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Measurements of the density coefficient and average target strength of herring using purse seine

by

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ABSTRACT

Integrator values were obtained from a school of herring. The fish density of this school was determined on the basis of a purse seine catch. From these values a conversion factor and average target strength for herring was calculated. The target strength value is compared with other reported TS values for herring.

INTRODUCTION

The relation between the integrated echo intensity and the density of fish, D, is:

$$D = C \times M + d$$

where:

D = Fish density per unit area

C = Conversion factor

M = Integrated echo intensity

d = Threshold density

The conversion factor C is usually found by regression of corresponding values of D and M. The magnitude of an integrator output from a certain fish density will of course depend on the characteristics of the sounder and integrator system, i.e. source level etc. However, it is often difficult to determine the fish density without taking the same instrument characteristics into account. The instrument characteristics are used when determining sample volume when counting single fish echoes on the recording paper, the beam shape pattern is used when applying Craig and Forbes statistical model etc.

The aim of the present experiment was to calculate a conversion factor from the formula $C = D/M$ where the D-value was found independent of the instrument characteristics. And from the C-value an average TS per kilo can be calculated.

MATERIAL AND METHODS

The experiment was carried out in March 1982 on the spawning grounds of the Norwegian Spring Spawning Herring. Two vessels participated, a purse seiner ("Roaldsen Senior") and a research vessel ("Michael Sars") which was equipped with an integrator.

In order to avoid "shadowing" of the acoustic energy, the experiment has to carried out on schools which were not dense. Further, schools near the surface has to be avoided, because they would not be recorded by the echo sounder.

Suitable recordings were observed in position N62^{o}30'8', E05^{o}36'. Figure 1 shows how the experiment was carried out. After the school was recorded, the purse seiner (RS) stopped. The research vessel (MS) then integrated on a courseline 0.12 nautical miles aft of the purse seiner. There was an integrator output every 0.1 nautical miles. Figure 2 shows the recordings on the echogram of the research vessel. The numbers on the echogram correspond to the log marking on Figure 1. Immediately after the research vessel had passed, the purse seiner moved as shown on the dotted line on Figure 1, and the marker buoy was dropped and the shooting of the purse seine began at A. The circumference of the seine is given by the full line.

The length of the purse seine was 260 fathoms (0.26 nautical mile), and this gives an enclosed surface area of 0.00508 (n.miles)^2. The depth of the seine was 45 fathoms which was approximately the same as the bottom depth. It is reconned that no herring escaped beneath the "leadline" before the net was pursed.

The purse seine catch was 815 hectolitres (75.8 tonnes). However, it was observed that some herring escaped over the floatline before brailing. The original amount of herring within the purse seine was set to 900 hectolitres (83.7 tonnes). Radar observations and depth indications from the echo sounder of the purse seiner during the fishing operation indicated that the purse seine fished within log marking 897.9, and that some of the recordings in log 898.0 was also included in the purse seine catch.

Table 1 shows integrator values from log 897.9 and 898.0. Values which are corrected for discrepancies in the TVG-functions are also included. The corrections are based on the TVG-curve for "Michael Sars" which is shown in Figure 3. Table 2 gives the instrument settings and constants for "Michael Sars".

RESULTS

The conversion factor is calculated by

$$C = \frac{\text{Catch x catchability coefficient of the purse seine}}{\text{area of the purse seine x Integrator value}}$$

$$C = \frac{83.7 \times 1}{0.00508 \times 60183} \text{ tonnes/integrator unit/(n.mile)}^2$$

$$C = 0.2738 \text{ tonnes/integrator unit/(n.mile)}^2$$

The density coefficient, C, depends on fish species and size, and on the characteristics of sounder and integration system. It is therefore convenient to write C as a product (Nakken 1975):

$$C = C_i \cdot C_f$$

where C_f depends only on fish species and size and C_i is an instrument constant which can be determined by absolute calibratio of the instruments.

