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Development of Sound-Fish Aggregating Devices (S-FAD) Applied at Lift Net

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***Abstract*—Fish produced sound from internal organs and air bubbles caused by the friction of fish bodies with the surrounding water. The sounds are used to interact with each other, and the sound produced is stronger when gathered during eating. The study aimed to develop a sound-fish aggregating device (S-FAD) and produce an artificial fish sound with suitable frequency for several fish species. The study used analytical descriptive and experimental fishing, which divided into two steps, (1) S-FAD tool construction using a descriptive method to explain every step in the construction of tool and consideration in the use of supporting tools, and (2) effectiveness testing step using an experimental fishing method to see the horde pattern (behavior) and the target strength using an echosounder. The sound wave aids trial was carried out on a lift net from morning to noon. Data retrieval by recording the fish-finder screen was carried out for 1 minute before and after the sound wave device was put into the water. The S-FAD test was done 60 times and hauling lift net in every multiple of 4 trials. The results showed that the average fish that approached and came together before and after the S-FAD installation was 2.18 ± 0.98 and 2.79 ± 0.71 fish. The highest number of caught fish when hauling at lift net with four times repetition was 79 fish from 7 types, including *Selaroides leptolepis, Stolephorus* sp., *Sphyraenidae* sp., *Scatophagus argus*, *Mugil* sp., *Portunus pelagicus*, and *Loligo* sp.**

***Keywords*— Sound-fish aggregating device; lift net; communication; fish.**

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I. INTRODUCTION

The development of a device that produces a sound could trigger the fish to come in the source of the sound, and then the fish can catch easily and efficiently. Currently, passive acoustic methods have been used to monitor marine mammals [1]. Generally, the signal obtained from recording animal sounds is weak, requiring amplification, and it is difficult to determine where the sound is coming. The definition of passive in terms of passive acoustic is a sound that only comes from the animal target [2].

The fish's lateral line and labyrinth structure could respond to the sound through the relative fluid movement around the fish's body. The lateral line is also sensitive to weak water movement. The lateral line not only senses the smooth movement of currents reflected by obstructions and can also find interference caused by hidden prey or attacking enemies [3]. It indicates that sound can be used as a fish collector. Other studies have stated that fish will make sounds naturally during the breeding season [4]. This is also in line with Mooney *et al.* [5] and Horvatić *et al.* [6], which revealed that *Padogobius martensii* makes a sound when interacting with the other sex that is produced by the swim bladder.

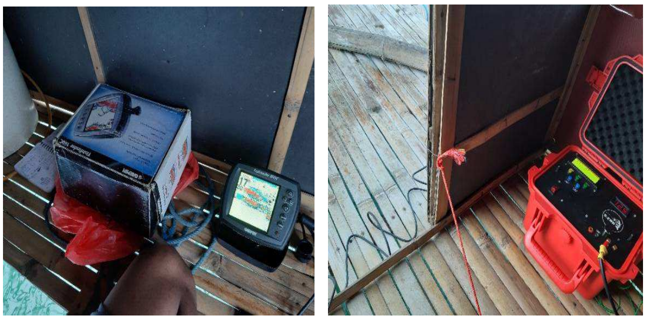
The study developed a sound-fish aggregating device (S-FAD), a FADs voice-based, as the result of recording (passive acoustic). This device is a sound-based fish calling device where the sound used is recording the target fish's voice. The basic concept of passive acoustics in fish is to detect sound when the fish is in the measurement area. These measurements are carried out using the software and by listening to it [7]. Therefore, the current study aimed to develop a sound-fish aggregating device (S-FAD) and produce an artificial fish sound with suitable frequency for several fish species.

II. MATERIALS AND METHODS

The methods used in the study were analytical descriptive, and experimental fishing. Generally, the study was divided into two steps, such as (1) S-FAD tool construction using a descriptive method, to explain every step in the construction of tool and consideration in the use of supporting tools, and (2) effectiveness testing step using an experimental fishing method to see the horde pattern (behavior) and the target strength using an echosounder.

