Indonesian short fin eel *Anguilla bicolor* (Mclelland, 1844) swim bladder as important organ for reflecting acoustic wave

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Abstract. Indonesian shortfin eel, *Anguilla bicolor* (McClelland, 1844) is one of fish that have swim bladder to assist swim and doing migration. Every fish has different shape, gas volume, dimension, and length ratio of swim bladder, which can play role in the difference in backscattering of acoustic energy. This study aims to determine the shape, dimensions and ratio of *Anguilla bicolor*’s swim bladder and their effect on target strength (TS) values. The research was conducted in two places, in the Acoustic lab, Department of Marine Science and Technology, Bogor University and Laboratory of Histology and Embryology, Faculty of Biology, Universitas Gadjah Mada. Retrieving data using the EK-15, Frequency 200 KHz tool and also the X-ray photo. The results show the shape of the swim bladder of *Anguilla bicolor* is elongated and consists of 1 room which is generally called a closed swim bladder. Acoustic detection results show that fish with large swim bladder volumes have large TS values and conversely fish with small swim bladder volumes have a small TS value.

1. Introduction

*Anguilla bicolor* is Indonesian native fish, it is one of fishes that have high economic value for export and domestic consumption purposes. Recently, *Anguilla bicolor* cannot be cultivated due to limited study on the fish biology. *Anguilla bicolor* larvae usually obtained from seashores, which then reared in the pond for the development until reaching certain size for consumption. Based on its swim bladder organ, fish are divided into two; swim bladder fish and non-swim bladder fish. Eel is a swim bladder fish. The swim bladder is internal organ in the dorso-ventral of fish body part that contains gas. This organ plays important role in controlling buoyancy of fish during swimming activity and enabling the fish to maintain its depth without floating upward or sinking. It also serves as a resonating chamber to produce or receive sound [1]. Based on the gas volume in the swim bladder, seawater fish have 5% and freshwater fish have 7% of body ratio volume. During swimming, swim bladder will secrete or absorb gas to keep the volume of swim bladder in a constant volume [1].

Based on its swim bladder shape, swim bladder fish were divided into two; fish with closed swim bladder and fish with open swim bladder. Fish with swim bladder generally have the ability to restore acoustic energy and are larger than fish without swim bladder. Research shows that this swim bladder is able to returns echo signals from outside with high efficiency of more than 50% of the energy that hits them [2].

The amount of acoustic energy that are scattered back by fish or a single target is known as the Target Strength (TS) value. Fish TS values are influenced by the existence of swim bladder [3][4][5][6][7]. This research was aims to determine the shape of *Anguilla bicolor* swim bladder and their contribution on values target strength of the eel.
2. Method

2.1 Research location
The study was conducted in the Acoustic Laboratory, Faculty of Fisheries and Marine Sciences, IPB and Animal Structure and Development, Faculty of Biology, Universitas Gadjah Mada on June 2019. X-rays taken at the Faculty of Medicine, Universitas Gadjah Mada on July 2019.

2.2 Fish collection
There are 23 eel specimens were collected on the period of 2017-2019, based on the area collection, fish were divided into two groups; 1). Cilacap seashores, and 2). Cikampak Bogor. 12 eel fish were obtained from Cilacap, Central Java, consist of Elver, yellow and silver stage of development. These fish were prepared for x-ray analysis. Moreover, 11 eel fish were collected from Cikampak, Bogor, were used for acoustic backscatter data, respectively.

2.3 Collection of data
Eels obtained were acclimatized for 2 weeks at the Laboratory of animal structure and development, Faculty of Biology, Universitas Gadjah Mada. Furthermore, the eels were measured for morphometry and X-ray analysis at the Animal Hospital, Universitas Gadjah Mada. Eleven eels were measured on controlled acoustic backflows, which were conducted on water tanks with a diameter of 1 meter and 1.27 meters in height, at the Acoustics Laboratory, Department of Marine Science and Technology, FPIK-IPB. Eels were placed under the transducer with a distance of about 110 cm, for eel acoustic proper detection. Data recording was performed in 3 minutes with a frequency of 200 KHz, a pulse length of 0.08 m and a pulse rate of 40 ping / sec using EK-15 device. Furthermore, the eel was measured for length and weight. At final stage of experiment, fish were aestheticized and dissected to measure its swim bladder.

The x-ray figure of eel swim bladder was measured with image-J program to calculate the length and width of the observed eel swim bladder. The correlation of eel body length and eel swim bladder length were analysis with statistical program. The results of the acoustic data recording were then processed with Echoview 3.5 demo version, and then tabulated for further analysis to see eel body length trends, swim bladder lengths and the TS values.

3. Results and discussion
Result on morphological observation showed that eel swim bladder were white in color, resembling thin but tough membranes. This swim bladder was a gas-filled organ. Based on the anatomical observation, the eel swim bladder consists only one chamber and there was no existence of pneumatic ducts; the channel that connects the swim bladder to the channel alimentary which then connects it to the water around the swim bladder. This swim bladders were completely closed from various external air sources and considered as closed swim bladder[8]. The existence of a swim bladder serves to regulate ability of the eel body on floating during the swimming activity, as room that resonates for producing sound or receiving sound and helps the fish respiration process. The morphological shape of eel bladders can be seen in Figure 1 and 2.
Figure 1. X-ray figure of pneumatocyst from different Eel development phase.