In logaritms: $10 \log C = 10 \log C_i + 10 \log C_f$
From the sonar equation: $10 \log C_f = -TS$
This gives: $TS = 10 \log C_i - 10 \log C$

The instrument constant C_i is a function of calibration constants, settings of the equipment and hydrographic factors such as sound velocity and attenaution in water: (Explanation of the terms in Table 2), $10 \log C_i = [(SR+VR)-(20 \log R+2\alpha R)+10 \log {}^{c\tau}/2+10 \log \Psi +A-V_o]$.

Using the values from Table 2:

$$10 \log C_i = -43.2$$

and

$$TS = -43.2 - 10 \log 0.2738$$

$$TS = -37.6 \text{ dB/kg}$$

Figure 4 gives the length distribution of the herring in the purse seine catch. The mean length of the herring was 34.6 cm and the above TS-value of -37.6 dB/kg will therefore refer to herring of 34.6 cm.

The C value is proportional to the length of the herring

$$C = k \cdot L$$

and $k = 0.2738/34.6 = 0.0079$

therefore $C = 0.0079\ L$ (L = length of the herring).

DISCUSSION

It was planned to carry out several experiments in order to obtain a series of different densities and integratorvalues. But this was not possible due to lack of suitable recordings, other fishing gears in the area which made purse seining impossible, and bad weather.

There are of course some uncertainties connected with the present experiment. It is difficult to have the purse seine shot exactly on the place where integration has taken place. Further, some herring could have escaped before the net was fully pursed. Or herring could have swim into the net making the calculated density larger, all depending on the direction of swimming. In the present experiment the catchability of the purse seine was set to 1.

Two papers dealing with target strength of herring was presented on the "Symposium on Fisheries Acoustics", Bergen, Norway in June 1982. Edwards and Armstrong (1982) report on carefully conducted mean TS-experiments on caged herring (length 9-24 cm). They give the following relation:

Target strength per kilo: $-17.09 \log L - 10.6$ dB
(L = length of the fish in cm).

Halldorsson and Reynisson (1982) report on in situ target strength measurements from an Icelandic research vessel. The herring (approximately 10-36 cm) were located on their wintering grounds at Iceland. They give the relation:

$$\overline{TS} = -(10.9 \log L + 20.9)$$

For herring of 34.6 cm the following comparison can be made:

	Target strength
Present experiment	- 37.6 dB/kg
Edwards and Armstrong	- 36.9 dB/kg
Halldorsson and Reynisson	- 37.7 dB/kg

The values above are mean values of target strength, and are the results of mean tilt angle distributions, state of swimbladders etc. There seems to be fairly good agreement, and perhaps one cannot expect the agreement to be 100 per cent. The herring in the present experiment was measured on the spawning grounds and the mean tilt angle distribution (i.e. behaviour) there may be different from that on the wintering grounds (Icelandic situation). Day-night variations, reactions to fishing operations and research vessels, different behaviour from different age groups may indicate that there may be different TS-values (and therefore C-values) for herring, each depending on a particular situation.

References:

EDWARDS, J.I. and ARMSTRONG, F. 1982. Measurement of the target strength of live herring and mackerel. Symposium on Fisheries Acoustics, Bergen, Norway, 21-24 June 1982. Contribution no. 78. (Mimeo).

HALLDORSSON, O. and REYNISSON, P. 1982. Target strength measurements of herring and capelin "in situ" at Iceland. Symposium on Fisheries Acoustics, Bergen, Norway, 21-24 June 1982. Contribution no. 20. (Mimeo).

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Table 1. Integratorvalues "Michael Sars"

Depth interval	Mean depth	Loggnr. 897.9 Read	897.9 corrected	898.0 read	898.0 corrected	TVG correction factor
25-50	37.5	53673	38108	99591	70710	0.710
50-75	62.5	6938	5599	7221	5827	0.807
75- max depth	80.0	1	0	143	121	0.848
Σ			43707		76658	

Mean value
log: 897.9 and 898.0 60183

Table 2. Instrument settings and calibration data R/V "Michael Sars".

