

Theme Session H

Effects of environmental changes on the biology, physiology and behaviour of pelagic fish

ICES CM 2007/H:01

Shedding light on recruitment mysteries: internal and external signals in the stock-recruitment relationship of North Sea herring

Joachim Gröger and Norbert Rohlf

Though the stocks of North Sea herring seemed recovered from small numbers since the mid-1990s we do recently observe a new decline in the spawning stock biomass. This is mainly caused by four consecutive years of small reproduction. Whilst the adults produce enough eggs and larvae, only a few of them survive until mature stages strongly affecting the recruitment process. The reasons for the bad recruitment are not clear. In this paper we investigate the influence of climate conditions, in particular of the North Atlantic Oscillation (NAO), that obviously triggers the interaction between the size of the spawning stock and the abundance of larvae. Hence, along with external physical factors we investigate the influence of internal biotic factors that may shed light on the fluctuation of herring offspring. Based on this we show, that herring recruitment is strongly cyclic and that approximately 60 % of the recruitment variance can be explained by specific constellations of spawning stock size and climatic conditions.

Keywords: North Sea, herring recruitment, stock-recruitment relationship, density dependence, climate effects, spectral analysis, Fourier decomposition, segmented regression.

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ICES CM 2005/H:02

Variability of biotic and abiotic factors in clupeoids life cycle in the Baltic

Andrzej Orłowski

Since 1981, acoustic information, collected in a form of calibrated measurements of integrated echoes energy is applied in Sea Fishery Institute to observe the relationships among clupeoids distribution in the Baltic and associated environmental factors. Data were collected during different seasons for each elementary distance units (EDSU) in standardized depth intervals and compared to the values of selected environmental parameters, measured parallel. Acoustic, biological and hydrological data were correlated in space and transferred to the complex data base, enabling 4D analysis of numerous factors, enable to characterize wide range of fish behaviour. The paper presents selected characteristics, describing the variability of environmental factors, within clupeoids short- and long-term life cycle. The analysis of abiotic factors is enhanced by presentation of specially prepared cross-sections of the herring in different stages of the gonad maturity. All the aspects were described with the task to take them into account in the procedures of measuring and modelling the target strength of herring and sprat, particularly in the specific Baltic circumstances.

Keywords: acoustics, biotic and abiotic factors, Baltic, clupeoids, target strength.

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ICES CM 2007/H:03

Comparison of the swimbladder between Baltic and Norwegian fjord herring: possible consequences for mean target strength

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Volume and shape of the swimbladder of Baltic and Norwegian fjord herring were measured, together with individual herring fat content. Swimbladder morphology was found to differ significantly between the two herring stocks. The larger swimbladder volume of Baltic herring is suggested to be associated with the low salinity of the Baltic Sea. The data was subsequently used to model the mean target strength as a function of depth and growth pattern. Preliminary analysis supports a different target strength to size relationship for Baltic herring, with a stronger echo, due to the much larger bladder.

Keywords: acoustics, target strength, swimbladder, modelling.

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ICES CM 2007/H:04

Snake pipefish (*Entelurus aequoreus*) intrusion as a new species into the Barents Sea ecosystem

Magnus Reeve, Erik Olsen, and Leif Nøttestad

The snake pipefish *Entelurus aequoreus* is a member of the *Syngnathidae* family. The open water species is distributed in the eastern Atlantic, from the Azores to Iceland and Norway, including the Baltic Sea. Concentrations of snake pipefish were observed for the first time in the Barents Sea in August–October 2005, after which both their distribution area and average density have increased substantially in 2006. The area inhabited by these fish increased three-fold from 2005 to 2006, using data from pelagic trawling. The density in these areas rose from an average of 2.4 to 9.3 caught fish per nautical mile of trawling. However, using trawl data to measure abundance may not be the most adequate method due to little knowledge of the behavioural patterns of this fish species. Snake pipefish have historically usually been associated with warmer temperate waters, so it is interesting to note that the increase in numbers may coincide with exceptionally high sea surface temperatures for that time of year. We plan to investigate this relationship in further detail with collection of relevant data in 2007.

