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Effects of water salinity on sound production of the spiny Lobster *Panulirus homarus* (Linnaeus, 1758) cultivated in the Laboratory

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ABSTRACT

Lobster *Panulirus homarus* is one of the aquatic invertebrates that produce sound with certain characteristics. The sound that produced is a representation of how this species to eat, protect itself, and as a response to environmental changes. Variability on behavior will produce different characteristics of sound. The lobster sound is observed using a hydrophone. The study aimed to determine the daily sound productivity of the *P. homarus* as a response to the salinity changes. Observation was carried out on the laboratory scale with a salinity reduction of 2 PSU per day. Results showed three types of the sound of the lobster, slow rattle, squeaking, and popping. All of the sounds is produced at a different salinity of waters. There is a significant relationship between the number of sound productivity of lobster and the decreasing water salinity.

Key words : *Sound production, Sound Characteristics, Panulirushomarus, Salinity*

Introduction

Spiny lobster is one of the important economic fisheries resources in Indonesia. This commodity has high prices compared to other fisheries commodities causing the lobsters to be widely exploited. The high demand commodities is not only from the domestic but also from foreign markets. The increasing demand for lobster exports is not proportional to its availability in nature. Continuous exploitation activities in the nature habitat can disturb the sustainability of the resources. To avoid the sale of lobsters that are not fit for consumption, there is a prohibition on the sale of lobsters that have been implemented in PERMEN-KP No. 56, 2016. The lobsters that are caught must not be in a laying condition, and the carapace length is over 8 cm or weighs over 200 grams per individual.

One of the efforts to accommodate the high demand for lobster is cultivation. Lobster cultivation activities include catching the baby lobster (post larvae), producing juvenile lobster, and cultivating lobsters where each activity is a separate business segment (Mustafa, 2013). The process of lobster cultivation can be carried out in floating net cages on the sea or controlled ponds on the terrestrial. Lobster enlargement in controlled ponds requires the suitable water quality, such as salinity. The seawater is used generally as the result of the filtering process, so it is very possible the changes in salinity to be occurred. Fluctuation in salinity in the rearing ponds can affect the growth and survival rate of lobster. The salinity suitable for lobster cultivation is 30-35 PSU, and the optimum salinity is 35 PSU (Mustafa, 2013). Lobster the growth of lobster was decreasing when the salinity decreases. However, a decrease in salinity will provide a more significant opportunity to develop commercial cultivation (Jones, 2009).

Some of the marine biota, including crustaceans, can produce the sound (Schmitz, 2002). The sound that is produced can provide important information about the existence, distribution and behaviour of species (Hamilton *et al.*, 2019). *Panalirus* sp. produces sound to protect itself from predators (Buscaino *et al.*, 2011; Jézéquel *et al.*, 2018; Patek *et al.*, 2009). Lobsters produce sound by rubbing two organs where each organ goes through a stick-slip motion (Patek and Baio, 2007).

The organs of lobster that produced the sound are plectrums and files (Buscaino *et al.*, 2011). The plectrum is a striped pad-shaped stridulating device whose bottom extends at the base of the second antenna, while the file is the centre of each antenna base (Cobb and Phillips, 1980). There is a linear correlation between the length of the carapace, the number and size of the plectrums and the mean duration of a sound pitch (Meyer-Rochow and Penrose, 1976). Recognizing the characteristics of the sound produced by Lobster can make it easier to study the condition of Lobster, especially in response to the salinity changes.

Materials and Methods

Two individual females (A and B) of Lobster *P. homarus* was observed in laboratory condition. Lobster A has 12 cm in total length and 105 grams in weight, while lobster B has 14 cm in total and 132 grams in weight. The lobster is the catch of fishermen in the Cilacap Waters (Central Java) and transported to the Marine Acoustic Laboratory of Fisheries and Marine Sciences Faculty, JenderalSoedirman University. Before the observation is conducted, lobsters were acclimatized for three days to adapt to their new environment. Both lobsters are reared in separate aquariums with 60 cm x 25 cm x 30 cm in length x height x width. To maintain dissolved oxygen levels in the aquariums, an air pump with a capacity of 2 x 4 liters per minute is used. The seawater used has an initial salinity of 32 PSU. The salinity was then reduced by 2 PSU per day until it reached 14 PSU. Decrease in salinity by mixing freshwater with a volume calculated using the following equation:

$$S = \frac{S_1V_1 + S_2V_2}{V_1 + V_2}$$

Where S is the desired salinity; S_1 is the salinity of fresh water; S_2 is the salinity of seawater; V_1 is the volume of freshwater, and V_2 is the volume of sea water. Lighting conditions in the laboratory are adjusted to environmental conditions during the day and night without additional lighting (Amron *et al.*, 2017; Amron *et al.*, 2018).

