ICES Journal of Marine Science, 53: 309–311. 1996

Target strength of the common jellyfish (*Aurelia aurita*): a preliminary experimental study with a dual-beam acoustic system

Erhan Mutlu

Mutlu, E. 1996. Target strength of the common jellyfish (*Aurelia aurita*): a preliminary experimental study with a dual-beam acoustic system. – ICES Journal of Marine Science, 53: 309–311.

An enclosure was designed for experiments estimating the target strength (TS) of the common jellyfish (*Aurelia aurita*) in the Black Sea. A BioSonics echosounder (Model 102) equipped with 120 and 200 kHz dual-beam transducers was used for the measurements. The average acoustic cross-section for each size class was used in functional regression equations to relate the mean TS (dB) of jellyfish to its disc diameter d (cm) and wet weight W (g). These were found to be as follows: $TS = 14.72 \log d - 74.63$ and $TS = 5.71 \log W - 69.41$ at 120 kHz; $TS = 39.65 \log d - 104.38$ and $TS = 14.53 \log W - 88.07$ at 200 kHz. The TS values were found to fluctuate periodically with time. The results showed a variation of -54 to -67 dB at 120 kHz for 15.5 cm diameter individuals, with a period of 7.5 to 10 sec; and a variation of -58 to -68 dB for 11.5 cm individuals at 200 kHz, with a period of 6 to 12.5 sec.

Key words: Black Sea, jellyfish, target strength.

E. Mutlu: Institute of Marine Sciences, Middle East Technical University, PO Box 28, 33731 TR, Erdemli, Icel, Turkey [tel: +324 521 2406, fax: +324 521 2327].

Introduction

After the invasion of the Black Sea by the non-indigenous species *Mnemiopsis leidyi* (Mutlu *et al.*, 1994), abrupt changes were observed in the recipient ecosystem (Zaitsev, 1992). It is stressed that monitoring the biomass and abundance of this ctenophore, together with two other gelatinous organisms (*Aurelia aurita* and *Pleurobrachia pileus*), is necessary as a basis for actions to minimize changes to the Black Sea ecosystem (Anon., 1994). An acoustic technique which reduces the time required for data collection and analysis would be a very practical and useful tool for measuring the populations of these species.

In this study, acoustic measurements were performed to estimate the target strength (TS) of the common jellyfish. The results may now be used to help investigate the population dynamics (e.g. stock assessment and size composition) of this gelatinous organism in the Black Sea.

Material and methods

The experiments were conducted in the Beykoz region of the Bosphorus, near Istanbul, over four days in January 1992. A BioSonics scientific echosounder (Model 102) equipped with 38, 120, and 200 kHz dual-beam transducers was used during the experiments (Fig. 1). The echoes were amplified by a $40 \log R + 2 \alpha R$ time-varied-gain function. *In situ* calibration of the echo-sounder and transducers was carried out (at the same place) using a tungsten calibration sphere before starting the experiment.

Acoustic measurements were made on live jellyfish placed in a quadrant enclosure. Three size classes of jellyfish (mean disc diameters 9.5, 11.5, and 15.5 cm) were used in the experiments. Five to ten individuals belonging to each size class were released into the cage and echo recording was performed separately at two frequencies. The enclosure was sometimes moved up and down in order to keep the jellyfish in the acoustic beam. In the laboratory, the data recorded on magnetic tape could be played back for post-processing. Records selected as valid echoes from single targets were used for final processing.

The mean backscattering cross-section (σ_{bs}) was established from the echoes of successive single pings. To establish an empirical relation between the TS of a jellyfish and its umbrella diameter and wet weight, regression analysis was applied to the data obtained at 120 and 200 kHz.

