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TARGET STRENGTH OF TINY ROACH

by

Kenneth G. Foote
Institute of Marine Research, 5024 Bergen, Norway

Torfinn Lindem
Physics Department, University of Oslo, PO Box 1048, Oslo 3, Norway

Åge Brabrand
Zoologisk Museum, University of Oslo, Sars Gate 1, Oslo 5, Norway

ABSTRACT

Seven frozen specimens of surface-adapted roach (Rutilus rutilus), of lengths 32-40 mm and masses 0.20-0.49 g, have been sectioned with a precision microtome. The swimbladder contours have been digitized and the swimbladder volumes determined. For ordinary ultrasonic frequencies the wavelength is much longer than the particular characteristic swimbladder dimensions. However, it is shorter than the wavelength at resonance. The sound scattering is computed according to a resonant swimbladder model.

INTRODUCTION

Very small roach occur in enormous quantities in some lakes. In order to estimate their density absolutely by acoustics, the target strength must be known.

It is the present aim to determine the target strength of roach of lengths 32-40 mm by means of a swimbladder morphometry and theoretical computation based on a resonant swimbladder model.

MATERIAL AND METHODS

The biology of seven specimens is shown in Table 1. These were caught by electrofishing in Lake Gjersjøen on 3 October 1986. The fish were immediately shock-frozen, then stored for later morphometry in the manner established by Ona (1982). This method has previously been applied to pollack (Pollachius pollachius) and saithe (Pollachius virens) (Foote 1985) and to walleye pollock (Theragra chalcogramma) (Foote and Traynor 1987), among other species.

Table 1. Biology of seven roach specimens.

Specimen no.	Length (mm)	Mass (g)	Swimbladder area (mm^2) Type 1	Swimbladder area (mm^2) Type 2	Swimbladder volume (mm^3) Type 1	Swimbladder volume (mm^3) Type 2
12	35	0.25	75.9	61.6	10.7	8.2
13	35	0.31	70.8	44.8	7.6	4.9
14	36	0.37	72.2	56.2	10.1	8.7
15	37	0.48	111.8	83.1	11.9	10.6
16	40	0.49	71.5	78.4	10.4	8.2
17	32	0.20	16.2	21.9	0.9	1.5
18	36	0.38	46.2	28.9	7.0	2.6

Because of difficulty in discerning the swimbladder wall both during the sectioning and on the section photographs, the photographs were interpreted independently by two of the authors, the first two, in analysis types 1 and 2, respectively. The results for the swimbladder surface area and volume are included in Table 1.

To compute the target strength, the resonant swimbladder model of Love (1978) is used. This model represents a swimbladdered fish by an air cavity surrounded by a spherical shell which supports a surface tension, is viscous and heat-conducting, and otherwise acts as a Newtonian fluid. Despite uncertainties in the values of surface tension and viscosity for roach tissue, not to mention the double-chambered nature of the swimbladder, use of data tabulated in Love (1978) and Løvik and Hovem (1979), and reasonable extrapolations too, indicates that the likely resonance frequency lies significantly below the frequency of application, 70 kHz. The backscattering cross section is therefore approximated by the geometric quantity πa^2, where a is the radius of the equivalent sphere having the measured swimbladder volume.

RESULTS

The backscattering cross section is presented in Table 2 for each of the analyses, together with the corresponding average σ and related target strength TS defined as in Urick (1975), namely

$$TS = 10 \log \frac{\sigma}{4\pi} \quad , \tag{1}$$

but with use of SI units.

The target strengths are regressed on fish length according to the equation

$$TS = m \log \ell + b \quad , \tag{2}$$

where ℓ is the fish length in centimeters. For the general case,

Table 2. Estimated target strengths of seven roach.

Specimen no.	Length (mm)	σ (mm²) Type 1	Type 2	Average	TS (dB)
12	35	5.9	4.9	5.4	-63.7
13	35	4.6	3.5	4.0	-65.0
14	36	5.6	5.1	5.4	-63.7
15	37	6.3	5.8	6.0	-63.2
16	40	5.8	4.9	5.4	-63.7
17	32	1.1	1.6	1.4	-69.5
18	36	4.4	2.3	3.4	-65.7

$$TS = 58.5 \log \ell - 97.3 \quad , \qquad (3)$$

with the standard error SE=1.5 dB. For the case m=20,

$$TS = 20 \log \ell - 76.0 \quad , \qquad (4)$$

with SE=2.0 dB.

DISCUSSION

The result in equation (4) may be compared with other data very simply through use of the intercept b_{20}=-76.0 dB. Reference to Foote (1987) indicates that the roach datum lies significantly under the best available datum for physoclists, -67.5 dB, and that for physostomes, -71.9 dB. These other data have been determined from *in situ* measurements on much larger fish.

Clearly, the present analysis is wanting, but then the authors know of none better. Given the significance of roach as the predominant teleost contributor to biomass in a number of lakes, it is important that the target strength be established, hence this effort.

It is hoped that this paper will inaugurate a more systematic study of the acoustic properties of small fish.

REFERENCES

Foote, K. G. 1985. Rather-high-frequency sound scattering by swimbladdered fish. J. acoust. Soc. Am. 78: 688-700.

Foote, K. G. 1987. Fish target strengths for use in echo integrator surveys. J. acoust. Soc. Am. 82: 981-987.