal deviation in values.

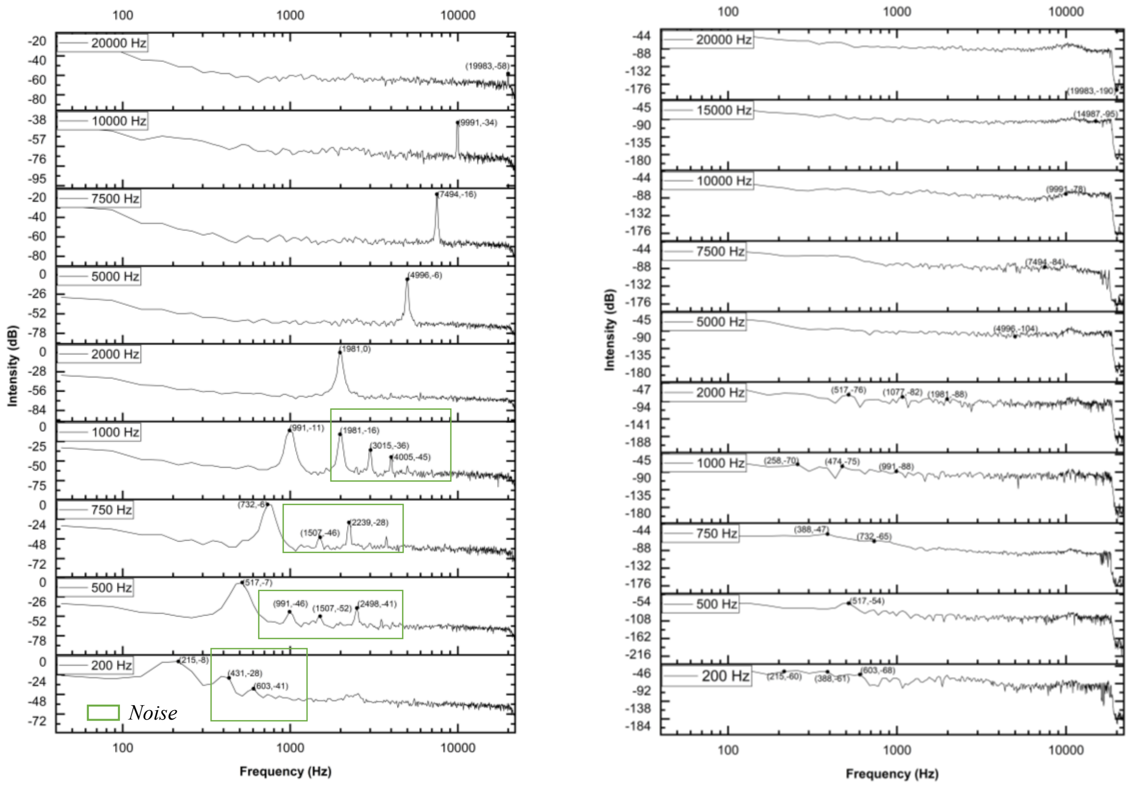
4.2. Measurement Results with Variations in Frequency for a Distance of 1 meter for Sound Waves in Air and Sound Waves Underwater

Figure 4 shows the response spectrum of the dolphinear DE200 in air and water measurements at a distance of 1 m with a frequency variation of 200 Hz - 20 kHz. In Figure 4 (a) it can be seen that in the frequency range of 20 Hz - 20 kHz the main frequency peaks can still be seen clearly, although there are peaks at other frequencies (marked by orange boxes in the figure) at low frequencies in the 200 Hz - 750 Hz range, which are allegedly noise that is also detected in the Audacity software. Meanwhile, Figure 4 (b) shows that the main frequency spikes are not too high and tend to be difficult to distinguish from noise that appears at other frequencies. This happens consistently in the frequency range of 200 Hz - 20 kHz. Although in Figure 2 (b) it is possible to obtain a peak value at a frequency close to the frequency of the sound, this will be difficult to do if the frequency of the detected sound source is unknown.