Echo sounder frequency: 38 kHz

Scale: 0-250

TVG/Gain: 20 logR - 20dB

Integrator: Nord 10 computer with Institute of Marine Research integrator program

Transducer: A2 keramisk $8^{o}x8^{o}$

Echo sounder gain: 8

Discriminator:	Echo sounder: 2-6
- " -	Nord 10 pelagic: 14.0 volt peak
	bottom : variable

Band width/pulse length: 3 kHz/0.6 ms

A : -19.4 dB

(SL + VL)	-144.8 ref. 0dB (measured January 1982 with copper sphere)
$10 \log \psi$	- 19.6 dB
$20 \log R + 2\alpha R$	64.5 (α = 10.5 dB/km)
$10 \log^{c\tau}/2$	- 3.5 dB
V_o	- 1.9

SL = Source level (dB//1μ Pasc ref. 1m)

VR = Voltage Response (dB//IV pr.μ Pasc)

α = Absorption coefficient (dB pr. km) which is used in the TVG-function

ψ = Equivalent transducer beam width >: $10 \log \psi$ (dB//ster)

c = Sound velocity (m/sec)

τ = Pulse length (sec)

A = Echo integrator gain setting

V_o = Average value of the input signals to the integrator which gives 1 mm integrator deflection at 0 dB gain in a 1 m interval (dB//1 volt)

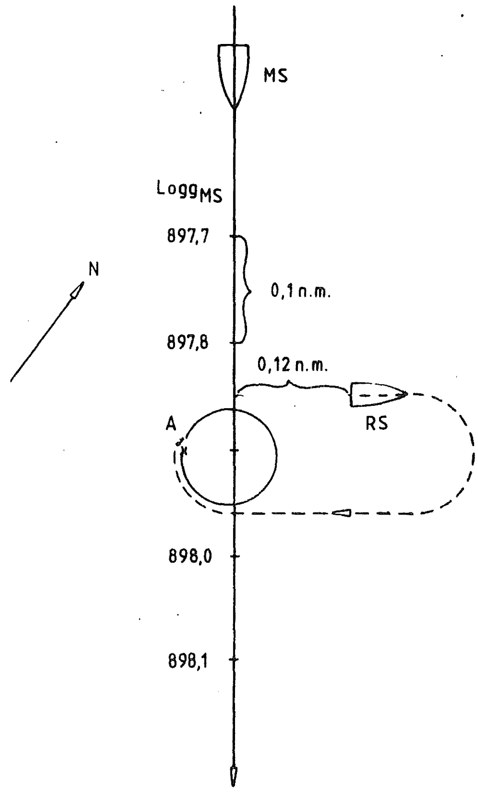

Fig. 1. Sketch of the integration-purse seining experiment. See text for explanation.

