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## GROWING MONITORING IN SEA CAGES: TS MEASUREMENTS ISSUES

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### Abstract

*Hydroacoustic monitoring of fish growing in sea cages needs of an accurate relationship between fish size and target strength (TS) for every species of commercial interest. We discuss the conditions for TS measurement in near range conditions in sea cages for the case of the dorsal and ventral aspects of gilt-head sea bream and bluefin tuna.*

*Gilthead sea bream dorsal and ventral TS distributions, obtained with a split beam echosounder, are uni-modal and the same results are derived for single beam data analysis when specific processing threshold criteria are applied. The expected linear relationship between the average TS and the logarithm of fish length is only found for the ventral case, being more accurate the uncompensated TS single beam analysis, probably due to near range errors.*

*Bluefin tuna dorsal measurements performed in a fattening farm from February to July did not show a significant variation of TS distributions, and we propose a synchronized system of echosounder and video recordings, in order to relate target strength and orientation and size of specific tuna in the acoustic beam. Preliminary results indicate that only ventral TS values correlate properly with tuna size.*

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### Introduction

In the recent years, marine aquaculture has grown considerably, due to the reduction of fish resources and to the rising demand of seafood, in the search of a sustainable exploitation of living resources. Nowadays aquaculture provides 50% of worldwide seafood human

consumption. Spain is the third producer of cultivated fish in the European Union (EU), mainly due to gilthead sea bream (*Sparus aurata Linnaeus*, 1758). Growing rate and total biomass estimation are essential clues for the fish farms production management, as well as for other management tasks like classification and distribution of fishes, incorporation of new batches, daily feeding rates calculation, etc. Different technologies have been used to perform these estimations (stereoscopic video cameras, passing-through frames, etc), but one of the most promising and versatile approaches is provided by the use of acoustic techniques, in particular of ultrasonic echosounders. The monitoring of fish growing needs of an accurate relationship between fish size and target strength (TS), and the near range conditions inside the cages can play an important role. Few studies have been performed in fish cages, but those realised with salmons (Knudsen et al., 2004), demonstrated that the average TS (only when measured from ventral aspect) correlate properly with fish size, and that a split beam echosounder could display fish tracks, even when the fishes were not totally insonicated. We want to extend those studies to the Mediterranean species and their intensive production conditions.

Another Mediterranean aquaculture hotspot is the fattening of captured bluefin tuna (*Thunnus thynnus Linnaeus*, 1758), which has become object of international debate because of the risk of the species extinction. An adequate tool for fattening monitoring would have important benefits for the producers, and the necessary TS studies could lead to the obtaining of a methodology to estimate and to record the catches of wild tuna during the transfer process from the net to the transport cage.

## Material and methods

First, we report the experiments of TS measurements with few gilthead sea bream specimen in a small cage placed in Gandia harbour (Spain), with a diameter of 3 m and 2.7 m depth, where the fishes could swim freely. In Table 1 the description of the different size classes with few specimen (to avoid echo superposition and therefore TS overestimation) is given.

Size class	1	2	3	4	5
Nº fishes	2-4	2-4	2-8	2	2-4
Mass (g)	158.8	178.7	194.4	235.7	268.7
Total length (cm)	20.3	21.1	21.7	23.1	24.2
Var. coef. Length (%)	0.25	0.42	0.51	0.55	0.42

Table 1. Biometric data for each gilthead sea bream size class

We used a Simrad EK60 split beam echosounder working at 200kHz and the 7° transducer mounted in the centre of the cage with the beam oriented vertically downward-looking for dorsal aspect (Figure 1) and in the bottom (upward-looking) for ventral measurements. Transmitted power was 90 W, pulse length 64 µs, and ping interval about 20 ms. The transducer/echosounder system was calibrated with a copper sphere of 13.7 mm in diameter.

The obtained data were processed using Sonar 5 Pro (Balk, 2009) in two ways: using the angular information obtained by the split-beam system to identify single echoes and pure echo level and duration analysis.

