Swimbladder on Fish Target Strength

By SUNARDI

ResearchGate

Swimbladder on Fish Target Strength

Article · August 2008
DOI: 10.12928/telkomnika.v6i2.561 · Source: DOAJ

4 authors, including:

Sunardi Sunardi
Ahmad Dahlan University

Jafri Din
Universiti Teknologi Malaysia

SWIMBLADDER ON FISH TARGET STRENGTH

Sunardi[1], **Anton Yudhana**[2], **Jafri Din**[3], **Raja Bidin Raja Hassan**[4]
[1, 2, 3]Faculty of Electrical Engineering, Universiti Teknologi Malaysia
Skudai 81310 Johor, Malaysia
[1, 2]Electrical Engineering Department, Universitas Ahmad Dahlan
Umbulharjo 55164 Yogyakarta, Indonesia
[4]Marine Fishery Resources Development and Management Department
Kuala Terengganu 21080 Terengganu, Malaysia
e-mail: sunargm@yahoo.com

Abstrak

Paper ini membahas kekuatan target (target strength, TS) untuk Selar boops (Oxeye scad) dan Megalaspis cordyla (Torpedo scad), yaitu ikan yang paling komersial di Malaysia. TS dapat ditentukan dari pengukuran in situ dan perhitungan akustik model ikan. Nilai TS, kedalaman, dan posisi (xyz) dari ikan target dapat dilihat dari echogram menggunakan FQ-80 Analyzer dengan pengukuran in situ. Citra sinar-X dapat digunakan untuk mengembangkan model ikan akustik. Persentase panjang dan luas permukaan swimbladder terhadap tubuh ikan Selar boops lebih dari Megalaspis cordyla dapat diukur setelah proses sinar-X. Persentase lebar dan volume swimbladders ke masing-masing ikan tak ada perbedaan signifikan. Data fisik swimbladder mendukung hasil dari pengukuran in situ dimana TS dari Megalaspis cordyla lebih besar dari Selar boops.

***Kata kunci**: kekuatan target, model ikan akustik, swimbladder*

Abstract

This paper discusses of target strength (TS) for the Selar boops (Oxeye scad) and Megalaspis cordyla (Torpedo scad), the most commercially fish in Malaysia. TS can be determined from in situ measurements and acoustic calculation of fish model. TS value, depth, and position (x-y-z) of targeted fish can be viewed from echogram using FQ-80 Analyzer by in situ measurement. X-ray imaged can be deployed to develop the acoustic fish model. The percentage of length and upper surface area for swimbladder to body fish of Selar boops more than Megalaspis cordyla can be measured after X-ray process. The percentage of width and volume of swimbladders to its each body are no significantly difference for both fish. These data of swimbladder physic support the result of in situ measurement which TS of Megalaspis cordyla stronger Selar boops.

***Keywords**: acoustic fish model, target strength, swimbladder*

1. INTRODUCTION

Sonar (Sound Navigation and Ranging) is a general term applied to equipment and associated software that receives and possibly transmits sound. An echo sounder is an instrument used by fishers and researchers to transmit and receive sound vertically through the water column [1].

Size and reflectivity of sound are combined into a parameter called the backscattering cross section (σ_{bs}), which is essentially the acoustic size of the object. The backscattering cross section can be expressed as the amount of reflected sound intensity measured one meter away from the target, relative to the amount of energy incident upon the target. This parameter is called the target strength (*TS*) and expressed in dB.

$$TS = 10 \log_{10} (\sigma_{bs}) \quad (1)$$

Transmitter of an echo sounder or sonar sends out a beam of sound through a transducer (a device which converts one type of energy to another, in this case electrical energy to sound energy and vice versa). The pressure wave radiates spherically from its source with the intensity decreasing inversely with the square of the distance traveled. The strength of sound source, called source level (SL), is similarly measured a unit distance away and expressed in units of loudness relative to standard. In underwater acoustic, the unit of loudness is in decibel (dB).

Actually, there are two parameters of sound that relate to its loudness. One is pressure associated with the sound wave. Sound sensor (transducer) responds directly to pressure since the pressure changes are caused by the particle vibrations. The other measure of loudness is sound intensity, or the power/area associated with the sound wave. Sound intensity is proportional to the square of pressure.