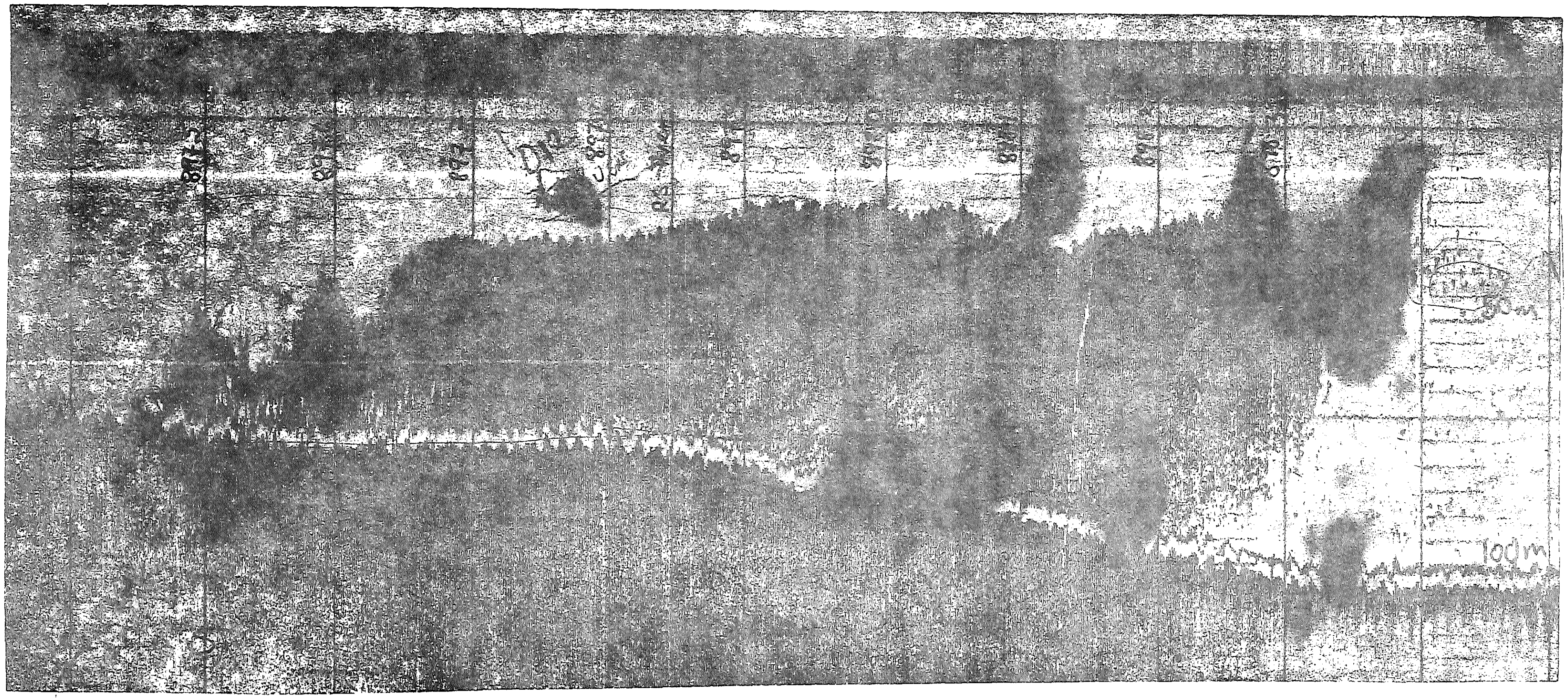

Fig. 2. Echogram from R/V "Michael Sars". Log numbers correspond to log numbers in Fig. 1.