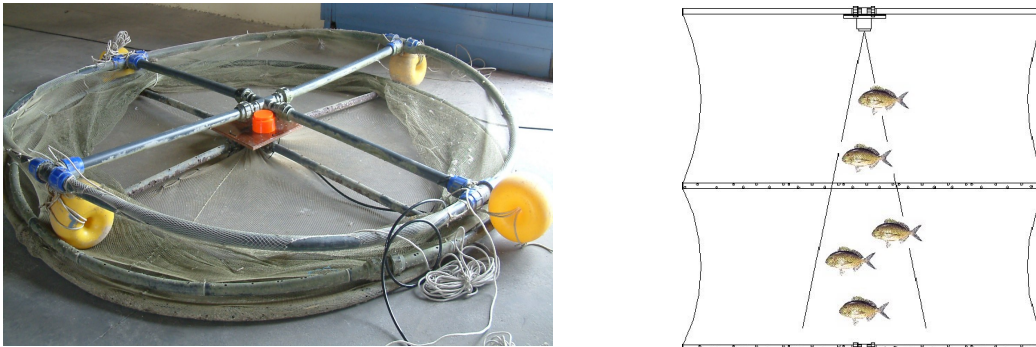


Figure 1. Cage detail and measurement scheme with gilthead sea breams.

Also we present an analysis of the dorsal measurements of bluefin tuna performed by the Spanish Institute for Oceanography (IEO) during the months from February to July of 2005 in an experiment oriented to record the behaviour and possible spawning activities of captured tuna (de la Gandara, 2005). The cage was monitored with a downward looking single beam EY500 @38 kHz, placed at the surface in the centre of the cage. The biometric information of the animals were only available at the end of the experiment when they were sacrificed. We have analysed the recordings with Sonar 5 Pro to extract TS uncompensated distributions from the elliptical single beam data.

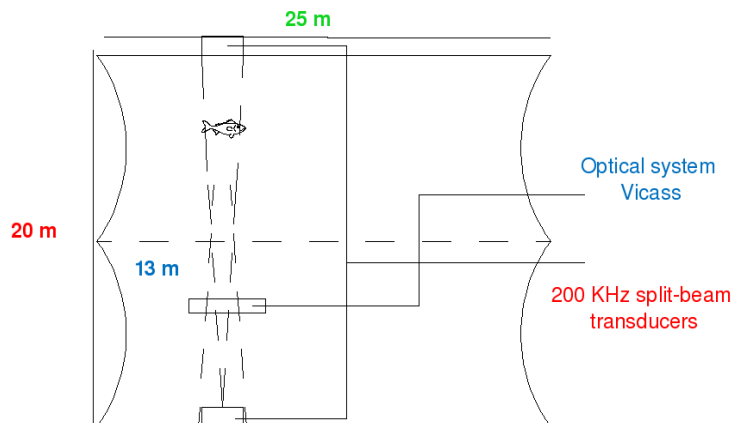


Figure 2. Measuring scheme with synchronized EK60 with two multiplexed transducers and stereoscopic video system upward-looking.

In parallel to this analysis we implemented an experimental set-up to measure dorsal and ventral TS of specific specimens of bluefin tuna in cages, identified and measured in length and width with a video stereoscopic system. Figure 2 shows the measuring scheme, with two multiplexed 200kHz transducers (surface and bottom) driven by an EK60, and a Akvasmart VICASS system upward-looking, both controlled by the same computer and therefore

synchronized in time. The echoes were related to specific video frames and we obtained the desired TS vs tuna size information.

## Results

Figure 3 shows the average TS measured for each size class both for ventral and dorsal aspects of gilthead sea bream, when considering the target angular information given by the split-beam echosounder. It is noticeable that dorsal aspect does not correlate at all with size whilst ventral TS does. In Figure 4 we have depicted for the smallest and biggest size classes the dependence with distance of the TS, evaluated for each 10 cm layer. We must point out that the variations in TS depend more on the number of valid detections than on the distance to transducer.

