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Bioacoustic: Percentage Click Sound of Indo-Pacific Bottlenose Dolphins (*Tursiops Aduncus*) in Captivity, Indonesia

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Abstract

Bioacoustics is a combination between biology and acoustic study which usually refers to a study on sound production, dispersion through elastic media, and reception in animals, including humans. Bio sonar signals dolphin radiated along the beam axis of an Atlantic bottlenose dolphin resemble short transient oscillations. The purpose of this research is to measure, analyse, distinguish dolphin sound characteristics and detect the click sound by the dolphins. Indo-pacific bottlenose dolphins, maintained in captivity, Indonesia, had the lowest intensity of 18.76 dB while the highest were 32.02 dB with 100% percentage. Sound frequency range of Indo-pacific bottlenose dolphins in captivity, Indonesia was between 13.211 – 15.245 Hz. The percentage maximum intensity in the frequency is 14 kHz can be seen the percentage shown in the amount of 100% and minimum percentage of 75% in frequency 13 kHz sounds are probably produced by air movements in the nasal plugs. Sub frequency of 10 kHz has a value of 649.89×10^3, and 14 kHz with anti-log value of 782.82×10^3. Frequency of the sounds produced by a bottlenose dolphin ranges from 0.2 to 150 kHz. The lower frequency vocalizations (0.2 to 50 kHz) are likely used in social communication. Social signals have their most energy at frequencies less than 40 kHz. Higher frequency clicks (40 to 150 kHz) are primarily used for echolocation.

Keywords: Bioacoustics; Bio sonar; Indo-Pacific bottlenose dolphins; Click sound; Intensity; Frequency

Introduction

Bio sonar signals dolphin radiated along the beam axis of an Atlantic bottlenose dolphin resemble short transient oscillations. Bioacoustics is a science that combines biology and acoustics, the science has long been developing since 1980. Bioacoustics usually refers to research on the production of sound, dispersion through elastic media, and reception in animals, including humans. This involves neurophysiology and anatomy for the production and detection of sound, and the relationship with the acoustic signal dispersion medium. The findings in this area provide evidence for us about the evolution of acoustic mechanisms, and evolution of animals that can be applied in the science of acoustics [1].

Part of the sound of the best known is the frequency, i.e., the number of vibrations of sound waves per second. Sound consists of a mixture of a variety of frequencies, therefore the sound is said to have the quality and colors are characteristic. A quantity which is closely related to the frequency is the wavelength (λ). Wavelength is the distance between the two wave fronts is closest to the displacement and velocity of particles together in a field of flat sound field. If the frequency (f) and the wave velocity c are known, then the wavelength can be determined by the formula [2].

$$\lambda = \frac{c}{f} \quad (1)$$

There has been a preponderance of evidence that implicates the nasal area of the dolphin as the site of sound production [3]. Used an array of contact hydrophones to measure dolphin sonar signals and obtained results that placed the sound source at a depth of 1.5-2.0 cm from the surface in the vicinity of the nasal plug. According in [4,5] used high speed x-ray motion pictures to observe movements of the laryngeal and nasal region associated with sound production in live phonating *Tursiops truncatus*, *Tursiops gilli*, and *Stenella longirostris*.

These are the same trials examined by [6]. This examples of the signal waveform for the same click measured by the hydrophones at the different azimuth for two of the hydrophone configurations. An example of the signals detected by the hydrophone (Figure 1). Sound dolphins have the lowest intensity value of 28.03 dB and highest is 32.01 dB. Parameter salinity 30 ppm and temperature of 23°C with a pool depth of 4.4 meters. Range frequency the highest is 14-16 kHz and intensity the highest 23 dB at the first day after meal a click sound [7]. Science of sound production is science in which there are bioacoustic method, previous research bioacoustics in freshwater fish according in [8,9], but in research about against salinity change used freshwater fish according in [10,11]. Research in sound production with whistle and click sound of dolphins (*Tursiops aduncus*), according in [12-14] (Figure 1).