The sound that produced by lobster are recorded by using passive acoustic techniques with hydrophone (Figure 1). The hydrophone converted the sound wave, which was produced by the lobsters, into electric voltage in millivolts. The electricity unit of sound that is still in an analog version is converted to a digital number to be saved in a digital format with the *.wav extension. The recording is conducted for 24 hours for each lobster. The video

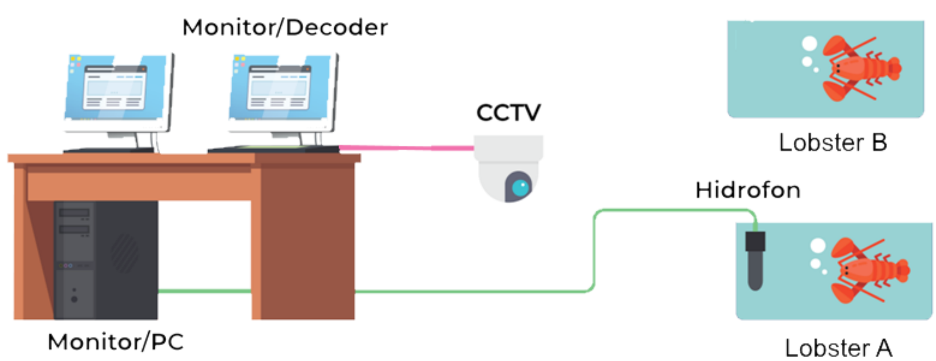


Fig. 1. Observation Layout

system retrieves data on fish behavior when it rests, territoriality, aggression, and social behavior. The video system is placed in front of the aquarium. The camera that is used is a CCTV camera with HD 1080p resolution. This camera is equipped with infrared to still observe the behavior of lobsters at night where the light is too dark.

Sound productivity of Loster *P. homarus* is analyzed based on its characteristics which include sound frequency, pulse duration and intensity. Sound productivity is calculated from the number of sounds produced during the recording period. Sound productivity was analyzed descriptively to explain its association with decreased salinity.

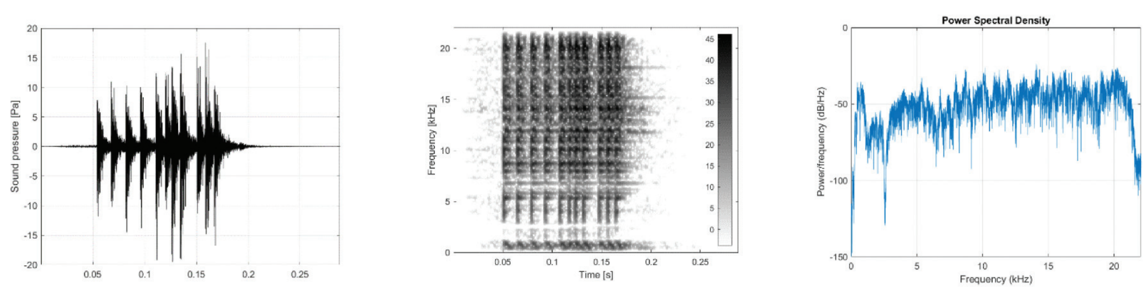
Result and Discussion

Sound Characteristics of *P. homarus*

Spiny lobster produces three types of sound, slow rattle/flutter (Meyer-Rochow and Penrose, 1976), rasp/squeak (Buscaino *et al.,* 2011), and popping/click (Mulligan and Fischer, 1977). Each type of sound has different characteristics that are influenced by its behavior. A rasp sound is produced when lobster intimidated by predator (Bouwma and Herrnkind, 2009). Rasp is a broadband sound with frequency range of 4 to 20 kHz. The intensity of the raps ranged from 715 to 83 dB re µPa, while the sound duration ranged from 24 to 154 ms (Figure 2). Rasp is a type of sound produced by a stick-slip mechanism (Patek *et al.,* 2009). This sound is generated when the antenna moves rapidly so that the terminal portion and plectrum rub against the scaly surface of the file in a backward-directed motion. There is a linear correlation between the length of the carapace and the dimensions of the sound-producing organs (number and size of the back of the plectrum) and the mean duration of a single squeak (Meyer-Rochow and Penrose, 1976).

Similar to squeak sound, the slow rattle is broadband-type sounds with frequencies ranging from 4 - 20 kHz. The slow rattle sound intensity ranges from 56 - 100 dB re µPa, and the duration is 300 ms (Figure 3). The slow rattle sound consists of 6 - 9 sound pulses with each duration of 20-37 ms, which are separated for 9-32 ms. This is closer to (Moulton, 1957) that the resulting slow rattle sound consists of 5 or 6 sound beats with a duration of about 250 ms.

Popping sound has a similar to raps and slow rattle where a broadband type sound is with frequencies ranging from 4 to 20 kHz. Popping sound intensity is 68 - 88 dB re µPa. Unlike raps and slow rattles, popping sounds consist of only one sound pulse with a pulse duration ranging from 4 - 152 ms.the popping sound does not show any specific behavior.



