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Horizontal target strength-size conversion equations for sea bass and gilt-head bream

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ABSTRACT

Horizontal hydroacoustics is a technique of remote fish detection that has proved to efficiently determine fish density and biomass in shallow or superficial waters. This non-intrusive technique could render better results than those obtained by conventional sampling when monitoring shallow waters. To apply this technique, we need equations that relate the amount of sound returned by fish, known as target strength (TS in dB), with their length (mm) or weight (g). This study presents horizontal conversion equations for the species gilt-head bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*), two of the most important species bred in aquaculture. Moreover, this study presents a new formula to calculate a mixed equation adjusted to the percentage of distribution of those species in case of mixed populations. The results in this research have been obtained by applying a simple setup that allows for high-quality acoustic data. These new equations will enable the application of this technique in order to estimate these species' density and biomass in shallow aquatic systems such as aquaculture ponds with semi-intensive production densities.

1. Introduction

Nowadays, aquaculture as a whole produces more than half of all fish consumed in the world. In southern European countries, gilt-head bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) are the most produced and consumed species (Apromar, 2016).

Quantity and biomass estimations of fish in ponds are essential for preparing the production and management plan of aquaculture companies. For example, feeding constitutes > 50% of production costs (Soliveres, 2015). This feeding estimation is based on the biomass of the ponds together with other factors, such as average fish size, time of year, water temperature, etc. The accuracy of these estimates allows for an optimization of the feeding processes and minimizes waste products, which improves the quality of water. In addition, the use of techniques that provide us with accurate estimates improves population management plans. This includes splitting the ponds, i.e. distributing the fish group from one pond into two different ponds in order to facilitate their growth and development as well as population monitoring.

Nowadays, in order to estimate fish biomass in shallow aquaculture ponds, managers conduct periodic samplings that usually give wrong estimates. They calculate the number of fish present in a pond as an approximation that takes into account the initial number of sowed fish and countable deaths. Biomass is estimated by multiplying this number by the average weight of fish captured by manual methods (Conti et al., 2006). In addition to not being accurate enough, this type of manual sampling causes a high level of stress in fish, which sometimes leads to pathologies and sudden deaths. Furthermore, these methods can monitor fish in normal production conditions, but they are not valid in exceptional situations where losses cannot be quantified, for example in cases of theft, predators or extensive deaths. In these cases, traditional methods cannot determine the quantity of fish remaining in the pond.

The results presented in this study belong to an extended project aimed at estimating biomass in fish production systems using non-invasive methods (PI_57052). Given that hydroacoustics is one of the most relevant existing capture-independent methods, applying it to shallow ponds would considerably improve fish's wellbeing. Unlike visual methods, hydroacoustics is also efficient when used in systems with poor visibility (Lucas and Baras, 2000; Simmonds and Maclennan, 2005; Kubečka et al., 2009) such as production ponds. However, hydroacoustics does not work properly in cases of very high densities. Therefore, it could only be used in production ponds with extensive or semi-intensive farming. Another advantage of hydroacoustics is that it studies the aquatic system at the exact moment when sampling is being performed, taking an instant picture of the situation in the pond.

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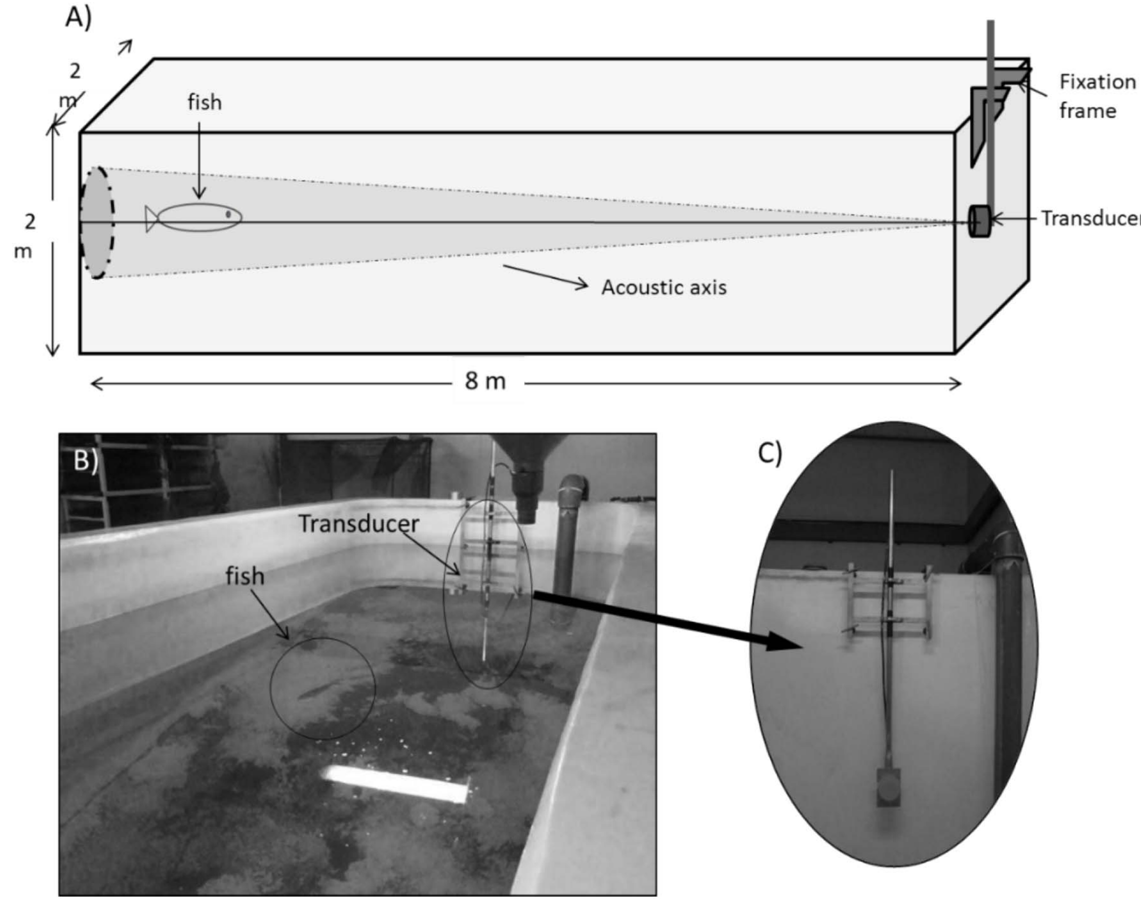

