FISH AS ACOUSTIC TARGETS

Literature Update

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FSH 538
November 2015
ACOUSTIC PROPERTIES OF TARGETS DEPEND ON MANY FACTORS!

**Behavior**
- Vertical migration
- Avoidance
- Tilt angle

**Morphology**
- Swimbladder
  - Gas filled
  - Physoclistous
  - No swimbladder
  - Physostomous
- Oil/fat filled

**Physiology**
- Maturity state
- Condition factor

**Frequency**

**Size**

**Depth**

**spp. ID**
Immobile fish
single beam

Live fish in cages

Wild fish

Detection of single targets
ST criteria

Representative individual
Representative measure of mean TS.

Representative biological sample
spp. composition

Length histogram TS histogram

IN SITU

EX SITU

Physiological, behavioral and environmental factors

Modelling

Zooplankton
Interpretation of experimental results

Figure 4. Apparatus for target strength measurements on live fish in a cage. The cage is 4 m in diameter, 1 m deep and 3 m below the transducer. A reference target provides continuous calibration of the transducer. (Adapted from Edwards et al. 1994)
AFTER 2005...

• Efforts directed to obtain good estimates of spp. TS

• Accurate TS-TL relationship

• Combining modelling, *in situ* measurements and behavioral studies

• New technologies: multibeam, broadband, AOS
In situ ST data to estimate fish tilt and yaw -> correlation with TS

Tilt, yaw and beam position have a significant influence on fish TS. (as fish moves away from acoustic axis -> greater effect of swimming behaviour on TS).

Orientation had minimal influence on aggregation’s average TS if the aggregation had variable tilt-angle distribution and was dispersed throughout the acoustic beam.
Approach to accounting for scattering directivity and fish behaviour in multibeam echosounder surveys.

Acoustic backscatter modelled by beam-incidence angle considering the scattering-directivity patterns of each fish.

- For a multi beam echosounder the TS of a fish can vary with its pit, roll and yaw angles – different effects depending on beam incidence angle (small effects of $\theta_R$).

- Some behaviours of fish in response to a vessel should be apparent in the pattern or CV of $Sv$ by beam angle.
New broadband methods for resonance classification and high-resolution imagery of fish with swimbladders using a modified commercial broadband echosounder (2010)

Timothy K. Stanton, Dezhang Chu, J. Michael Jech, and James D. Irish

1.7 – 100 kHz Pulse compression technique

Improvements over conventional narrowband systems:

- Resolution (20 – 3 cm for lower and higher freq. respectively).
- Resonance classification: at low freq. resonance frequency could be observed -> accurate estimates of size and density of fish.
- Spectral discrimination (fish and zooplankton).
- Signals at the lower frequencies don’t depend on orientation of the fish -> changes in echo level associated to changes in numerical density.

Figure 8. Numerical density of Atlantic herring as determined through resonance classification using the low-frequency acoustic channel. Data are from same transect as in Figure 5, but over a greater distance. There is an artefact in the data, just above the seafloor, associated with the high echo level from the seafloor.
Broadband

Backscatter from excised backbone increases linearly with frequency – below 150 kHz minor contribution to total sandeel backscatter -> size of targets.

68–450 kHz, and tilt angles +/- 30

- Scatter from the backbone is significant around 0 tilt angle.
- The head, including gills, important scatterer when the fish is tilted.
- Flesh and backbone give strong backscatter
- with wide directivity, increasing with frequency.

Original Article

Scattering properties of Atlantic mackerel over a wide frequency range

Tonje Nesse Forland¹, Halvor Hobæk¹, and Rolf J. Korneliussen²*

Figure 9. Dorsal aspect, medium size group: the backscattered TS from 10-cm backbone (averaged over nine backbones), 10-cm flesh segment (averaged over three flesh segments), whole head, head without gills and skull are plotted for 0° tilt angle (top panel) and for tilt distributions of N(0°,10°) (bottom panel).

Original Article

Broad bandwidth acoustic backscattering from sandeel—measurements and finite element simulations

Tonje Nesse Forland¹, Halvor Hobæk¹, Egil Ona², and Rolf J. Korneliussen²*
Measurements of TS in horizontal directed SONAR.

- The lowest TS when head or tail faced the sonar beam - highest values perpendicular to the sonar beam.
- The TS distribution differed between fish with one- and two-chambered swimbladders.
- TS - fish aspect relative to the sonar beam can be described by a linear model for fish with two-chambered swimbladders and by a quadratic model for fish with one-chambered swimbladders.
• Trawl mounted Acoustic Optical System (AOS): Echosounder, cameras, lighting and batteries

• TS measurements from target visually identified

• Additional frequencies and stereo cameras to estimate fish length

• Remove uncertainties in TS associated with target ID and ST selection.