When the sound wave encounters a density difference (i.e. target), an echo propagates radially outward from the target back to a receiver. Echoes returning to the sound source are termed backscattered sound. The amount of sound energy returned from a target is dependent on the choice and configuration of hardware, water characteristics, location, composition, and behavior of detected.

Aquatic organisms are complicated scatterers by nature of their shape (cylindrical or spheroid), deformation (curvature of the body and swimbladder), and composition (exoskeleton, muscle, bone, fat, presence and shape of swimbladder) [1-2].

Biological variation in backscatter of fish is depends on behavioral, morphological, ontogenetic, and physiological factors [3-4]. Natural variations in swimbladder volume and shape may cause variation in fish Target Strength (TS). The important factors that are assumed to alter the TS significantly are stomach content, gonads, body-fat content, pressure, and tilt angle [5].

Length, tilt, and depth influence the shape or orientation of the swimbladder and have a major influence on TS also influences the amount of sound reflected by a fish [6].

For typical fish lengths (1-100 cm), swimbladders scatter sound over a range of three orders of frequency magnitude (hundreds of Hz to hundreds of kHz). Backscatter intensities of fish without swimbladder are much lower than any swimbladdered species [7]. Acoustic scattering by a swimbladder is four or more times greater than the scattering by fish bodies at any given frequency [2]. An air-filled swimbladder can contribute up to 90% of backscattered sound [8-9].

This paper discusses of TS for the Selar boops (*Oxeye scad*) and Megalaspis cordyla (*Torpedo scad*), the most commercially fish in Malaysia, determined from *in situ* measurements and will be compared with swimbladder physic by using X-ray process.

2. RESEARCH METHODOLOGIES

In situ measurement has been deployed at the South China Sea, north of Redang Island, Terengganu, Malaysia. TS measurements had been conducted using Furuno FQ-80 Scientific Echo sounder which including in the Research Vessel of KK Senangin II with dual-frequency capabilities, low-frequency (38 kHz) and high-frequency (120 kHz) [10]. The transducer is positioned 2.8 m at the bottom of the vessel.

The FQ-80 must be properly calibrated in order to measure biomass effectively. The calibration is performed using a “calibration sphere” which has a precise TS value. The net cage size of 3m x 3m x 3m was placed under transducer and below of the Research Vessel as shown in Figure 1.

The first step of deployment fish acoustic model is to know about morphology of fish and its swimbladder. We had been deployed X-ray imaged of Selar boops and Megalaspis cordyla at Health Centre of Universiti Teknologi Malaysia. Fish morphology, position, and size of swimbladder can be viewed from X-ray images, as shown in Figure 2.

Anatomical variation in lateral and dorsal was compared by measuring upper surface area using swimbladder digitized file, (as shown in Figure 3). Frequency-dependent changes in the magnitude of backscatter for the entire fish are primarily due to the morphology of the swimbladder; oscillations in scattering magnitudes are primarily due to the fish body. The frequency-dependent oscillations also depend on the aspect of the swimbladder relative to the incident sonar beam.

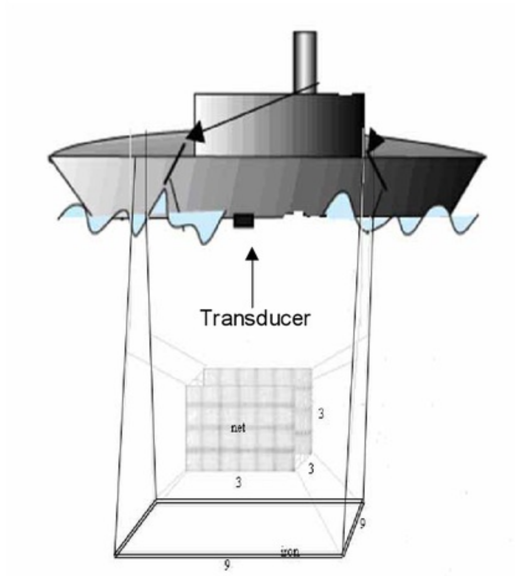


Figure 1. Net deployment at below of the research vessel

Figure 2. X-ray imaging for fish

Sound-scattering characteristics of swimbladdered fish differ from those of similar sized zooplankton. Gas-filled swimbladders resonate sound at wavelength (λ) that are many times larger than the length of fish (L). The backscattering cross section (σ_{bs}) from any fish is depends on acoustic carrier frequency over a large range of L/λ.