The sound wave aids trial was carried out on a lift net, a catching tool, from the morning to noon. It was done because the fishermen usually carry out fishing activities at night using a lamp. The sound wave test was done in the morning to noon to observe the effect of sound wave aids on the attractiveness of fish. The test was done sixty times alternately before and after the sound wave aids entered the sea waters. The length of the sound wave instrument cable was thirteen meters from above sea level to the water. Before the sound wave aid was put into the water, the duration of time was 15 minutes and 30 minutes after the aid was put into the water. Data retrieval by recording the fish-finder screen was carried out for 1 minute before and after the sound wave device was put into the water. The fish-finder recording showed the fish pictures that have been caught at a depth of several meters for 1 minute of recording.

The S-FAD test was done 60 times and hauling lift net in every multiple of 4 trials (on trials 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, and 60). Furthermore, the test results were analyzed using a pairwise comparison test. The fish-finder and S-FAD are shown in Fig. 1.



(a) (b)

Fig. 1 Device's picture. A) fish-finder, B) S-FAD

III. Results and Discussion

A. The Fish Sound Waves

Fish that have a swim bladder tend to make a sound; the presence of a swim bladder adds to the loudness of the sound produced. The swim bladder causes it as an empty room that can act as a resonant space that produces a sound. Popper and Hawkins [4] stated that these sounds natural, especially during the breeding season. It is also supported by Mooney *et al.* [5] and Horvatić *et al.* [6] that *Padogobius martensii* produced a sound when they interacted heterosexually due to its swimming bubble.

Guan *et al.* [8] stated that there was three group types of animals that produced sound with different characteristics, including (1) crustacea, especially shrimp, (2) teleost with swimming bubbles, and (3) aquatic mammals such as whales and dolphins. Fish (a) group of vertebrates can produce sound through their swimming bubbles. This sound is a form of communication with each other. The sound can be produced stronger when the fish come together while eating. *Padogobius martensii* can produce sound when interacting with the other sex produced by swim bladders [5].

Scianidae is a well-known fish that can produce a sound. The sound was produced through the interaction between the sonic muscles and the swim bladder and is often associated with reproduction impairment. Several studies showed that Atlantic Croaker often produced a "knock" voice when they interacted with each other with an average sound duration of 97 msec (SD = 56, 95% C.I. = 88–106) and correlated positively with Atlantic Croaker density [9]. *Johnius macrorhynus* makes a sound with a frequency of up to 5 kHz, with two peaks around 1 and 2 kHz, the first being the dominant frequency. The first interpulse interpretation, the main interpulse interval, the pulse repetition rate, and the pulse duration can serve as diagnostic characteristics for species-specific sounds as buzz [10].

Sciaena umbra (L., fam. Sciaenidae) produces the main sound frequency below 2 kHz and an average peak frequency of 270 Hz. Pulse periods are short, with a mean duration of 20 ms and a pulse period of 100 ms. Sound lasts for about 500 ms. Three types of sound patterns are irregular (I), regular (R), and chorus (C). Their described acoustic parameters show that I, R, and C differ in pulse duration, pulse peak frequency, and pulse period. The occurrence of three types of calls changes throughout the night: the R pattern occurs primarily at dawn and dusk, C predominates after nighttime, while the I sound pattern is produced sporadically during the entire nocturnal period [11].

Gulamah fish emit sounds with an average sound amplitude of -54.97 dB with an average frequency of 732.129 Hz, with a sound duration of 130 milliseconds, as shown in Table 2.5. This is not much different from the frequency of yellow croaker (*Pseudosciaena crocea*) studied by Gao et al. [12] where the peak frequency of the fish is 800 Hz. One of the factors that influence the low and high sound frequency is the age of the fish, the more mature the fish, the lower the frequency. The mean frequency value of yellow croakers (*Pseudosciaena croce*) in the 7–8-month-old fish group ranged from 1311.2 Hz - 1036.8 Hz, which was significantly higher than the signal from the 13–15-month group of fish, namely 692.8 Hz. - 688.2 Hz, and 3-year-old fish groups ranging from 712.8 Hz - 676.0 Hz [13].

The study was done to determine the sound produced by *Scianidae* fish at Tombokboyo waters, Tuban. The average sound amplitude of Scianidae fish was about -54.97 with an average frequency of 732.129 Hz, and sound duration 130 milliseconds, as seen in Table 1.

