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NOTE

First descriptions of diurnal pelagic aggregations of the Argentine red shrimp (*Pleoticus muelleri*) using a broadband echosounder operating at multiple frequencies

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ABSTRACT. This is the first description of diurnal pelagic aggregations of the bottom-dwelling Argentine red shrimp (*Pleoticus muelleri*) registered with a broadband scientific echosounder. A pelagic trawl net and an underwater video camera were used to validate all the information presented in this paper. Shrimp aggregations were characterized by increasing frequency response, more evident at frequencies greater than 120 kHz. Identification of the acoustic signature of this resource is of particular interest for the development of new methodologies to complement the traditional swept area method of estimation.

Key words: Hydroacoustic, frequency response, echosounder.

Primeras descripciones de agregaciones pelágicas diurnas de langostino (*Pleoticus muelleri*) utilizando una ecosonda de banda ancha operando frecuencias múltiples

RESUMEN. Reportamos la primera descripción de agregaciones pelágicas diurnas de langostino (*Pleoticus muelleri*) utilizando una ecosonda científica de banda ancha. Toda la información presentada en este manuscrito fue validada por medio de una red de arrastre pelágica y una cámara de video submarina. Las agregaciones de langostino se caracterizaron por poseer una respuesta en frecuencia creciente, siendo más evidente a frecuencias superiores a 120 kHz. La identificación de la firma acústica de las agregaciones pelágicas de langostino es de particular interés para el desarrollo de nuevas metodologías que complementen la evaluación tradicional de este recurso, realizada a través del método por área de barrida.

Palabras clave: Hidroacústica, frecuencia de respuesta, ecosonda.

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The Argentine red shrimp, *Pleoticus mulleri* (Spence Bate, 1888) (Decapoda, Soleoceridae), is a crustacean with a wide latitudinal distribution in the southwestern Atlantic Ocean, ranging from southern Brazil (23° S) to Santa Cruz province (50° S), Argentina (de la Garza et al. 2017). The species has a wide bathymetric distribution, being found from 3 to 190 m deep. It is characterized by a benthic-demersal behavior during the day, hindering the acoustic detection of the species near the bottom. It is the fishery with the greatest impact on the Argentine economy due to its life cycle, high reproductive potential, resilience, and successful fishing management. It was the largest shrimp export in 2018, representing more than 60% of the total income of fishing currencies of the country (SSPyA 2023).

Several investigations have been conducted by the Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP) to evaluate changes occurring in the shrimp population. Hydroacoustic techniques are currently one of the most widely used tool for estimating species abundance and distribution in the pelagic environment (Simmonds and MacLennan 2007). In Argentina, this methodology is basically used for the estimation of the abundance of important fishing stocks such as anchovy (*Engraulis anchoita*), mackerel (*Scomber scolias*), Fuegian sprat (*Sprattus fuegensis*) and blue whiting (*Micromesistius australis*) (Cabreira et al. 2009, 2011; Casarsa et al. 2019). Acoustic techniques have been used to study a variety of crustaceans, including krill (*Euphausia superba*), the most common and important species in the Antarctic ecosystem (Madureira et al. 1993; Cox et al. 2010; Valdez et al. 2022). In Argentina, acoustic techniques were utilized for the study of pelagic concentrations of *Grimothea gregaria* (Diez et al. 2012, 2016).

During an environmental survey carried out on December 2018 aimed to characterize the frontal system of Peninsula Valdés (Figure 1), daytime pelagic concentrations of Argentine red shrimp were detected by a scientific echosounder operating multiple frequencies (Macchi 2019). During the survey, the acoustic acquisition was carried out continuously (24 h) by using a calibrated broadband echosounder SIMRAD EK80 operating six split beam transducers: 18, 38, 70, 120, 200, and 333 kHz. Transmission of pulses were simultaneous and in a continuous wave (CW). A pulse duration of 1 ms at maximum power was established for information acquisition. Two of the fourteen trawls carried out for validating echorecords (trawl station 6 and 12) were direct-