TS at depth were examined by using Boyle's law to model swimbladder compression at depth. Swimbladder volume reduction due to increasing pressure at depth was developed using Boyle's law and by varying the ratio of dorsal to lateral compression [11].

The diversity of acoustic backscatter models and the range of commercially available sonar frequencies emphasize the need for a general acoustic model of aquatic organisms. Presence, structure, and orientation of swimbladder in fish are species dependent [2].

Figure 3. Swimbladder observation after X-ray process

3. RESULTS AND DISCUSSION

In situ measurement of Selar boops and Megalaspis cordyla had been conducted. The range of fish targeted and the average of single TS detected at low/high frequency as shown in Table 1. No significantly differences of depth and TS for both fish, but Megalaspir cordyla need less of source level. In other words, TS of Megalaspis cordyla is higher than Selar boops.

After *in situ* measurement, total length, fork length, width, and body weight has been measured as shown in Table 2. From this fact, Megalaspis cordyla is larger than Selar boops. Fish images at lateral view had been taken from digital camera as shown in Figure 4. Individual fish can be anesthetized to suppress movement while imaging. Fish were radiographed dorsally and laterally using X-ray. Figure 5 and Figure 6 both consist of images taken from X-ray, lateral and dorsal view. From X-ray images, morphology of fish body and its swimbladder can be viewed.

Table 1. TS data from *in situ* measurement

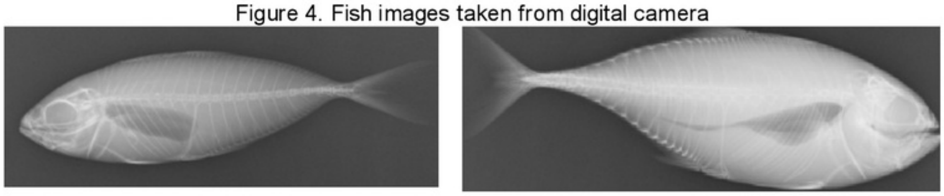
Variable	Selar boops	Megalaspis cordyla
Source level (dB)	236	225
Range of fish depth (m)	6.98-7.69	8.44-10.99
TS average at low frequency (dB)	-44.49	-45.34
TS average at high frequency (dB)	-43.96	-43.06

Table 2. Size of fish

Variable	Selar boops	Megalaspis cordyla
Total length (cm)	16	23
Fork length (cm)	13	19
Width (cm)	4.5	5
Weight (gram)	50	135

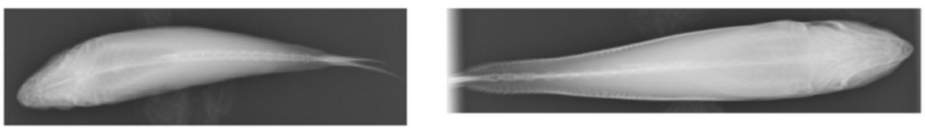
(a) Selar boops (b) Megalaspis cordyla

Figure 4. Fish images taken from digital camera



(a) Selar boops (b) Megalaspis cordyla

Figure 5. Fish images taken from X-ray (lateral view)



(a) Selar boops (b) Megalaspis cordyla

Figure 6. Fish images taken from X-ray (dorsal view)

For each image, the body and swimbladder were traced, scanned, and digitized. To represent a fish body and swimbladder in three dimensions, dorsal and lateral points can be elliptically interpolated. Soft X-ray images of fish are shows the flesh, skeletal elements, and the swimbladder. The gas-filled swimbladder has a dark image because air absorbs the X-rays less than flesh. Length, width, volume, and upper surface of swimbladder for two fish then can be measured and had been compared with its body as shown in Table 3. Swimbladder's angle to the body length had been measured too.