Figure 2. The swim bladder of Silver eel. (A) Silver phase; (B). Yellow phase; (C) Silver phase from dorsal view; (D) Silver phase from ventral view; (E) Silver phase from Lateral view.

Pneumatosis or swim bladder is an air-filled organ contained in the preanal cavity, composed by membranes attached to the intestine that has many blood vessels and retemeriable as an auxiliary organ to manage gas volume between the cavity and blood vessel. The swim bladder in the eel is composed in one space and is enclosed [9].
Table 1. Size measurement of eel swim bladder (Anguilla bicolor) based on the development stage of the eels of elver, yellow and silver.

| No. | Eel Phase | Total body length (mm) | Swim bladder length (mm) | Swim bladder width (mm) | Ratio  
|-----|-----------|------------------------|--------------------------|-------------------------|--------
| 1   | Elver     | 214                    | 27.37                    | 3.70                    | 0.12791 |
| 2   | Elver     | 237                    | 33.80                    | 4.65                    | 0.14260 |
| 3   | Elver     | 267                    | 33.28                    | 5.07                    | 0.12466 |
| 4   | Elver     | 285                    | 37.68                    | 7.57                    | 0.13219 |
| 5   | Elver     | 356                    | 47.13                    | 8.59                    | 0.13240 |
| 6   | Yellow    | 496                    | 68.99                    | 12.40                   | 0.13910 |
| 7   | Yellow    | 514                    | 71.03                    | 17.97                   | 0.13819 |
| 8   | Yellow    | 526                    | 74.90                    | 18.51                   | 0.14240 |
| 9   | Yellow    | 615                    | 87.03                    | 17.66                   | 0.14151 |
| 10  | Silver    | 744                    | 102.83                   | 30.07                   | 0.13821 |
| 11  | Silver    | 746                    | 97.05                    | 35.12                   | 0.13009 |
| 12  | Silver    | 747                    | 98.28                    | 30.83                   | 0.13157 |

The elver phase is the first phase of eel after migration from sea to the fresh water, with the body length of elver phase varies from 10 cm to 40 cm. Measurement result in this study exhibit that, the size of the elver was in between 20 cm to 35 cm and the size of the swim bladder were 27 mm to 47 mm. Yellow phase is the most active phase of the eel, which most of its activity was for feeding. In this yellow phase, the growth of eel occurs rapidly, its body length can reach more than 70 cm and the swim bladder could growth up to 30 mm. The silver phase is a mature phase that has undergone silvering process. In this phase, eel can be up to 150 cm in size. In this study, the silver phase size ranged from 74 cm to 100 cm, while the yellow phase ranged is around 40 to 60 cm. The ratio of swim bladder to the body length in each phase ranges is around 12-14%.

The regression analysis between eel body length and eel swim bladder length (Figure 2) show a regression equation of $Y = 0.1363x - 0.3373$, where the $x$ is the eel body length and $Y$ is the swim bladder length, with a value of $R = 1$, which means the relationship of the eel body length to the swim bladder length is very strong. the $R^2 = 0.99$ means that eel body length contributes 99% to the swim bladder length.

Figure 3. Regression of eel body length and eel swim bladder length.
The measurement of acoustic backscattering of eel showed that eel with a longer swim bladder length gave greater values of **Target Strength** (Table 2). This can be seen in sample no. 1 where eel with total body length 450 mm, and swim bladder length 50 mm has a TS value of -41.78 dB, for eel samples no. 8 with 350 mm eel body length and 21 mm swim bladder length has a TS value of -48.61 dB. This shows that the longer the total body eel, the longer swim bladder they had. It is assumed that the longer swim bladder the more gas volume in the bladder. The greater volume of the swim bladder will contribute to the higher value of TS, vice versa. The correlation between swim bladder size and TS Value were presented in Figure 3, which can be seen that the eel’s body length trend was followed by the swim bladder length and the value of TS. The longer eel body, the longer swim bladder and the higher the TS value too [4].

**Table 2.** Eel (*Anguilla bicolor*) target strength value.

| Eel sample | Eel Body Length (mm) | Eel Swim bladder Length (mm) | TS value (dB) |
|------------|----------------------|----------------------------|--------------|
| 1          | 450                  | 50                         | -41.78       |
| 2          | 400                  | 30                         | -45.61       |
| 3          | 380                  | 28                         | -46.27       |
| 4          | 350                  | 25                         | -50.64       |
| 5          | 430                  | 40                         | -43.76       |
| 6          | 320                  | 25                         | -50.84       |
| 7          | 430                  | 30                         | -44.93       |
| 8          | 350                  | 21                         | -48.61       |
| 9          | 350                  | 24                         | -48.44       |
| 10         | 430                  | 30                         | -44.8        |
| 11         | 300                  | 22                         | -51.01       |

4. Conclusion
This study shows that the *Anguilla bicolor* swim bladder was elongated and consists of one chamber and described as a closed swim bladder. There was a close relationship between eel body length and swim bladder length. The acoustic study results show that eel with longer body length have longer swim bladder and have larger TS value while the smaller body length of eels have smaller swim bladder lengths, and smaller TS values.

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