TARGET STRENGTH MEASUREMENTS OF GILTHEAD SEA BREAM WITH SINGLE-BEAM QUANTITATIVE ECHOSOUNDER

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Abstract
Target strength (TS) measurements for ventral aspect of gilthead sea bream (*Sparus aurata*) have been performed in a scaled aquaculture cage. The measurements have been made with a Simrad EK-60 scientific echososunder working at 200 kHz with a single-beam composted transducer specific of the Simrad ES15 echosounder (aperture of 30 degrees), designed for aquaculture control among other applications. Linear relationships of *TS* versus the logarithms of length have been derived. It must been underlined the obtaining of high values of the correlation coefficients and a high resolution of the ventral expressions for fish size predictions. Lower mean values of *TS* distributions are obtained for single-beam mesurements respect split-beam measurements as expected.

Keywords: target strength, , single-beam, gilthead sea bream.

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1 Introduction

The worldwide decline of ocean fisheries stocks and the increasing demand of marine products are the main causes of the rapid growth of aquaculture [1]. For the proper performance of a fish farm is essential to know the growth rate and the total biomass of fish. In order to estimate these parameters, it is common the use of intrusive techniques in sea cages which are costly and inaccurate. In addition, they can induce stress for the fish and increase its mortality [2]. It is for this reason that there is a growing interest in developing and implementing non-invasive techniques based on optical or acoustic systems to determine size, biomass and abundance of fish in sea cages [3].

The target strength (TS) of fish becomes an important role in acoustic systems as indirect estimation of length or mass of individuals. TS measurement is especially significant for species with swimbladder, like cod (*Gadus morhua*) or gilthead sea bream (*Sparus aurata*), because it contains gas inside, resulting in an increase of more than 90% of TS [4]. Several studies have been carried out on the relationship between TS and total body length for different species such as salmon (*Salmo salar*) [5] or cod [6], performing acoustic detection by split-beam echosounders. Soliveres studied the use of split-beam echosounders for indirect estimation of biomass and size of gilthead sea bream from ventral and dorsal TS, with gain compensation and without it [3].

The intensity of scattered echo, therefore the TS, depends on fish size, activity, orientation and position within the acoustic beam [7]. Split-beam data include phase information, angular position of the target relative to the transducer so it is possible to compensate TS values by transducer directivity. Since single-beam data does not provide phase information, uncompensated TS is used. Nevertheles, the latter are cheaper, which is especially beneficial if permanent installation of this technology is intended in sea cages. That is why an interest on the development of a method capable of indirect determining of fish size and biomass from TS by single-beam echosounder has been developed.

There are not many studies about fish detection by single-beam echosounder in sea cage. Guillard and Gerdeaux [8] performed *in situ* determination of TS distribution of roach (*Rutilo rutilo*), measured by single-beam echosounder, in order to prove the reliability of the estimation of TS through the Craig Forbes algorithm [9] comparing it with theoretical estimation by the equation of Love [10]. Rudstam and Hansson [11] contrasted TS distributions and fish density obtained by using single-beam echosounder with those obtained using split-beam. Both methods were comparable although first estimations were lower.

The aim of this study is to determine the relationship between size of gilthead sea bream and TS from ventral measurements by a 200 kHz single-beam echosounder.

2 Material and methods

TS of four different sizes of gilthead sea bream was measured by a single-beam echosounder (Simrad, 200-28CM). Fish groups defined by size (15.27, 16.76, 18.70 and 22.24 cm) were formed from 20 to 25 individuals. The measures were taken inside a floating cage in Gandia's port waters, which was 5 m diameter and 4 m high. The transducer was placed in the bottom faced upward to measure ventral TS. The emission frequency was 200 kHz, with ping duration of 64 μs, a sample interval of 50 ms, a band width of 18.76 kHz, and a power of 50 W. The beam aperture was 30º, considering an intensity drop of -3 dB according to transducer directivity.

Every group was measured during about 70 hours and the temperature was recorded daily. Salinity and pH were considered constant (36 ‰ and 8, respectively).

The preliminary study for classification of fish by size and the experimental process were carried out in [1].

Data processing was carried out using Sonar5-Pro and Matlab softwares. TS values were obtained applying a 40 log R TVG function. The analysis range was from 1 m to the surface, the latest determined by bottom detection tool. A target tracking tool was used to detect echoes from a single fish. In order to take the best quality traces four criteria were defined: -46 dB TS threshold, minimum target length of 35 pings, maximum ping gap of 1 ping and gating rate of 5 mm.

It was decided to work with maximum TS (TSm) of each track due to the lack of phase information needed to TS compensation. Distributions of TSm were obtained, together with mean TSm and standard deviation, for each size group.

Linear regression analysis between ventral TSm and logarithmic of body length (log L) was performed with the objective of determine the relationship between them according to

$$TS = a \cdot \log L + b \quad (1)$$

where *a* and *b* are constant for given fish species [12]. It would allow fish size estimation from TS.

3 Results and discussion

The four lengths of gilthead sea bream have been acoustically analyzed. Table 1 shows the number of tracks analyzed, TSm results and standard deviation obtained for each size class.