Keywords: snake pipefish; distribution pattern; Barents Sea; climate change.

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ICES CM 2007/H:05 **Withdrawn**

ICES CM 2007/H:06

Target strength of Baltic herring and sprat in relation to changes of their biological characteristics: effects on acoustic abundance indices estimates

S. M. Kasatkina

It is common practice that the target strength of Baltic herring and sprat is estimated using a known regression: $TS=20\log L - 71.2$ derived about 20 years ago. However, in publications presented by different authors in recent 5 years, the estimates of herring TS are higher as compared with those obtained in the 80s. On the other hand, the existing practice of using one and the same regression TS for sprat and herring has not yet been corroborated by either experimental or model research.

For discussion the up-to-day status of the above said regression the author presents the results of herring and sprat TS in situ measurements made within a wide range of fish lengths in 2002–2006, and analyzes biological characteristics of the two fish species and their variations observed over recent decades. Bootstrap procedure was used to derive TS regressions, accompanied by the uncertainty estimates of their parameters. Significant interspecific discrepancies between TS of herring and sprat were revealed, herring TS values being by almost 4 dB higher as compared with those obtained in the 80s. The observed variations of herring TS were traced against a background of considerable changes of their biological characteristics. A comparative analysis of main morphometric/anatomical characteristics confirms revealed differences between acoustic characteristics of the two fish species. In conclusion, changes in the fish biological characteristics as a source of uncertainty in herring and sprat abundance indices obtained from the acoustic survey data is discussed. The author demonstrates the latter from the positions of such factors as target strength and differential catchability of the survey trawl.

Keywords: target strength, in situ, herring and sprat biological characteristics, acoustic assessment of abundance index, trawl differential catchability .

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ICES CM 2007/H:07

On target strength of Baltic herring

Natalia Gorska

Reliable TS – length relationship is required to improve acoustic algorithms of abundance estimation of Baltic herring. The proposed relationships, empirically obtained in the different parts of the Baltic Sea,

produce up to 8 dB – difference in the herring TS. To obtain an accurate TS – length relationship the variability should be understood. It requires identifying the factors controlling Baltic herring TS and understanding their relative impact. It was the main motivation of the study. The Modal Based Deformed Cylinder Model and the Distorted Wave Born Approximation were employed in modelling of backscattering by fish swimbladder and body respectively to illustrate the backscatter sensitivity to the biological, acoustical and environmental parameters. The decrease of the herring target strength with depth due to swimbladder compression was evaluated at different frequencies used in the acoustic abundance estimation of Baltic herring. The fish morphology impact on the depth dependence was demonstrated. The frequency dependence of herring TS and its sensitivity to the fish morphology and the depth were analyzed. The TS dependence on the herring orientation was studied. The impact, of the backscattering sensitivity to the depth, orientation and frequency, on the TS-length relationship of Baltic herring was considered. The reasons of the variability of the TS of Baltic herring, observed in the different acoustic surveys, were discussed and some recommendations for the future study were presented.

Keywords: acoustical techniques of fish abundance estimation, TS-length relationship, target strength of Baltic herring, modelling.

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ICES CM 2005/H:08

The influence of fish morphological and behavioural parameters on acoustic data in algorithmic reconstruction of fish length distribution

Marek Moszynski and Andrzej Stepnowski

The paper investigates the algorithm for estimation the fish length distribution from acoustic target strength data. The theory of scattering from a tilted cylinder is used for modelling the fish directivity pattern of swimbladdered fish. The model allows formulating the dependence of target strength on two main components: fish maximum target strength and the fish directivity pattern. As both terms depend on fish length, the inverse technique could be used to reconstruct unknown fish length distribution from acoustic data, when morphological parameters of fish are properly assumed. However, as it is shown, the algorithmic approach is very sensitive to some of behavioural parameters of swimming fish. Thus, although the effect of unknown fish tilt angle could be partially removed by statistical processing, the mean value of fish tilt angle still may produce large errors. The method and its results are verified on actual data acquired during the survey and compared to trawl catches.

Keywords: fishery acoustics, target strength, fish directivity pattern.

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