TABLE I
AVERAGE SOUND AMPLITUDE AND FREQUENCY OF FISH

No	Parameter	Min	Peak	Max	Unit
1	Frequency	37.83	732.129	1795	Hz
2	Peak Amplitude	-45	-54.97	-75	dB
3	Duration	0.068	0.13	0.315	milliseconds

The spectrogram frequency and amplitude picture of *Scianidae* fish were shown in Fig. 2 to Fig. 4. This spectrum data become a development reference for FADs. Sound is the most important thing against communication on several types of fish [14]. Fish can produce several types of sound amplitude to communicate in information transfer [15]. Information about sound signals explains the imminent danger condition, aggressive condition to threatening predators, and marriage call. A sound is also produced by other activities such as eating, moving, avoiding enemies, and reproducing [16].

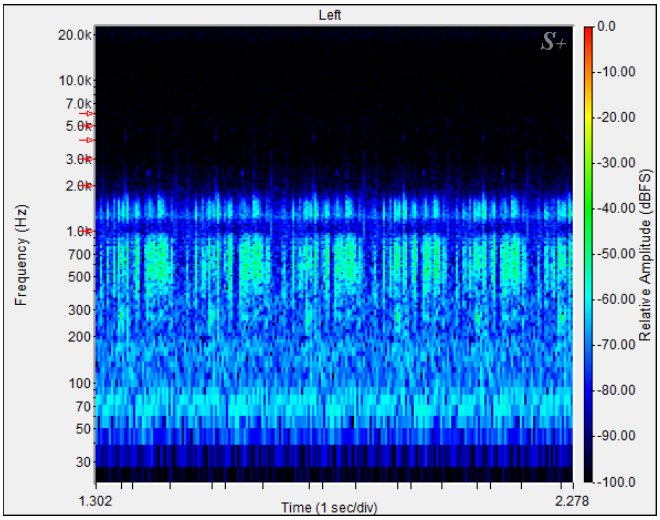


Fig. 2 Frequency and amplitude spectrogram correlation of Scianidae fish

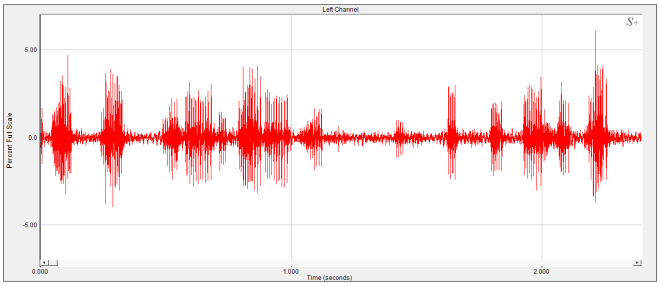


Fig. 3 Voice duration interval of Scianidae fish

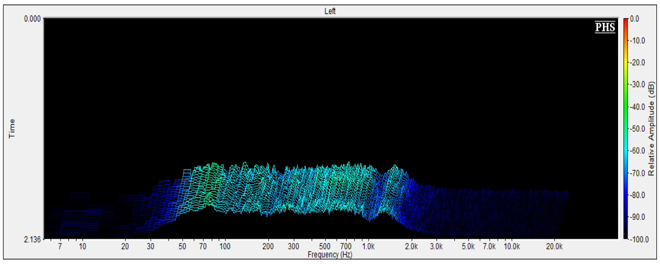


Fig. 4 The relative amplitude of *Scianidae* fish

B. Sound–Fish Aggregating Device (S-FAD)

Sound waves with certain frequencies issued by S-FAD aim to collect fish within a certain distance to get closer to the sound source and fishing gear. The main series of S-FAD equipment construction tools are generally divided into three subsystems, namely:

1) APK Android system: In this section, the sound database of the *Sciaenidae* fish was stored and played based on the Android application, where the system can be updated as the sound spectrum of other fish is studied.

2) Panel box system: This part of the panel box (Fig. 5) converts the electrical signal into a sound signal. An amplifier amplifies the sound before being connected to an underwater speaker to be transmitted to the water.