Marine mammals are capable of echolocation is an incredible ability to distinguish objects with good detail. This is presumably because the bones in her skull had been arranged to form a parabolic reflection that focus sound in the forehead [15]. Melon, waxy-shaped organ located in the forehead and a lens, focusing the sound produced in the nasal plugs so that the sound will be emitted in the direction desired by the marine mammals. At the same time, the sound waves bounce off

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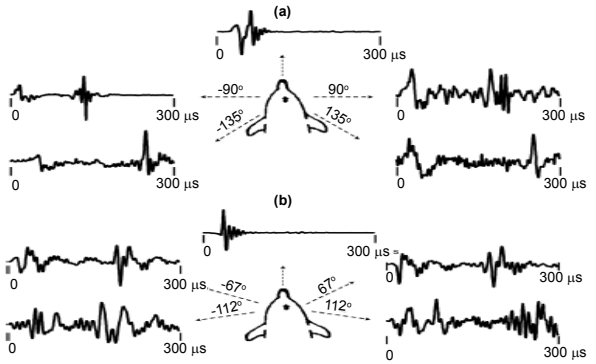

Figure 1: Examples of the signal for the same click [6].

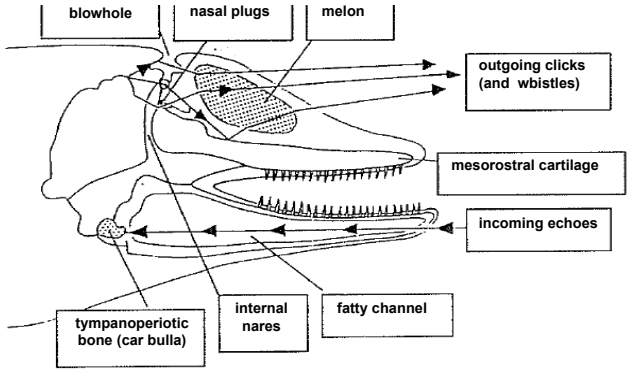

Figure 2: Production and receipt mechanism sound for bottle nose dolphin (*Tursiops aduncus*) [17].

objects back will be channeled through fatty channel, which contains oil and is located in the lower jaw, until it reaches the inner ear [15]. Distribution of sound can be made more precise and meticulous with the help of froth bubbling [16]. The mechanism of sound production and reception in the bottle nose dolphin (*Tursiops aduncus*) can be seen in (Figure 2).

Research on dolphin sounds a Quantive [16-19]. A dolphin has two dorsal bursa/phonic lip complexes, which can operate independently and simultaneously. Bottlenose dolphins can produce both clicks and whistles at the same time. All three researchers conducted a study on the distribution of dolphins in the Pacific Ocean and perform application of science bioacoustics toward the sound spectrum and distinguish each species of high and low frequencies. Marine mammals are capable of echolocation is an incredible ability to distinguish objects with good detail. This is presumably because the bones in her skull had been arranged to form a parabolic reflection that focus sound in the forehead [15]. Dolphin doesn't have vocal cords in its larynx. Sounds are probably produced by air movements in the nasal passage. The frequency of the sounds produced by a bottlenose dolphin ranges from 0.2 to 150 kHz. The lower frequency vocalizations (about 0.2 to 50 kHz) are likely used in social communication. Social signals have their most energy at frequencies less than 40 kHz. Higher frequency clicks (40 to 150 kHz) are primarily used for echolocation [15].

Research Method

We made the recordings between in May 2016 in captivity, Indonesia with two indo-pacific bottlenose dolphins (*Tursiops aduncus*). Sounds were recorded with a High Tech SQ 03 hydrophone (sensitivity -162 dB re $1V\mu Pa^{-1}$ @ 20°C with frequency response is ±1.5 dB from 7 Hz to 22 kHz) placed just above the rim of a territorial in aquaria with connected to Sea Phone Sensor (Dolphin Ear), with recording software is Wavelab 6. Sounds were digitized at a rate of 22 kHz (16 bit resolution) with Wavelab 6 software and analysed with Raven Pro 1.5 software with sound duration at rate of 500 ms (Cornell Lab of Ornithology).