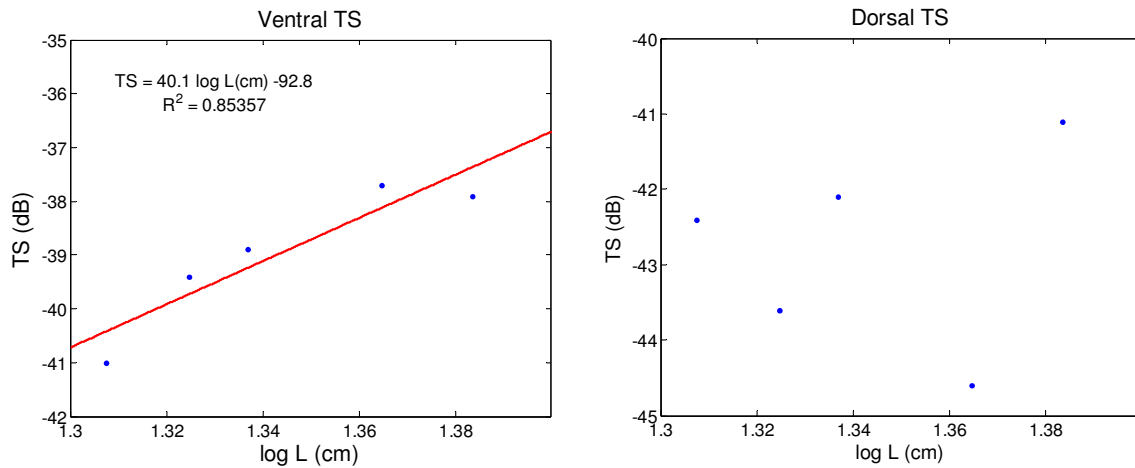


Figure 3. Average TS from ventral (left) and dorsal (right) aspect; data obtained with a split-beam echosounder Simrad EK60 at 200 kHz and processed with Sonar 5 Pro.

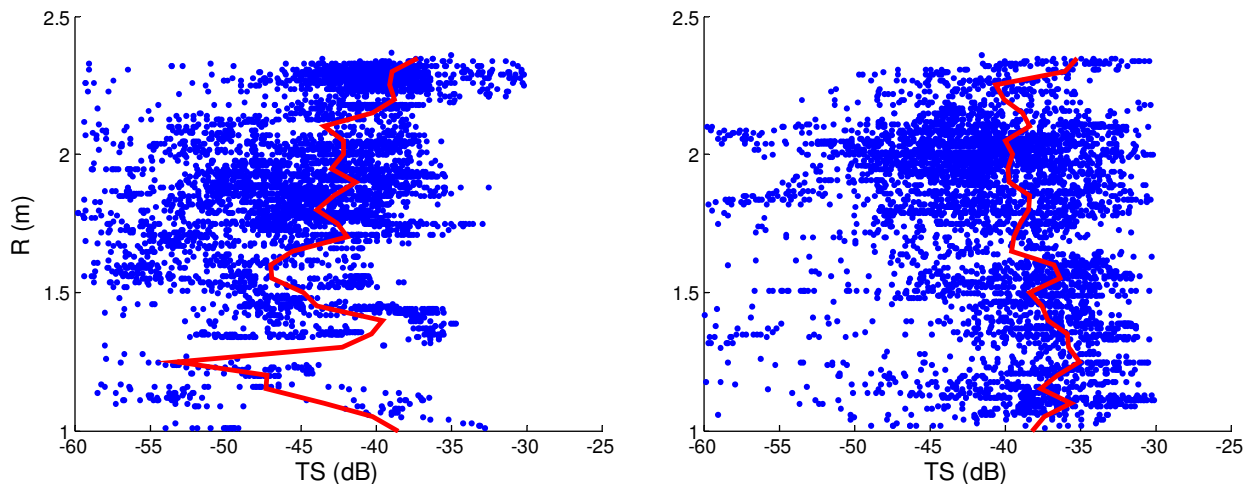


Figure 4. TS dependence with distance, ventral aspect for classes 1 (left) and 5 (right).

The analysis of the data was performed ignoring the angular information, that could be affected for the near range conditions and the relative size of fishes versus the beam aperture

offered a better linear correlation, mainly when applying the threshold criterion before selecting the individual echoes by their duration.

Figure 5 shows the TS distribution of the tracks detected in the tuna dorsal data at 38 kHz for different months during the stage in the fattening cages. No relevant changes were observed and the average TS remained between 24 and 25 dB for animals with an average fork length of 182 cm with a standard deviation of 7%, and an average weight of 120 kg with a standard deviation of 24%.