Figures 4 (a) and (b) show a decrease in the intensity recorded at frequencies above 18 kHz. This occurs in both air and underwater measurements. This may indicate the limitation of the dolphinear DE200 which is only effective at recording up to a frequency of 18 kHz. However, it is also possible that this is due to the lack of sound or noise sources that appear with frequencies above 18 kHz. This is still uncertain because no comparison instrument in this study can detect sound at that frequency.

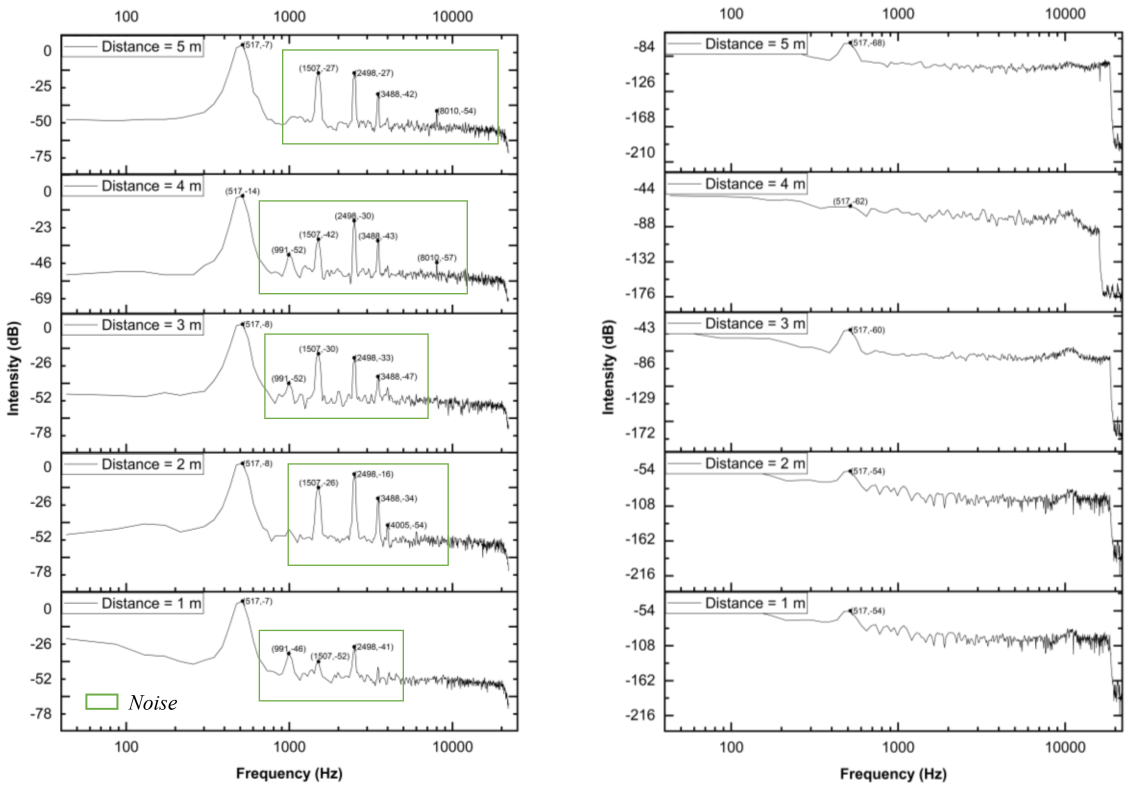
4.3. Measurement Results with Variations in Distance for 500 Hz Frequency of Sound Waves in Air and Underwater

Figure 5 shows the response spectrum of the dolphinear DE200 in the air (a) and (b) underwater measurements. Based on Figure 5 (a), it can be seen that the air measurements show peaks at the main frequency close to the frequency of the sound source (500 Hz) at all distance variations (1-5 m). Several other peaks appear at frequencies other than 500 Hz, but their intensity does not exceed the intensity of the main frequency. Meanwhile, Figure 5 (b) shows that at a frequency of 500 Hz, there are peaks for distance variations of 1 m, 2 m, 3 m, and 5 m, and the peaks are not so visible at a distance of 4 m. This indicates that the sound source at this frequency can still be detected in measurements under the water. Figure 5 also shows that there is a decrease in intensity at frequencies above 18 kHz. This indicates a limited reading of the device or a lack of sound sources at that frequency.