1054–3139/96/020309 + 03 $18.00/0

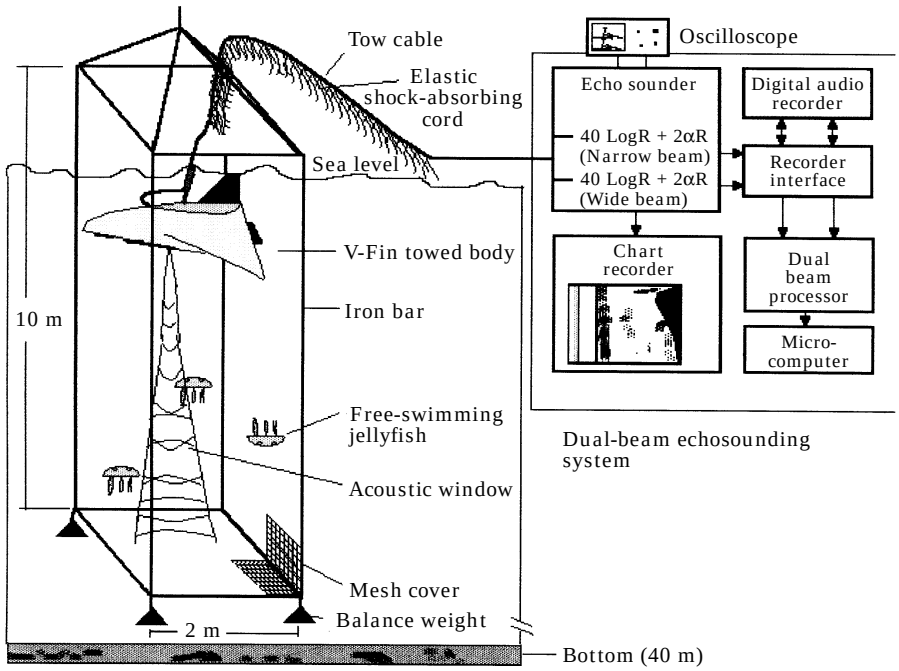

Figure 1. Schematic drawing of the experimental enclosure and block diagram of the hydroacoustic data-collection system.

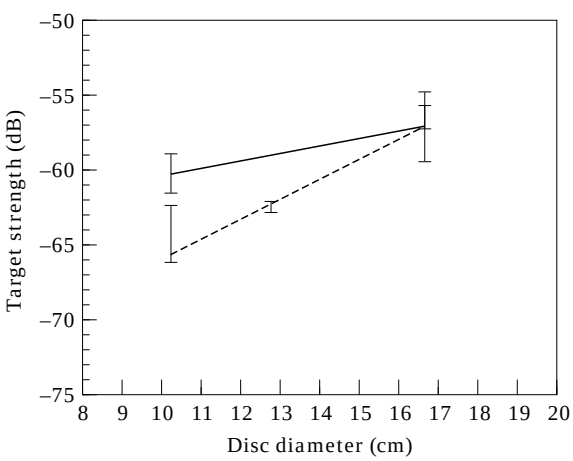

Figure 2. Range of the observed target strength for each size class vs. the disc diameter of *Aurelia aurita*. —— 120 kHz TS = 14.72 log d − 74.63 (r = 1, n = 25 pings). – – – 200 kHz TS = 39.65 log d − 104.38 (r = 0.97, n = 159 pings).

The swimming rhythm of *Aurelia aurita* was determined by analysing the TS oscillation obtained from a series of pings.

Results

The relationship between the TS, the disc diameter (cm), and the live weight (g) of *Aurelia aurita* was established at 120 and 200 kHz. The mean TS varied from − 56 to − 64 dB (Fig. 2 and Table 1). The results are summarized in Table 1. The empirical relationships between the TS in dB, the disc diameter (d; cm), and the wet weight (W; g) for *Aurelia aurita* are given in Table 2.

Each swimming cycle was repeated every 10–30 pings for all sizes, equivalent to 5–15 sec at 2 pings sec^{-1}. The variation in TS at 120 kHz, due to swimming, was from − 54 to − 67 (dB) for individuals of 15.5 cm mean diameter. This had a period of 7.5–10 sec. For individuals of 11.5 cm mean diameter, the TS at 200 kHz

Table 1. Average target-strength measurements of free-swimming common jellyfish in the experimental cage.