Result and Discussion

Characteristics of dolphin sounds

The resulting sound of dolphins is divided into three categories. (1) The sound of click is used in echolocation [20]. (2) Voice pulsed radiating often described as squawks, yelps, barks and others [21]. (3) The whistle sound is air-tight band with a frequency modulated. According to Madsen et al. [22] whistle function for communication. Dolphins can emit various amplitude sounds for communication in the exchange of information. Examples noise spectrum processed using Wavelab 6 software used is the result of recording dolphin sounds of Indo-pacific bottlenose dolphins (*Tursiops aduncus*) (Figures 3 and 4).

There is completely example of the sound spectrum that is processed using software Wavelab 6 used is the result of recording dolphin sounds of Indo-pacific bottlenose dolphins (*Tursiops aduncus*). Color spectrum looks brighter is the signal or the noise from the center of dolphins. With a color bar that is shown by the brighter (high) is the source of the sound or voice center. The high value of the linear intensity with bright colors produced on the noise spectrum of dolphins Dolphin. The top and bottom is the voice that comes together with one another, but results of the following view is a view that issued stereo. Figure 4 showed of click sound with range time 0- 8.20 ms, and has highest power in color bar 100 kU. Frequency with maximum intensity percentage clicks sound show in (Figure 5). Click sound power have range 80-100 kU with -3 dB according in [23-25]. Frequencies with maximum intensity percentage click sound can be seen in (Figure 6).

Figure 5 showed graph of click sound frequency dolphins that releases a clicking sound with a frequency of 7 kHz and 14 kHz. Sub-frequency sound generated from the image above that 7 kHz, 10 kHz, and 14 kHz. The frequency of 7 kHz has anti-log value is 647.08×10^3 with the percentage is 83% and the frequency of 14 kHz has anti-log value 782.82×10^3. Sub frequency of 10 kHz has a value of 649.89×10^3, and 14 kHz with anti-log value of 782.82×10^3. The percentage of the maximum intensity in the frequency of 14 kHz can be seen the percentage shown in the amount of 100% and a minimum percentage

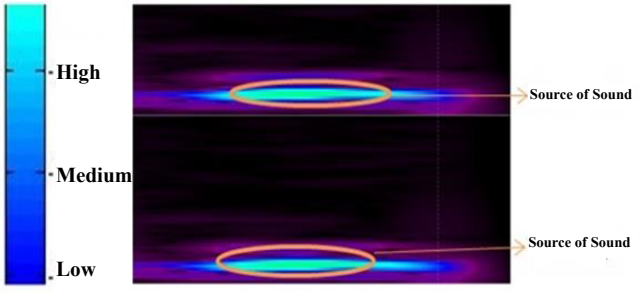

Figure 3: The spectrum of the sound generated using Wave lab 6 software [29].