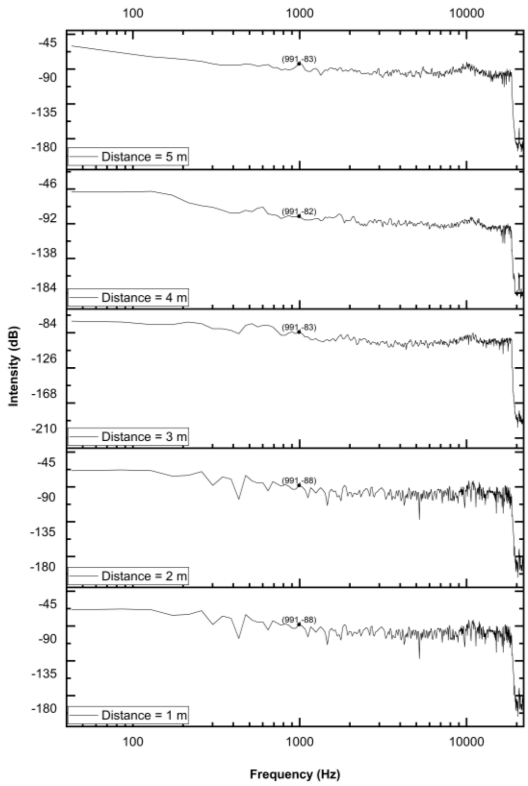
(a) (b)

Figure 4. Measurement Results with Variations in Frequency at a Distance of 1 meter (a) for Sound Waves in Air and (b) Underwater

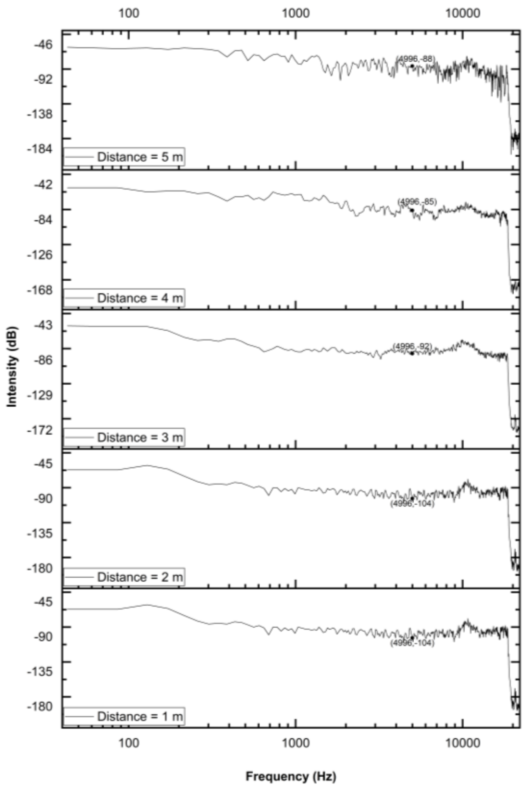


(a) (b)