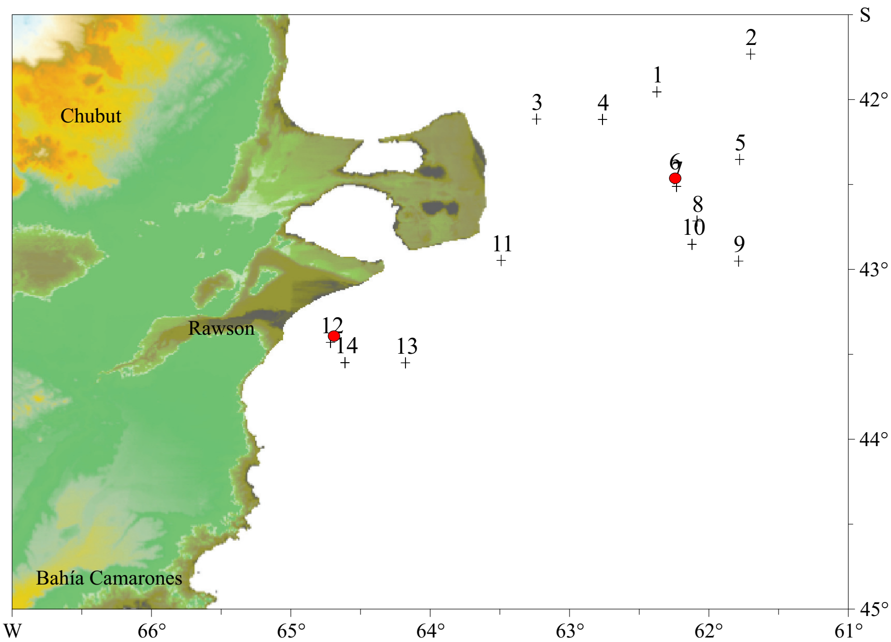

Figure 1. Research area and trawls carried out during the survey. Red dots indicate trawls executed to identify acoustic information with crustacean characteristics.

ed to identify acoustic information that matched characteristics of crustaceans (Figure 1). A pelagic net designed on the scale of the large Nichimo net was used to capture midwater organisms. Net dimensions were 47 m headline, 7 m vertical opening, 400 mm wingspans, and 60 mm cod end. Acoustic telemetry sensors monitored real-time performance of the fishing gear, allowing the measurement of the vertical opening of the net and the position in the water column during trawling. The catch obtained was separated by species, weighed and individual shrimp cephalothorax length (CL) was measured. Shrimps were classified by sex and maturity stage using the scale described by Boschi (1989). Acoustic data were post processed using LSSS (Large Scale Survey System) applying a minimum threshold of -70 and a maximum of -30 dB. A frequency response from 38 to 200 kHz was determined for each area. At depth where aggregations of interest were detected, the low signal/noise ratio of the 333 kHz frequency led to discarding it from the multifrequency analysis. Thanks to good weather conditions and visibility of the water, an underwater video camera was installed in the CTD rosette, which also documented the presence of shrimps in the pelagic environment.

An acoustic backscatter layer between 20 and 30 m deep (40 m from the bottom) was observed on December 8 at 4:30 am (7:30 GMT) in the absence of sunlight. Thus, to identify the backscattering layer, a trawl sampling was carried out (Figure 2; station 6). The corresponding catch consisted mainly of 20 kg of shrimp and 2 kg of anchovy. There were two types of acoustic aggregations differing in morphological and acoustic frequency response observed at dusk (Figure 3). The first scattering layer (between 20 and 30 m) presented distinctive characteristics of diurnal anchovy schools (Cabreira and Madirolas 2007) and decreasing frequency response (typical of gas bladder fishes) (Figure 3 A). The second scattering (between 32 and 42 m) was formed by small aggregations with an increasing frequency response, typical of crustacean-like organisms (elastic shelled organisms with no gaseous structures) (Figure 3 B). It is important to highlight that the typical behavior of shrimp during daytime is the formation of bottom-associated aggregations.