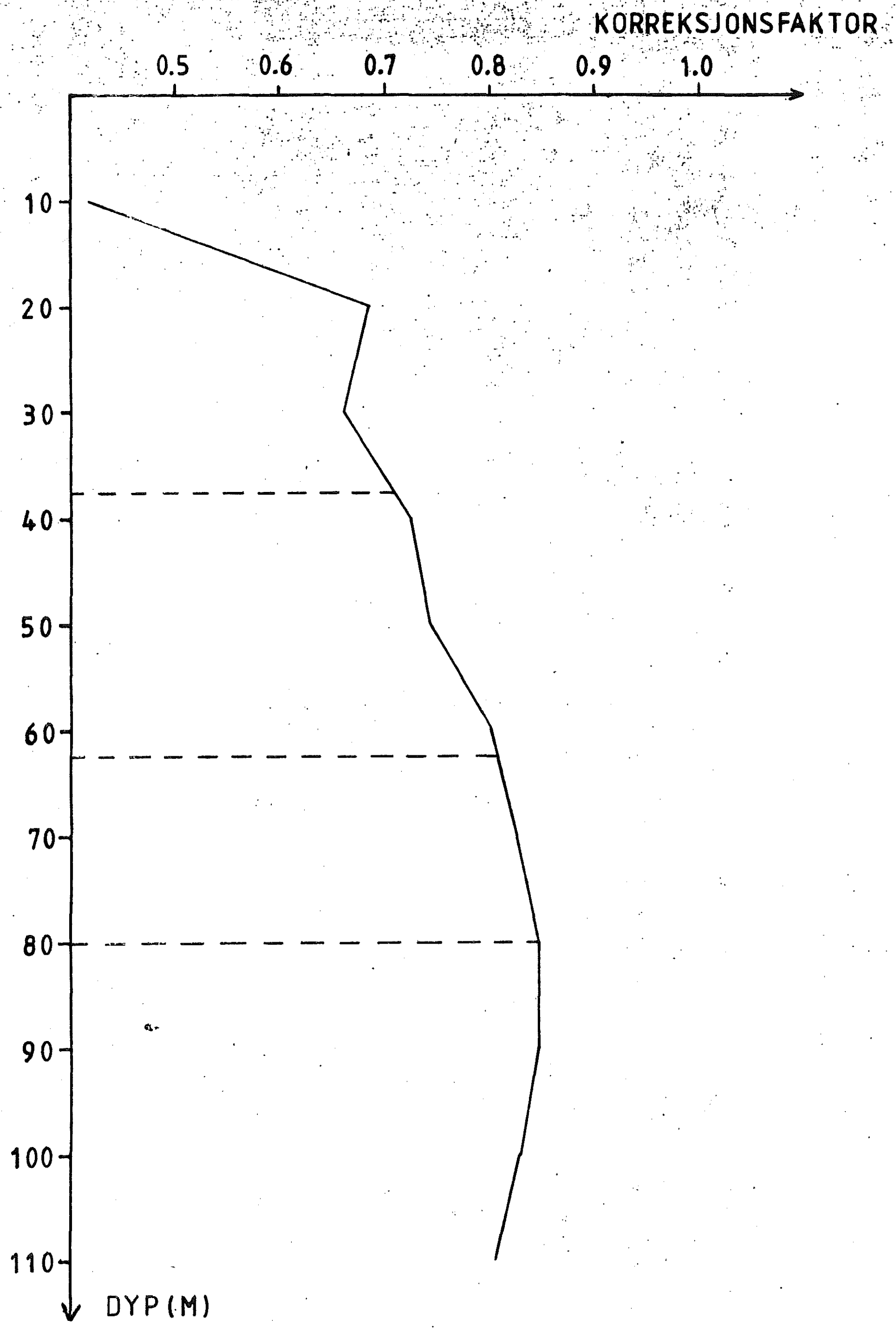

Fig. 3. TVG-curve R/V "Michael Sars".

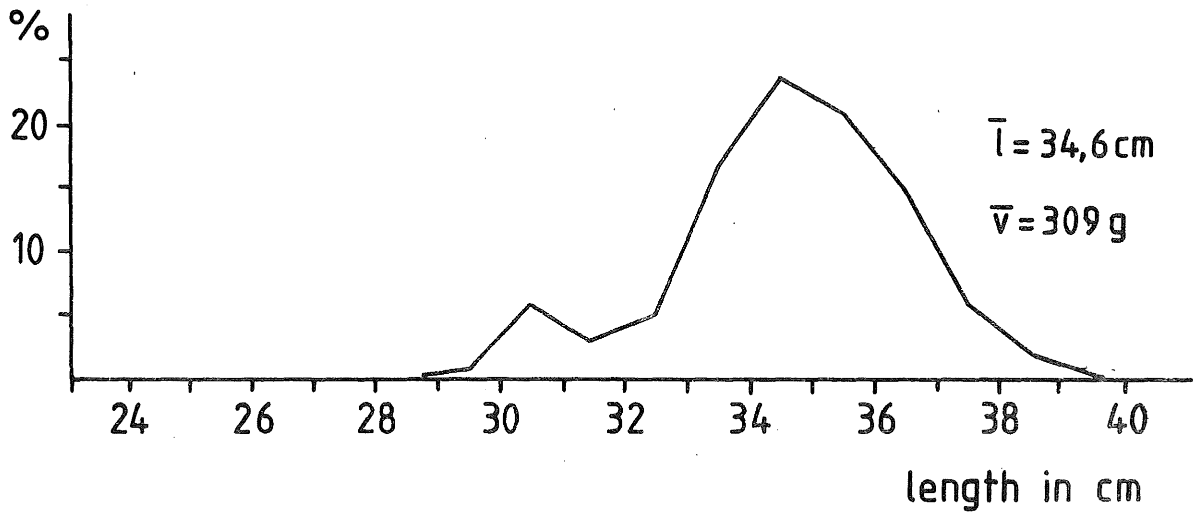

Fig. 4. Length distribution of herring from the purse seine catch.