In situ TS measurement of capelin (Mallotus villosus villosus) in the Barents Sea at 38 kHz

Viacheslav A. Ermolchev and Tatjana M. Sergeeva

Abstract

Now the acoustic target strength relationship $TS = 19.1 \log(TL) - 74.0$ is used in trawl-acoustic surveys (TAS) on assessment of capelin (Mallotus villosus villosus) stock. In this report we present results of in situ TS measurement of capelin for different length TL at the frequency of 38 kHz obtained by PINRO in the Barents Sea in 2000 - 2004 during trawl-acoustic survey (TAS) of capelin stocks. The research vessels we have used, R.V. “Persey–3”, “AtlantNIRO”, “Smolensk” and “Fridtjof Nansen” are equipped with SIMRAD EK500 and EK60 scientific echo sounders with the split-beam transducer for directly measuring fish target strength. The echo sounders are connected to an IBM PC with the specially developed software packages LTSD100 (Length and Target Strength Distributions) and FAMAS (Fisheries Acoustic Monitoring & Analysis System) to collect and process results of measuring fish target strength.

Simultaneous check hauls of the studied fish concentrations were conducted by pelagic and bottom trawls with small-meshed size insertions for estimation the length composition and the mean length ($\overline{TL}$) of capelin. Based on the analysis of all the data we defined the acoustic target strength relationship for capelin of length 4.4-18.7 cm: $TS(PINRO) = 21.4 \log(TL) - 75.4$. On our opinion, the currently used relationship $TS = 19.1 \log(TL) - 74.0$ probably giving understated target strength values and the biomass are overestimated to 10 – 30%.

In PINRO in the sea expeditions the works on determination of capelin target strength in situ of different length in different seasons in the day and night time and for different depths still continue.

Keywords: capelin, directly measuring, in situ, target strength.

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**Introduction**

Trawl-acoustic surveys (TAS) on assessment of capelin stock are in the intensive progress. But there are still problems connected with the accuracy of these estimations. It is known that accuracy of estimating of fish stocks with the use of TAS depend on solving of many problems, the following of which have to be considered as the main ones: increase accuracy of determination of target strength TS of capelin *in situ* and dependences of capelin target strength TS on their total length TL (the target strength relationship) in different seasons, in the daytime, in the nighttime and for different depths. The results of capelin target strength determination *in situ* at the frequency of 38 kHz derived Norwegian (IMR, Bergen), Icelandic (IMR, Reykjavik), Canadian (FMI, St. John’s) and New Zealandian (NIWAR, Wellington) researches are presented in several reports (Dalen et. al., 1976; Dalen and Nakken, 1983; Dommasnes and Rottingen, 1984; Foote et al., 1986; Vilhjalmsson, 1994; Rose, 1998; O’Driscoll and Rose, 2001; Jorgensen and Olsen, 2002; Jorgensen, 2003).

By combining the results from the instrument calibration on the standard sphere, *ex situ* measurements of capelin TS from 13–18 cm, *in situ* measurements by echo trace counting of unspecified lengths and measurements of TS on stunning fish Norwegian and Icelandic researches derived the following target strength relationship for capelin (Dalen et. al., 1976; Dommasnes and Rottingen, 1984; Vilhjalmsson, 1994):

\[
TS(\text{Capelin, IMR}) = 19.1 \log (\text{TL}) - 74.0
\]  

(1)

On the basis of *in situ* TS data in Newfoundland waters the Canadian and New Zealandian researches derived the following target strength relationship for capelin from 5 -14 cm (Rose, 1998; O’Driscoll and Rose, 2001):
In this paper we present the results of capelin target strength estimation in situ carried out in PINRO in 2000-2004 during trawl-acoustic survey of fish stocks in the Barents Sea and of comparison between Norwegian, Icelandic, Canadian, New Zealandian and Russian data.

**Materials and methods**

In May-June 2000, September-October 2001, February-March and August-December 2004 in the Barents Sea the research vessels we have used, R.V. “Persey–3”, “AtlantNIRO”, “Smolensk” and “Fridtjof Nansen” were equipped with SIMRAD EK500 scientific echo sounder at the frequency of 38 kHz with the split-beam transducer for directly measurements of the fish target strength and the target strength distributions. In August 2004 R. V. “Smolensk” and “Fridtjof Nansen” were equipped with the modern SIMRAD EK60 scientific echo sounders with the modern software of post processing BI60 v.2.1.1.