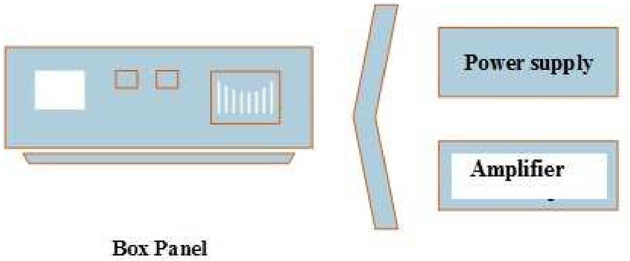


Fig. 5 The part of the panel box

3) Sound output system: The sound output system (Fig. 6) used a piezoelectric wrap to watertight. In this section, a 20-meter-long underwater cable connected it.

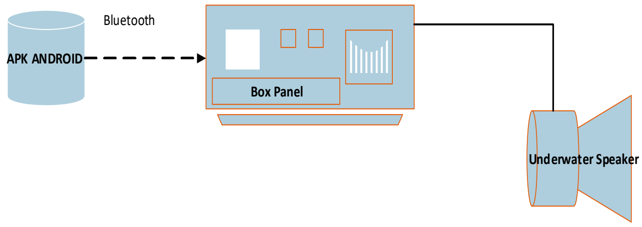
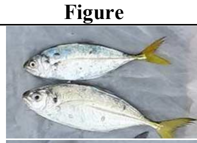
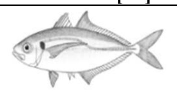
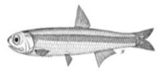
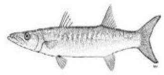
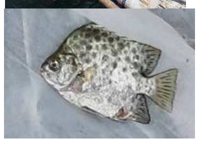


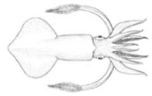
Fig. 6 S-FAD subsystem part

C. Fish Haul before and after using S-FAD

The S-FAD test was done 60 times and hauling lift net in every multiple of 4 trials (On trials 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, and 60) and a total of 79 fish were caught. The catch consists of 7 dominant fish species, as shown in Table-2.

TABLE II
RESULT OF CATCHING LIFT NET

Species	Amount	Figure	Reference [17]
(*Selaroides leptolepis*)	38		
Teri nasi (*Stolephorus sp.*)	10		
Barakuda (*Sphyraenidae sp.*)	4		
Kiper (*Scatophagus argus*)	1		
Belanak (*Mugil sp.*)	13		
Rajungan (*Portunus pelagicus*)	4		

Species	Amount	Figure	Reference [17]
Cumi-cumi (*Loligo sp.*)	9		
Total	**79**		

The results showed there were 79 fish that were caught of all species. The highest number of fish that were caught was Selaroides leptolepis (38 fish), followed by Mugil sp. (13 fish). The lowest number of fish was Scatophagus argus (1 fish) (Fig. 7).

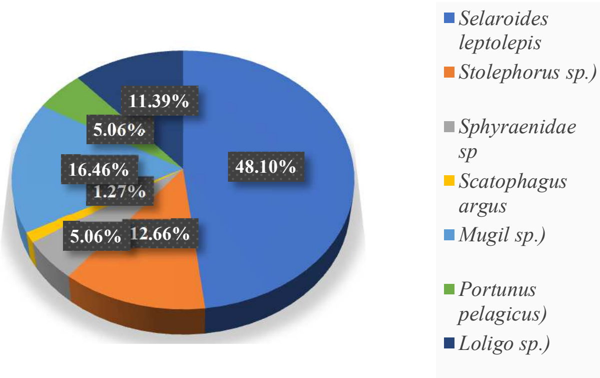


Fig. 7 Type of fish species

D. Relation of Difference of Fish Finder's Frequency from Fish Finder Screen

The study results showed the largest catch data per fish before using S-FAD in the 58th trial, with a total of 18 fish. Then, for the highest results after using S-FAD in the 20th trials with 19 fish. Fig. 8 was a graph of the 60 test that showed the average data score after using S-FAD was higher than before using S-FAD. The catch result data obtained from the fish-finder is shown in Fig. 8. The distribution of catching fish based on the water dept is shown in Fig. 9, and the hypothesis test results of the comparison between two populations were shown in Fig. 10.

