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Marian Peña, Lou Andrès, Rafael González-Quirós, 2023. [Target strength of Cyclothone species with fat-filled swimbladders.](#)

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Abstract: The use of acoustic scattering models provide estimates of single target echoes that allow acousticians to convert acoustic information into biologically meaningful measures. The literature on organisms' target strength is extensive but is mainly focused on commercial stocks of small pelagic fishes and zooplankton species. A few models of swimbladdered fishes of the mesopelagic zone are also available. However, deep species of the lower mesopelagic and bathypelagic zones tend to have regressed swimbladders or lack one. These habitats have low numerical densities and thus single target studies and angle variation are of particular relevance. *Cyclothone spp*, the most abundant fishes in the planet and a major constituent of the biomass in the bathypelagic zone, possess gas-filled swimbladders in the upper mesopelagic zone and in larvae stages of all species, but deeper species gradually fill their swimbladder with age. They thus change from a gas-bearing acoustic scattering to a fluid like type. This study applies the Kirchhoff Ray Mode (KRM) model based on real fish body shapes of *Cyclothone* individuals derived from photographs of organisms captured along the year in the Bay of Biscay in order to obtain target strength (TS) of these individuals. Width versus standard length (SL) values fitted the following equation: $\text{width} = 0.01 + 0.02 \cdot \text{SL}$. Estimated TS values in the Rayleigh zone at broadside had significant linear correlations with SL that can be employed as an approximation of their scattering ($\text{TS} = 35 \cdot \log_{10}(\text{SL}) - 119$, $\text{TS} = 35 \cdot \log_{10}(\text{SL}) - 106$ and $\text{TS} = 35 \cdot \log_{10}(\text{SL}) - 97$ at 18, 38 and 70 kHz respectively). TS at 120 and 200 kHz were not significantly correlated with standard length. Changes in fish body sound speed and density values highly vary the TS level. Assuming neutral buoyancy (body density close to surrounding seawater density), mean TS values were located at -91, -85, -78, -77, -80 dB at 18, 38 and 70, 120 and 200 kHz respectively. TS changes with orientation were also considered depicting important variations in echo level as well as in TS spectra. This study provides relevant information on the acoustic characteristics of lower mesopelagic and bathypelagic *Cyclothone* species that can be employed to better infer knowledge from acoustic recordings in those areas.

Keywords: Acoustics, Target strength, Cyclothone spp, Fluid-like, KRM, Mesopelagic, Bathypelagic, Seasonal variations, Orientation