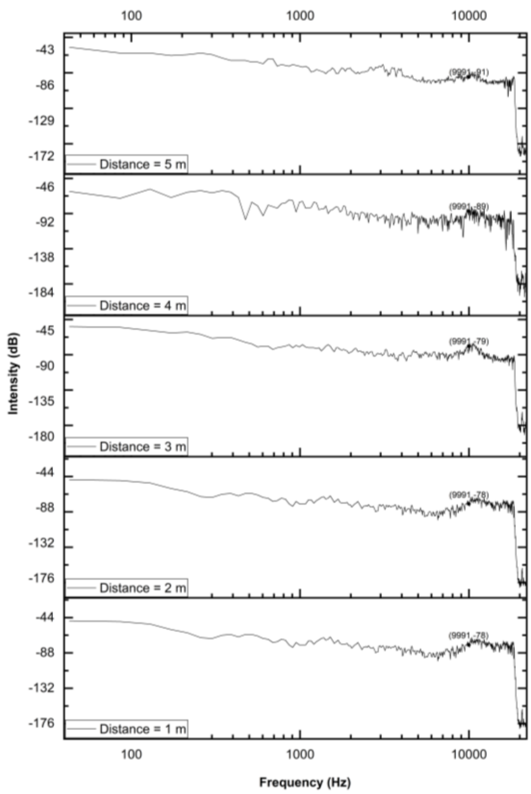
Figure 5. Measurement Results with Variations in Distance at 500 Hz Frequency (a) for Sound Waves in Air and (b) Underwater



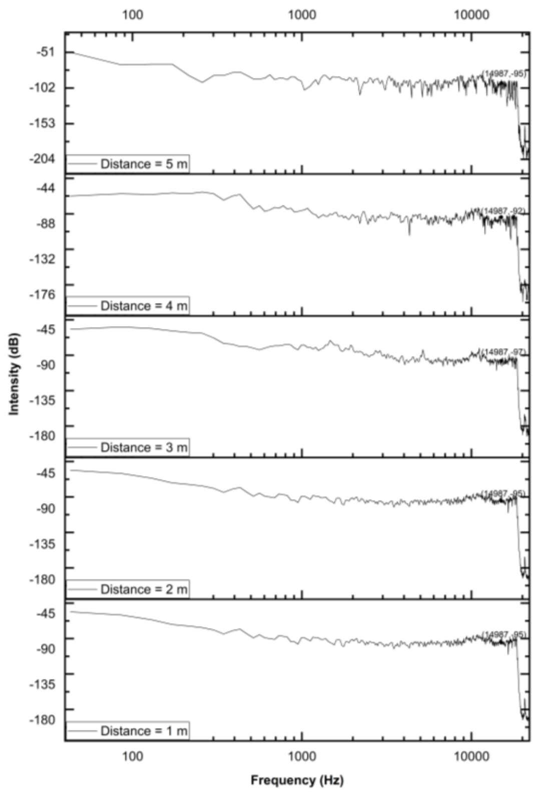
(a)



(b)



(c)



(d)

Figure 6. Measurement Results with Distance Variation for Frequency (a) 1000 Hz, (b) 5000 Hz, (c) 10 kHz, (a) 15 kHz

The results of frequency measurements above 500 Hz underwater using the dolphinear DE200 are shown in Figure 6. The spectra at 1000 Hz, 5000 Hz, 10 kHz, and 20 kHz do not show any peaks at the main frequency that are easy to detect. This is because there are many other higher peaks in the region outside the main frequency. This will make it difficult when recording is done without knowing the target frequency of the sound source.

Based on the measurement results and the previous description, it shows that a more comprehensive analysis technique is needed for the data recorded by the DE200 dolphinear. Spectrum analysis only provides a fairly good picture at a frequency of 500 Hz. If it is used for the study of biota in the mahakam river such as river dolphins (pesut), of course, it will not be effective, especially since there is still a lack of information about the frequency emitted by mahakam river dolphins.

5. Conclusion

Based on the research conducted, the frequency response spectrum of the dolphinear DE200 can show a peak at the main frequency (frequency close to the sound source) at a frequency of 500 Hz in water measurements, but at frequencies above 500 Hz (1000 Hz, 5000 Hz, 10 kHz, and 15 kHz) the spectrum does not show a peak at the main frequency that is easily detected. This indicates that spectrum analysis alone is not sufficient to analyze the recorded data from the DE200 dolphinear.

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