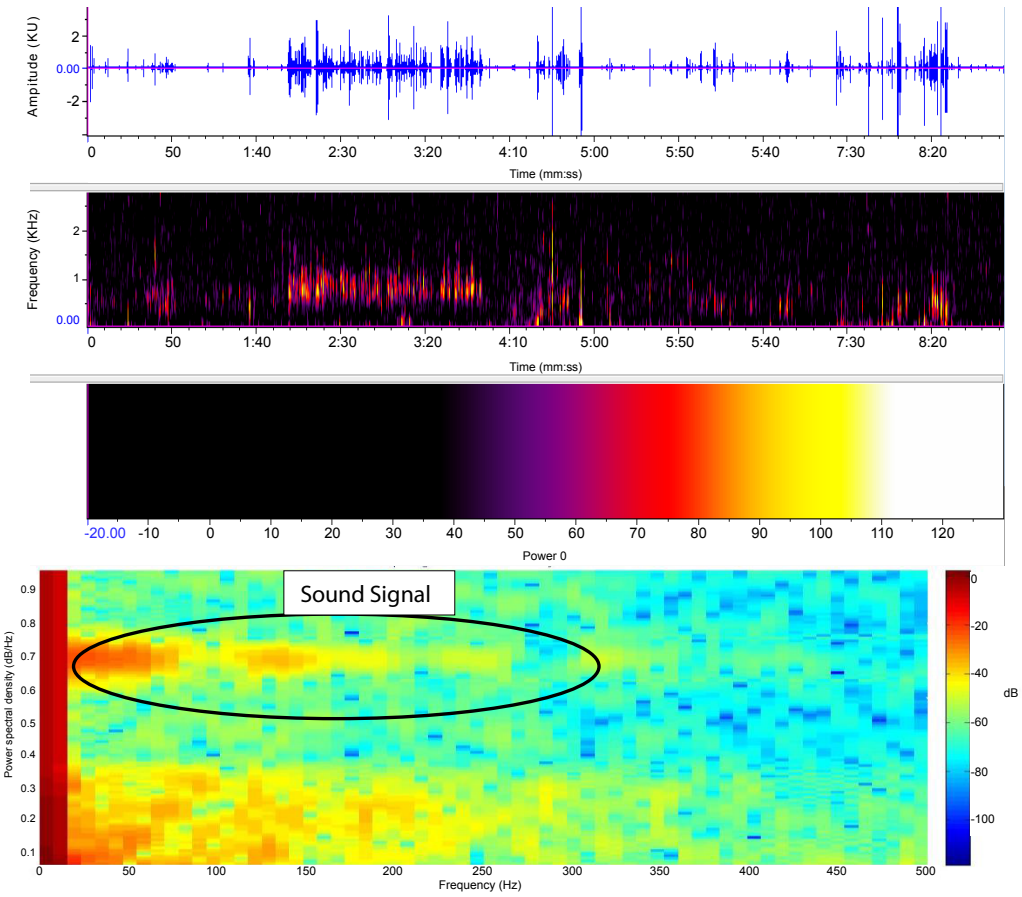

Figure 4: Click sound of Indo-pacific bottlenose dolphins [29].

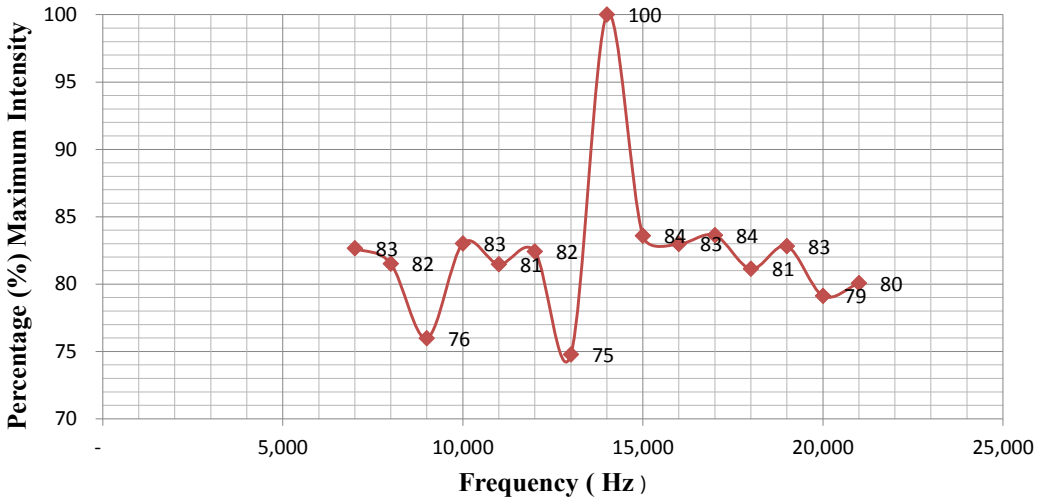

Figure 5: Frequency with maximum intensity percentage click sound [29].