The echo sounders were connected to an IBM PC with the software package LTSD100 (Length and Target Strength Distributions) developed in PINRO (Ermolchev, 2000; Ermolchev et al., 2004) and software package FAMAS (Fisheries Acoustic Monitoring & Analysis System) developed in TINRO for to collect and process the results of fish target strength.

Simultaneous check hauls of the studied fish concentrations were conducted by bottom 2283 and pelagic 2492 trawls with small-meshed size insertions with full mesh sizes 16mm, pelagic 03TRPGA8-623-000 and bottom Campelen1800 trawls with small-meshed size insertions

\[
TS(\text{Capelin}, \text{FMI}) = 23.3 \log(\text{TL}) - 77.1; \quad R^2 = 0.95; \quad \text{SE} = 0.8; \quad n = 6, \quad (2)
\]
with full mesh size 22 mm for estimation the length composition of capelin. The target strength relationships $\overline{TS} = B \log(\overline{TL}) + A$ (the geometric mean estimate of the functional regressions of mean target strength of fish \textit{in situ} $TS$ on their mean length $TL$ in catches or GM regressions) were computed by the method described in Ricker (Ricker, 1973).

**Results**

In May-June 2000, September-October 2001, February-March and August-December 2004 in the Barents Sea about 1000 trawling were carried out with simultaneous measurements of distribution of fish target strength in the fishing zone (Figs. 1-2).

All data processing resulted in the following relationships of the GM regression between mean target strength $\overline{TS}$ of capelin and their mean length $\overline{TL}$ (Fig. 3).

For capelin with mean lengths in catches from 4.4-18.7 cm in day and night:

$$TS(PINRO) = 21.4 \log(TL) - 75.4; R^2 = 0.96; SE = 0.73; n = 71$$

(3)

For capelin with mean lengths in catches from 5.2-18.7 cm in the daytime:

$$TS(\text{in the daytime}) = 23.2 \log(TL) - 77.5; R^2 = 0.96; SE = 0.63; n = 32$$

(4)

For capelin with mean lengths in catches from 4.4-18.2 cm in the nighttime:

$$TS(\text{in the nighttime}) = 21.1 \log(TL) - 74.9; R^2 = 0.96; SE = 0.74; n = 33$$

(5)

The target strength for capelin in the nighttime is bigger than in the daytime by 0.5-1.0 dB for length < 10.0 cm.
Figure 1. Example of FAMAS processing echogram on capelin in the fishing zone by SIMRAD EK60 echo sounder; mean length of capelin in trawl catch $\overline{T_L} = 8.8$ cm.

Figure 2. Example of FAMAS processing echogram on capelin in the fishing zone by SIMRAD EK60 echo sounder; mean length of capelin in catch $\overline{T_L} = 6.2$ cm.
Figure 3. Dependencies between the target strength TS of capelin *in situ* for 38 kHz and their length TL.
**Discussion and conclusions**

On the basis of the derived data analysis of the following conclusions can be done.
In the result of comparison of all data we made sure that the derived in FMI and PINRO target strengths of capelin from 5-18 cm appeared to be similar and higher than expected from TS-length relationship of IMR. During the TAS for capelin stocks the usage of the current target strength equation (1) instead of equations (2) or (3) leads to the biased errors of estimations of capelin target strength, abundance and biomass: target strength of capelin with length classes from 5.0 cm to 20.0 cm are underestimated from 0.3 to 1.5 dB accordingly (Figure 2), the abundance and the biomass of capelin aggregation are overestimated to 10-30 %. The same conclusion described by R. Jorgensen and K. Olsen (Jorgensen and Olsen, 2002): the observed mean TS for capelin from the local Balsfiord stock was >1 dB higher than expected from the TS-length relationship for Barents Sea capelin used during abundance estimation. Based on the comparative analysis of all the data, the conclusion that while conducting trawl-acoustic surveys (TAS) for capelin stock the highest accuracy should be expected while applying the TS-length relationships (2) or (3).

It should be noticed that we have a little in situ data on capelin target strength.
Therefore, in PINRO in the sea expeditions (in situ) the works on determination of capelin target strength of different length in different seasons in the day and night time and for different depths still continue.

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References