Table 1 – Results of analysis performed on the measurements obtained by 200 kHz single-beam .It is shown the number of analyzed tracks, the mean TSm and the standard deviation for each size of gilthead sea bream.

		TSm (dB)	
L (cm)	*Nº of tracks*	*μ*	*σ*
15.27	242	-40.8303	1.7349
16.76	1329	-39.4987	2.0855
18.70	4849	-37.3800	2.2715
22.24	1284	-37.5694	2.7517

Few tracks have been collected from the smallest size. A greater number of them is required to do a representative analysis of TS distribution. However the study has been carried out with available track amount.

Growing TS with increasing length was expected according to equation 1. Nevertheless, 18.70 cm class shows a mean TSm slightly higher than 22.24 cm class. Standard deviation does grow with increasing length, which was also expected due to the greater possibility to detect a wider range of echo level with a larger size [3].

Relative frequency distributions of TSm for each size class are shown in Figure 1. The group of the smallest length shows a bias toward smaller TS. It seems to be due to the established threshold, which restricts the minimum values accepted in the analysis.

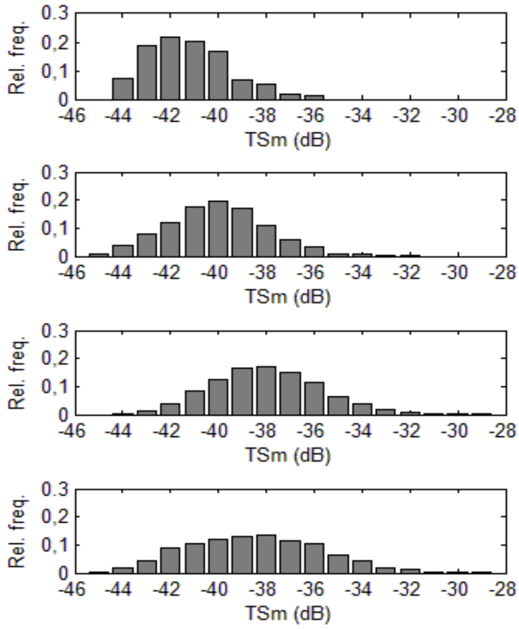

Figure 1 – Relative frequency distributions of TSm for each size class of gilthead sea bream exposed from lowest to highest length from top to bottom.

Table 2 shows the result of lineal adjustment between TSm and log L. The slope takes a value around 20 and the intercept around -65 dB. In Figure 2 the relationship between the two variables is plotted. It may suggest that there is a correlation, considering that a larger deviation of 18.70 cm class is observed. However it does not show a statistically significant adjustment.

Tabla 1 – Results of least-squares linear adjustment between TSm and log L. Slope, a, intercept, b, determination coefficient, R^2, critical F value and root mean squared error, RMSE.

*TSm = a * log L + b*	
a	20.5434
b	-64.6479
R^2	0.7657
Critical F value	0.1250
RMSE	0.4868

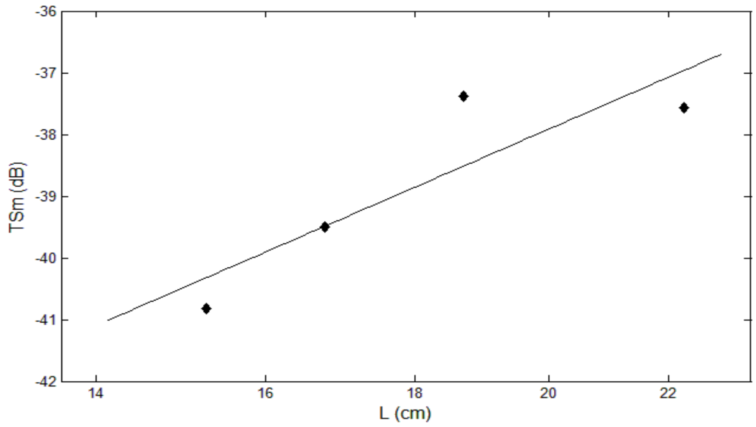

Figura 2 – Relationship between TSm and log L. Length are shown in cm instead of log L.

If these results are compared with those obtained by Soliveres [3] for maximum uncompensated TS measured by a 200 kHz split-beam echosounder applying a maximum gain compensation of 12 dB, it is observed a function quite similar with a better correlation.

A relationship between TS and body length is provided, nevertheless, in order to obtain more conclusive results, it would be advisable to complement this investigation applying different analysis methods, including single-beam data correction, as well as one more size of gilthead sea bream and analyzing more tracks for each group.

It must be taken into account that the results have been obtained under conditions different to those of production. Under production conditions, the transducer should be deeper and the density and there is a high fish density. For such reason it would be convenient to measure inside real sea cages. It would be also advisable to determine the dorsal aspect of gilthead sea bream in order to check which is the best disposition of both systems.

4 Conclusion

It has been determine a function which expresses the relationship between the gilthead sea bream body length and the TS, obtained by means of ventral detections with 200 kHz single-beam echosounder. It would be desirable perform an analysis extension to show more conclusive results to prove the possibility of determining the fish size from its acoustic register with single-beam.

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