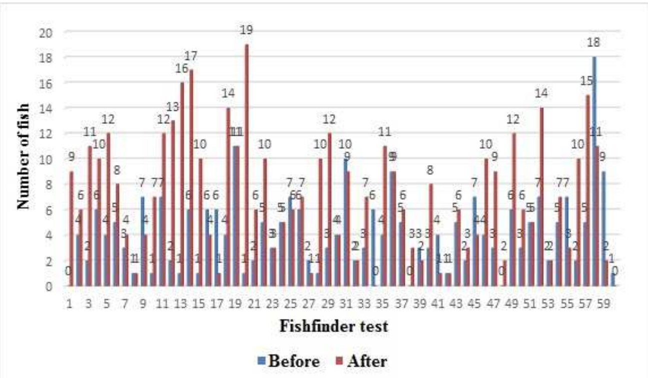


Fig. 8 Graph of fish frequency data from fish-finder screen

Furthermore, many fish are found in 8 meters of depth (Fig. 9). Based on catch results, small pelagic and small demersal fish mostly dominate and live in 6-10 meters of depth.

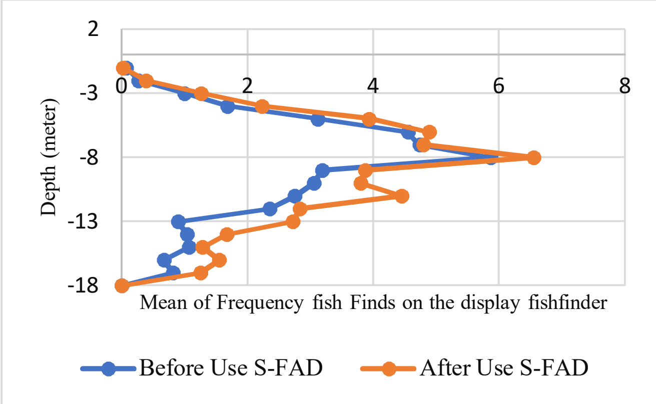


Fig. 9 Fish distribution

The results paired T-test showed a significant difference in the number of fish before and after using S-FAD. It was indicated that sound could be used to gather schools of fish for a more efficient fishing effort. Rosana and Rifandi [18] conducted an electronic FAD trial on Lancang Island, Seribu Islands, Jakarta, where the number of gill nets caught using piknet compared to without piknet was significantly different. The average number of catches using piknet is higher than without piknet. The paired T-test showed that the average fish collected with S-FAD was 2.79 ± 0.71 (SD), whereas before using S-FAD was 2.18 ± 0.98 (SD) fish.

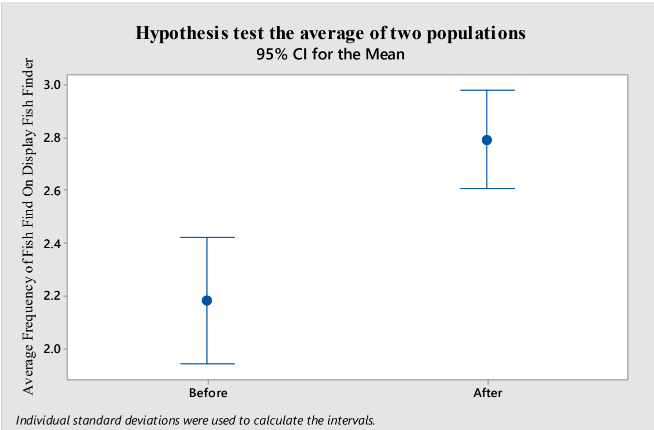


Fig. 10 Hypothesis test results of two population comparison

IV. Conclusion

Based on the test of S-FAD utilization at lift net obtained the average catch fish was higher than without using S-FAD. The first trial before using S-FAD has 79 fish catch. In comparison, the observation on the fish-finder screen showed that the average fish catch before and after using S-FAD were 2.18± 0.98 (SD) and 2.79 ± 0.71 (SD) of fish.

Acknowledgment

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