Table 3. Swimbladder to fish body ratio

Variable	Selar boops	Megalaspis cordyla
Swimbladder : body length	3.6:13 = 28%	8.5:19 = 45%
Swimbladder : body width	2.3:4.5 = 51%	2.5:5 = 50%
Swimbladder : body volume	3.4:61 = 5.6%	5.1:113 = 4.5%
Swimbladder : upper body surface	5.9:43.9 = 13.5%	14:71 = 19.7%
Swimbladder's angle to body length	18^0	8^0

The percentage of width and volume of swimbladders to its each body are no significantly difference for both fish. But, the percentage of length and upper surface area for swimbladder to body fish of Megalaspis cordyla is more than Selar boops. Upper surface area of swimbladder for Megalaspis cordyla is wider and less tilt angle than Selar boops. From physical swimbladder facts, we can suggest that TS of Megalaspis cordyla. This assumption is the same with results from *in situ* measurement.

4. CONCLUSION

In situ TS measurement using sonar has been deployed. TS value, depth, and position of fish targeted can be viewed from echogram by Top view of TS using FQ-80 Analyzer. X-ray imaged has been deployed. The percentage of length and upper surface area for swimbladder to body fish of Selar boops more than Megalaspis cordyla. The percentage of width and volume of swimbladders to its each body are no significantly difference for both fish. Deeply analysis for all about these data to calculation of TS value based on X-ray images can be deployed in the next research by using acoustic fish model.

ACKNOWLEDGMENT

Thanks for Research Management Centre (RMC) Universiti Teknologi Malaysia (UTM) for management support of Science Fund (Vot. 79011). The Health Centre UTM is thanked for assisting X-rays.

REFERENCES

[1]. J.K. Horne, "**Acoustic Approaches to Remote Species Identification: a Review**", Fish. Oceanogr. Vol. 9(4), pp. 356-371, 2000.
[2]. J.K. Horne and C.S. Clay, "**Sonar Systems and Aquatic Organisms: Matching Equipment and Model Parameters**". Can. J. Fish. Aquat. Sci, vol. 55, pp. 1296-1306, 1998.
[3]. K.G. Foote, "**Averaging of Fish Target-Strength Functions**", Journal of the Acoustical Society of America, vol. 67, pp. 504-515, 1990.
[4]. E. Ona, "**Physiological Factors Causing Natural Variations in Acoustic Target Strength of Fish**", Journal of the Marine Biological Association of the United Kingdom, vol. 70, pp. 107-127, 1990.
[5]. R. Jorgensen, "**The Effects of Swimbladder Size, Condition, and Gonads on the Acoustic Target Strength of Mature Capelin**". ICES Journal of Marine Science, vol. 60, pp. 1056-1062, 2003.
[6]. E.L. Hazen and J.K. Horne, "**A Method for Evaluating the Effects of Biological Factors on Fish Target Strength**", ICES Journal of Marine Science, vol. 60, pp. 555-562, 2003.
[7]. S. Gauthier, J.K. Horne, "**Potential Acoustic Discrimination within Boreal Fish Asemblages**". ICES Journal of Marine Science, vol. 61, pp. 836-845, 2004.
[8]. K.G. Foote, "**Importance of the Swimbladder in Acoustic Scattering by Fish: a Comparison of Gadoid and Mackerel Target Strengths**", Journal of the Acoustical Society of America, vol. 67, pp. 2084-2089, 1990.
[9]. K. Sawada, Y. Takao, and Y. Miyanohana, "**Introduction of the Precise Target Strength Measurement for Fisheries Acoustics**", Turk J Vet Anim Sci., vol. 26, pp. 209-214, 2002.
[10]. Furuno Electric, Co. Ltd**., "Furuno FQ-80 Scientific Echo Sounder**", Nishinomiya, Japan.
[11]. E.L. Hazen and J.K. Horne, "**Comparing the Modeled and Measured Target Strength Variability of Walleye Pollock (Theragra chalcogramma)**", ICES Journal of Marine Science, vol. 61, pp. 363-377, 2004.

Swimbladder on Fish Target Strength

ORIGINALITY REPORT

6%

SIMILARITY INDEX

PRIMARY SOURCES

1	pastebin.com Internet	53 words — 2%
2	journal.uad.ac.id Internet	21 words — 1%
3	community.uthm.edu.my Internet	15 words — 1%
4	Nadzri Seman. "In situ fish Target Strength measurements compared with X-ray images of swimbladder", 2008 International Conference on Computer and Communication Engineering, 05/2008 Crossref	14 words — 1%
5	xplorestaging.ieee.org Internet	11 words — 1%
6	ccsenet.org Internet	9 words — < 1%

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	ON		