Disc diameter (cm)	Wet weight (g)	Displacement volume (ml)	Target strength (dB)	
			120 kHz	200 kHz
9.5	40.21	22.7	− 60.24	− 64.27
11.5	65.89	35.5		− 62.48
15.5	142.51	71.1	− 57.10	− 56.47

Table 2. Functional regression equations relating mean TS in dB at two frequencies to the disc diameter (d; cm) and wet weight (W; g) *Aurelia aurita*; and the dependence of the wet weight (W; g) and the displacement volume (V; ml) on the size (d; cm).

120 kHz	200 kHz	
TS = 14.72 log d − 74.63	TS = 39.65 log d − 104.38	$W = 0.12*d^{2.58}$
TS = 5.71 log W − 69.41	TS = 14.53 log W − 88.07	$V = 0.12*d^{2.33}$

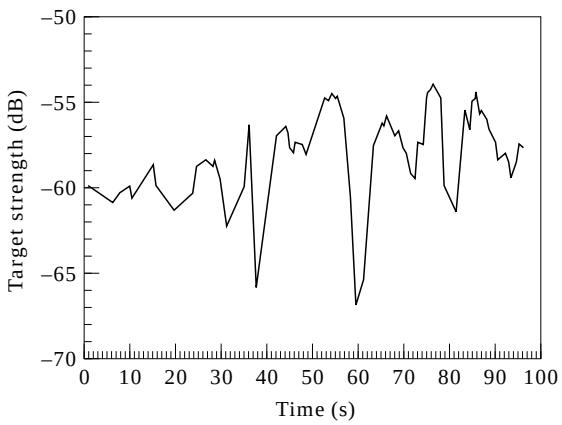

Figure 3. Variation of target strength due to the swimming behaviour of *Aurelia aurita* in the enclosure.

varied from − 58 to − 68 dB with a period of 6–12.5 sec (Fig. 3).

Discussion

The TS of jellyfish is much lower than that of fish due to the lower reflectivity of the jellyfish as a result of its high water content (>95%). The TS increases with size, but more slowly than the 20 Log L dependence usually observed in fish. Estimates of the TS of some other gelatinous organisms have been reported, for example those of O. Nakken (pers. comm.) for *Aurelia autrans* and Wiebe *et al*. (1990) for the comb-jelly (*Bolinopsis* sp.). Nakken found a range of − 54 dB (8 cm) to − 51.7 dB (16 cm) at 38 kHz and − 54.2 dB (8 cm) to − 50.1 dB (16 cm) at 120 kHz. Wiebe *et al*. (1990) reported that the TS of a ctenophore 45 mm in length was only − 80 dB at 420 kHz.

It is suggested that such variability in TS values among different species of gelatinous animals arises primarily from the rhythmic contraction of the umbrella, and secondarily from the orientation of the body with respect to the vertical. Certain other factors, such as the physiological condition of animals, may also influence the results.

Acknowledgements

This study was funded by the Turkish Scientific and Technical Research Council (TUBITAK), and by the Scientific Affairs Division of NATO within the framework of the Science for Stability Programme. Furthermore, I am indebted to Drs Ferit Bingel and Ali C. Gücü for their constructive suggestions.

References

Anon. 1994. Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* in the Black Sea. First meeting of the GESAMP (Group of Experts on the Scientific Aspects of Marine Pollution), UNEP (OCA)/GES.WG. 35/13, 63 pp.

Mutlu, E., Bingel, F., Gücü, A. C., Melnikov, V. V., Niermann, U., Ostr, N. A., and Zaika, V. E. 1994. Distribution of the new invader *Mnemiopsis* sp. and the resident *Aurelia aurita* and *Pleurobrachia pileus* populations in the Black Sea in the years 1991–1993. ICES Journal of Marine Science, 51: 407–421.

Wiebe, P. H., Greene, C. H., Stanton, T. K., and Burczynski, J. 1990. Sound scattering by live zooplankton and micronekton: empirical studies with a dual-beam acoustical system. Journal of the Acoustical Society of America, 88: 2346–2360.

Zaitsev, Yu. P. 1992. Recent changes in the trophic structure of the Black Sea. Fisheries Oceanography, 1: 180–188.