of 75% in frequency 13 kHz. In paper of Freitas et al. [26] click sound common bottlenose dolphin (*Tursiop aduncus*) produces a clicking sound in the frequency range to 14,000 Hz - 15,000 Hz, with a range that is 20-25 dB intensity, it can be explained that the research conducted in captivity, Indonesia has range, frequency and intensity of the same. According to Wahlberg M et al. [27], Lubis MZ [28] Wulandari [29] describes the value of the intensity of the clicking sound is generated by using an index of voice transmission -3 dB, the results obtained that the

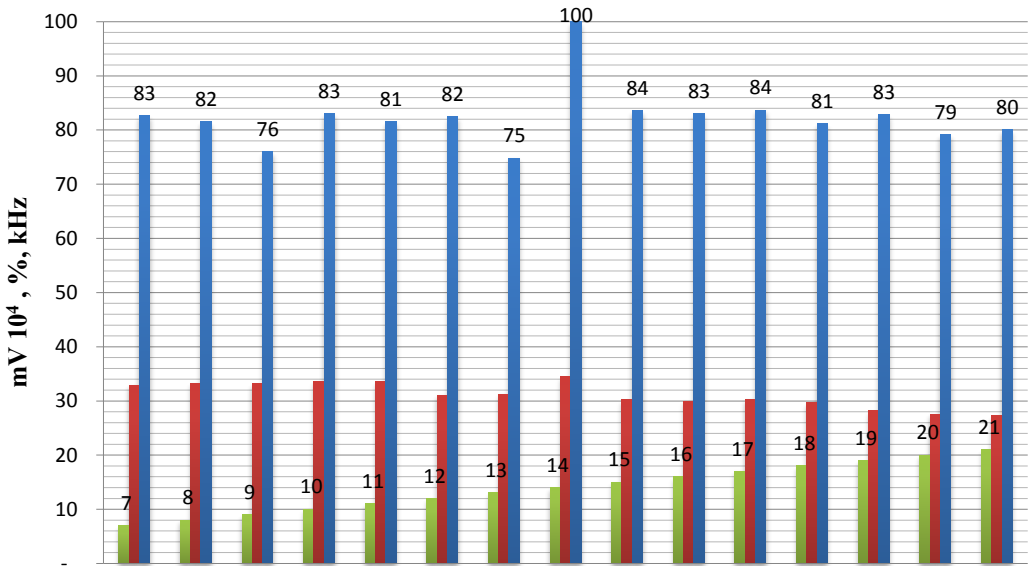

Figure 6: Graphs of frequency with mV, Hz and % click sound [29].

clicking sound of the common bottlenose dolphin (*Tursiop aduncus*) had a higher intensity is 29 dB tursiop truncatus than 26 dB. Research has been done before, namely Jensen [30] and Erbe [31] show that the value range intensity (dB) and frequency range as well as the resulting percentage has similarities with the research conducted in captivity, Indonesia.

Figure 6 showed frequency graph click sound of dolphins that releases a clicking sound. Blue color is percentage, green is frequency, and red is intensity with a frequency of 7 kHz and 14 kHz. Sub-frequency sound generated from the image above that 7 kHz, 10 kHz, and 14 kHz. The frequency of 7 kHz has anti-log value is 647.08×10^3 with the percentage is 83% and the frequency of 14 kHz has anti-log value 782.82×10^3. Frequency sub frequency of 10 kHz has a value of 649.89×10^3, and 14 kHz with anti-log value of 782.82×10^3. The percentage of the maximum intensity in the frequency of 14 kHz can be seen the percentage shown in the amount of 100% and a minimum percentage of 75% in frequency 13 kHz. It shows a clicking sound produced by dolphins has a high fluctuation is at a frequency of 14 kHz.

Conclusion

Sound frequency range of Indo-pacific bottlenose dolphins in captivity, Indonesia was between 13.211–15.245 Hz. The percentage maximum intensity in the frequency is 14 kHz can be seen the percentage shown in the amount of 100% and a minimum percentage of 75% in frequency 13 kHz sounds are probably produced by air movements in the nasal plugs.

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