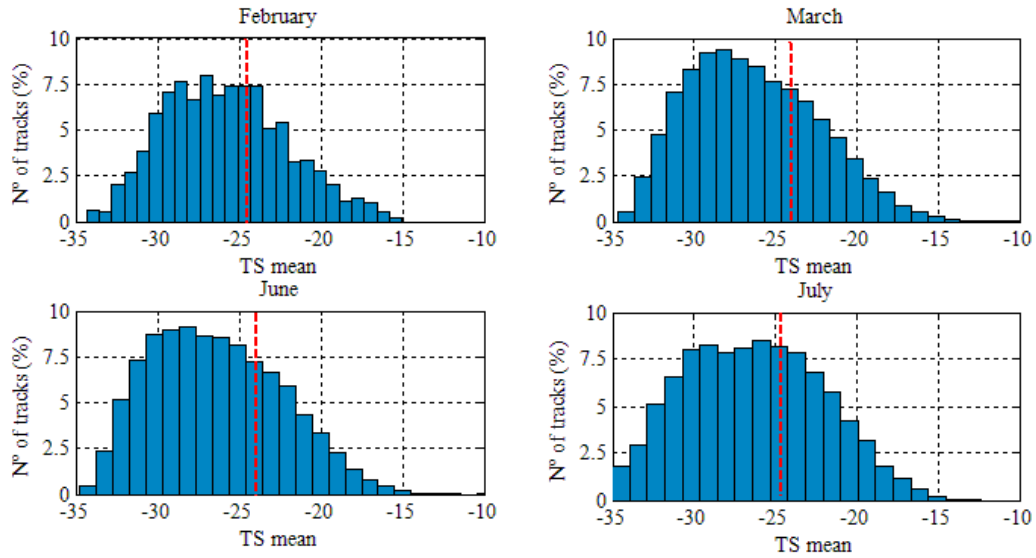


Figure 5. Bluefin tuna TS distributions for four months in the fattening cages

The combined use of video cameras and a 200 kHz split-beam echosounder provided the direct measurement of tuna size and TS; Figure 6 shows both an example of video recording and related echogram and a first ventral TS vs. length relationship, together with the evolution of TS with distance. The dorsal measurements did not correlate properly with size.

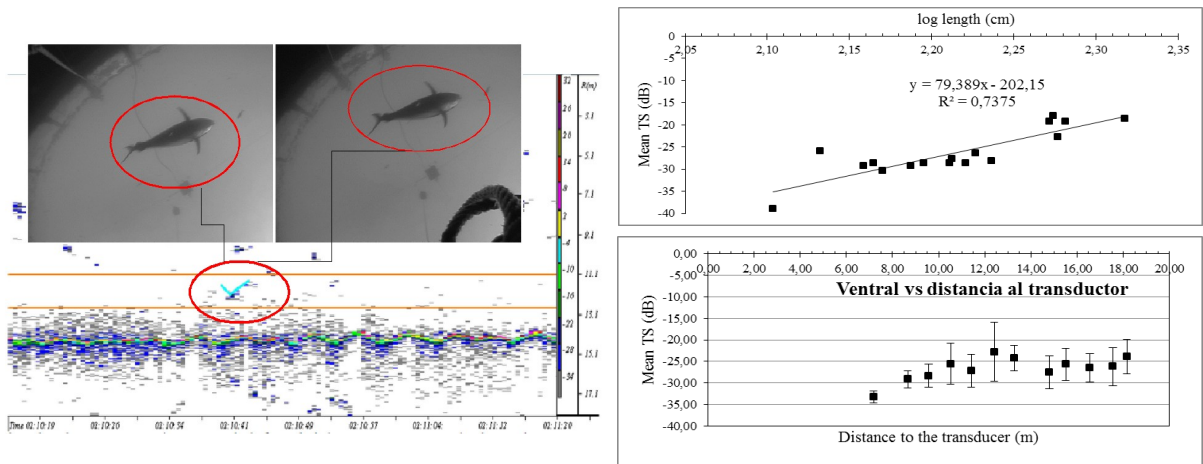


Figure 6. Bluefin tuna specific TS vs its individual length at 200kHz; preliminary results.

## Discussion

The TS dependence with range was expected due to several reasons: fish partially insonicated, bias introduced by the angular compensation from no punctual fishes, and measurements at the near field from the fish. Nevertheless, for the case of the gilthead sea bream we have not observed clear trends, but a strong dependence with the number of valid detections. One could expect to find an increasing mean TS with distance, and this evolution to be of the same order for all classes, since the differences in size of the animals were not very big.

The dependence with distance for the case of the bluefin tuna seems to be more clear, but also the size of the animals is much bigger in comparison with the same beam of the measurements at 200 kHz. This seems to confirm to a certain extent the hypothesis.

A clear point is the different behavior of the scattered field when observed from the dorsal and ventral aspects. The role of swimbladder and the possible effects on the measurements of the point size violation, phase errors and the near field of the fishes must be studied for a full comprehension of the problem.

## Conclusions

The results obtained both for gilthead sea bream and bluefin tuna have confirmed that only ventral measurements of TS could provide a tool for growing monitoring as was shown for salmon cages. A single beam system could offer a good performance for such tasks .

Dorsal TS mean of the Bluefin Tuna with average size of 182 cm is between -24 and -25 dB, while the TS maximum is around -20.5 dB. All standard deviations of TS are around 20%, what reveals that the variations of dorsal TS of tuna along the feeding period are negligible and no correlation is found with the possibly obtained fattening.

Combined used of video sizing and synchronized echogram reveal as a promising tool for TS determination and its relationship with the fishes condition factor.

## References

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