On December 12 at 8:20 am (11:20 GMT) it was decided to conduct an additional identification trawl that matched the range of the second layer (depth close to 30 m) characterized by an increased frequency response (Figure 4; station 12). After 15 min of trawling, the catch was mainly composed of shrimp (400 kg). Aggregations corresponded to the presence of reproductive concentrations (70% of mature and impregnated females) with modes at 39 and 48 mm CL (mean 42.38 mm) for males and females, respectively (Figure 5). The presence of adult shrimp moving in the pelagic stratum at 30 m depth was

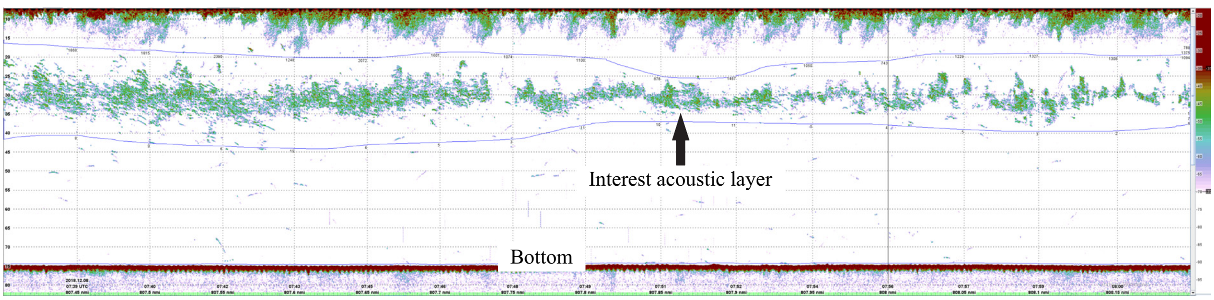

Figure 2. Pelagic trawl carried out at night over an acoustic backscatter layer detected between 20 and 30 m deep (echogram from 120 kHz).

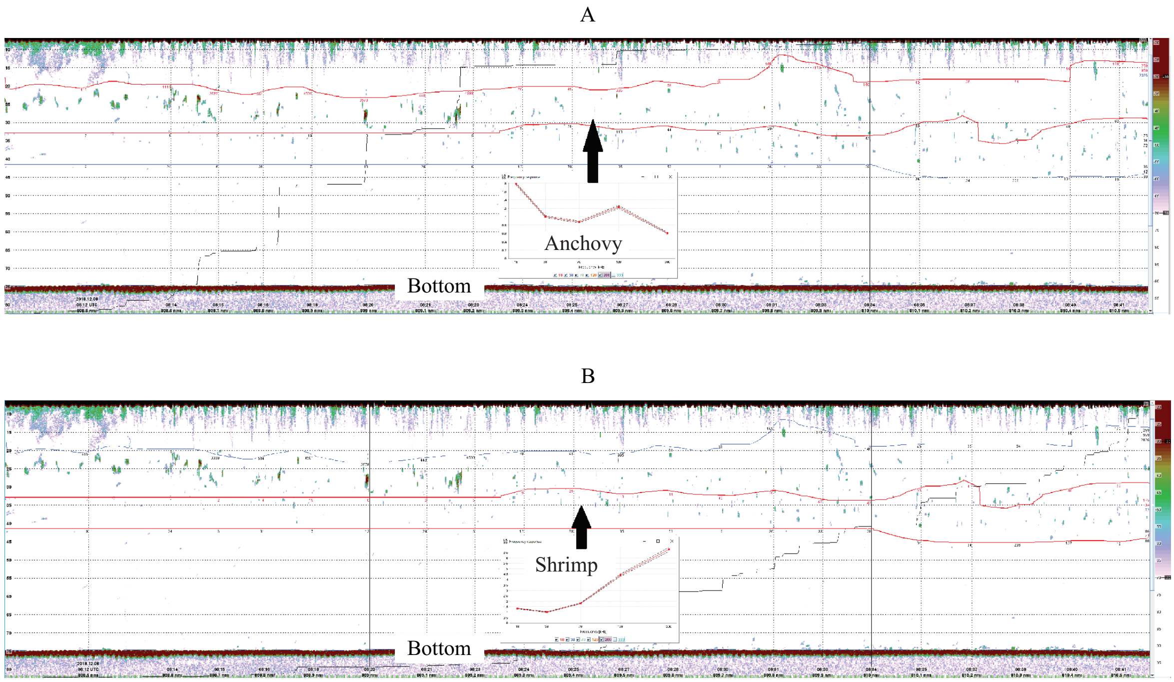

Figure 3. Formation of two types of acoustic aggregations during the dusk differing in morphological aspect, vertical position in the water column, and variation in acoustic frequency responses. Note that two echograms are the same highlighting anchovy (A) and shrimp (B).