(a) (b) (c)

Fig. 2. Sound characteristics of raps; (a) waveform; (b) spectrogram; and (c) PSD

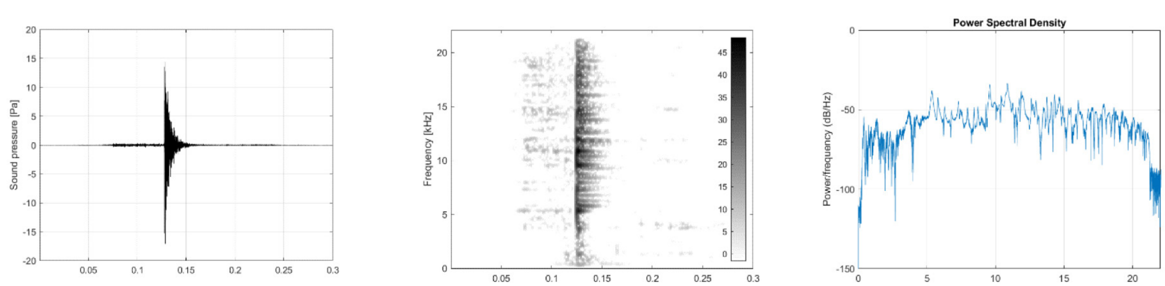
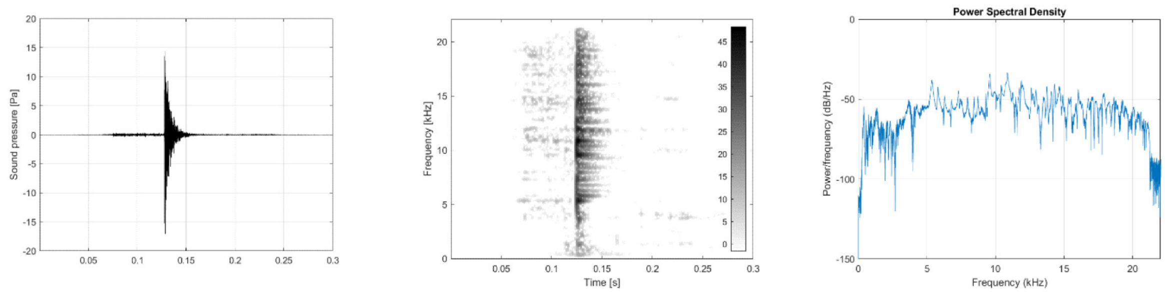


Fig. 3. Sound characteristics of slow rattle; (a) waveform; (b) spectrogram; and(c) PSD



(a) (b) (c)

Fig. 4. Sound characteristics of popping; (a) waveform; (b) spectrogram; and (c) PSD

Sound productivity of *P. homarus* as a response to the salinity changes

The decreases in salinity had an impact to the sound productivity of *P. homarus* (Figure 5). This figure showed that the comparison of sound production between the individual lobsters at different salinity conditions from 32 to 14 PSU. The comparison curve of the sound productivity of lobster A and B per day with a decrease in salinity shows a significant relationship between the level of sound productivity and a decrease in salinity. All of the individual lobster shown a decrease in the number of sounds from the salinity of 32 to 20 PSU. However, when the salinity was lowered again from 20 to 14 PSU, the sound productivity of the two individual lobsters tended to increase.

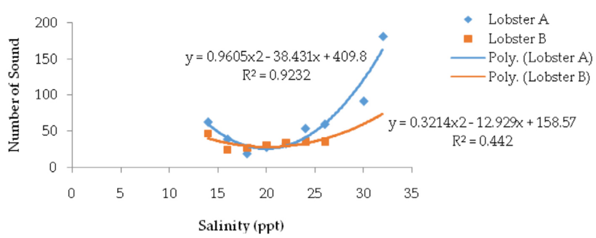


Fig. 5. Sound productivity of individual lobster based on the decreases in salinity

Changes in the living environment of lobsters, where in this case is salinity disturb chemosensory in lobsters (Ross and Behringer, 2019). The spiny lobster can survive up to a salinity of 14 PSU. Some lobsters such as *Homarus americanus* can survive in salinity from 14 to 8 PSU, but the other factors such as temperature, oxygen, and acclimatization conditions also influence (Dufort *et al.*, 2001). However, low salinity inhibits the growth rate of spiny lobsters (Vidya and Joseph, 2012). On the fifth day, Lobster has undergone an adaptation process due to environmental changes to compensate for the situation and increase sound production. One of the adaptation mechanisms of lobsters to salinity is the regulation of Na^+/K^+ -ATPase expression in the antenna glands (Buranajitpirom *et al.*, 2010). Furthermore, lobsters cannot survive prolonged exposure to low salinity, which may have long-term effects on the growth or reproductive organs of lobsters.

Conclusion

There are three types of the sound of the lobster, slow rattle, squeaking, and popping. All of the sound is produced at a different salinity of waters. There is a significant relationship between the number of sound productivity of lobster and the decreasing water salinity.

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