Fig. 1. A) Diagram of the experiment. B) Photograph of the experiment C) Photograph of the tranducer's frame.

Therefore, it would be useful even in the exceptional cases previously mentioned.

Horizontal hydroacoustics is a technique where sound is used to study aquatic ecosystems. Acoustic instruments (the echosounder) transmit and receive sound waves used to detect fish and other objects beyond the water surface (Simmonds and MacLennan, 2005). The key to properly interpreting hydroacoustic data is the target strength value returned by fish (TS in dB re $1m^2$). This value allows one to create conversion equations to translate the sound returned by fish (TS) into biological parameters that can be measured, such as length or weight. The use of these equations allows calculating the size and quantity of fish in an ecosystem (Lucas and Baras, 2000). Moreover, in horizontal applications, it has been proven that changes in TS are related to changes in the swimming direction of fish. Therefore, horizontal conversion equations need to be developed for the three main orientations: side, oblique and head/tail (Foote, 1980; Kubecka and Duncan, 1998; Hazen and Horne, 2003; Frouzova et al., 2005; Henderson et al., 2007; Kubilius and Ona, 2012; Rodríguez-Sánchez et al., 2015).

Despite the fact that some conversion equations already exist for several fish species (Burwen and Fleischman, 1998; Lilja et al., 2000; Frouzova et al., 2005; Boswell and Wilson, 2008; among others), these are not sufficient to meet the needs of hydroacoustics. General equations could be used to convert acoustic data. However, given that TS values are species-dependent, the results will be more accurate if species-specific equations are used when converting data. Consequently, this article is aimed at developing horizontal conversion equations for gilt-head bream (*Sparus aurata*) and European sea bass (*Dicentrarchus labrax*). Sometimes, ponds are composed by a mixture of these two species with known proportions. To calculate density and biomass in these situations, the equation of the species with a highest representation in the system is normally used. This paper also presents a simple method to create a mixed equation adapted to the percentage of these two species when surveying mixed ponds. All these equations will allow the application of this technique for routine estimations of density and biomass in shallow waters such as aquaculture ponds.

2. Material and methods

2.1. Experimental set-up

The experimental design to obtain the equations was conducted in the facilities of the company Pesquerías Isla Mayor S.A. (PIMSA, Spain), specifically in one of the tanks of the fattening room in its hatchery facilities. The experimental tank was a rectangular pool (2 × 8 × 2 m). A calibration test was performed before the start of the experiment in order to ensure that there were no significant echo returns coming from the pool. The test entailed performing a horizontal calibration and collecting recordings from the calibration sphere, which was a 13.7 mm copper sphere (TS = −45 dB) placed at seven different distances with respect to the transducer (meter by meter, from 1 to 7 m away from the transducer). The mean deviation in the expected TS was lower than 0.6 dB at every distance.

TS data was recorded with a Simrad EK60 scientific echosounder (Simrad Kongsberg Maritime AS, Horten, Norway) equipped with a 200 kHz circular split-beam transducer (ES200-7C). The transducer was placed on a stainless-steel clamping frame on one side of the pool. It was aimed horizontally, parallel to the water surface (Fig.1). The acoustic axis was located 1 m from the surface. The acoustic unit was calibrated with the calibration copper sphere according to the standard calibration method (Simrad, 2004). Echosounder settings are listed in Table 1.

The sound records of a total of 15 individual sea bass and 15