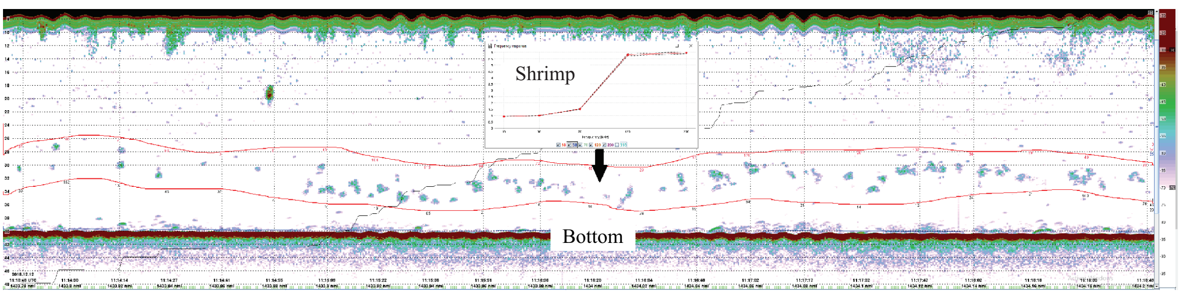

Figure 4. Trawl carried out at 30 m depth aimed at validation of echorecording. Catch composed mainly of shrimp (400 kg).

also confirmed by underwater videos (Figure 6). The acoustic signature of shrimp, showed in this report, is of particular interest for the development of new methodologies that complement the traditional evaluation of the resource carried out through the swept area method. The appearance of pelagic concentrations of the species during daylight hours has generated a new challenge to understand its behavior and population dynamics. The availability of more precise and robust instruments, new methods and protocols for data collection, and innovative analysis methodologies are making it possible to exploit the acoustic differences to characterize different organisms. This makes this tool more consistent for reliable identification and contribute to obtain more precise estimates of the abundance of fishery resources.

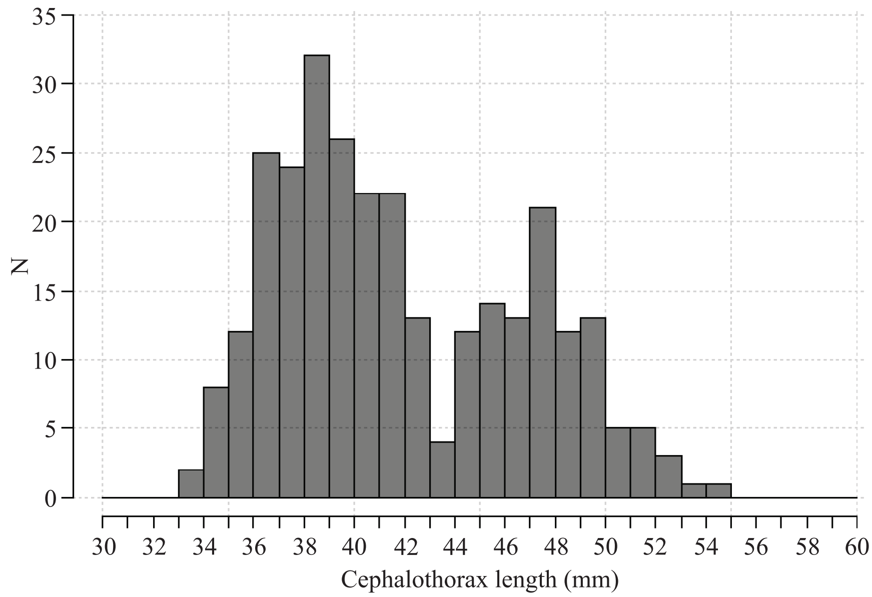

Figure 5. Cephalothorax length (mm) of *Pleoticus muelleri*.

Figure 6. Underwater camera images taken to validate the acquired echorecordings. Left: a side view of a shrimp. Right: ventral view of shrimp specimens moving in the pelagic stratum at 30 m depth.

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Author contributions

Ariel G. Cabreira: investigation, conceptualization, formal analysis, methodology, writingoriginal draft, writing-review and editing. Gustavo J. Macchi: investigation, writing-review and editing. Paula Moriondo Danovaro: investigation, conceptualization, writing-review and editing.

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