Theme Session B
The contribution of acoustics-derived indices for ecosystem-based fisheries management: technological and analytical challenges and recent advances

ICES CM 2012/B:01

Patchwork of the spatial distribution of small pelagics off Northwest Africa with non-linear geostatistics
Cheikh Baye Isselmou and Nicolas Bez

In Northwest Africa, pelagic resources are an essential economic activity, particularly off Mauritania where they constitute about 90% of catches. To confirm that acoustic densities provide reliable observations of the order of magnitude of abundances rather than precise measurements of fish densities, we applied non-linear geostatistics to produce: (i) patchworks of classes of densities and (ii) indices of abundances from acoustic data collected during yearly surveys of RV “Fridjoff Nansen” from 1995 to 2006. This method, developed in the mining sector, has been rarely applied to fisheries previously. We show that it provides valuable and reliable results when applied to abundance indices for pelagic fisheries in Northwest Africa. Simple and cross-variograms of indicator variables based on four different thresholds of densities exhibit a stable year-to-year spatial pattern of density classes. Our results indicate also that (i) after a period of fluctuation between 1995 and 2000, abundance indices exhibit a slow and continuous increasing trend from 2001 to 2006, and that (ii) from 2001 to 2006 the geographical distribution of high abundance areas became wider through extending further offshore each year, roughly from 0.56 miles in 2001 to 0.92 miles in 2006.

Keywords: abundance index, non-linear geostatistic, Northwest Africa, small pelagic, spatial distribution.

Contact author: Cheikh Baye Isselmou, Mauritanian Institute of Oceanographic Research and Fisheries, Mauritania [e-mail: baye_braham@yahoo.fr].

ICES CM 2012/B:02

Combining bottom-trawl and acoustic data to quantify expected biases in abundance estimates from bottom-trawl and acoustic surveys
Stan Kotwicki, Alex De Robertis, Jim Ianelli, André E. Punt, and John Horne

Abundances of semi-pelagic fish are often estimated using acoustic-trawl and bottom-trawl surveys, both of which sample a limited fraction of the water column. Acoustic instruments have a near-bottom acoustic dead zone (ADZ), in which fish near the seafloor cannot be detected. Bottom-trawl surveys cannot account for fish that are located above the effective fishing height (EFH) of the trawl. We present a modelling method that combines acoustic and bottom-trawl abundance and habitat data to derive ADZ correction and bottom-trawl efficiency parameters. Our results show that predictions of fish abundance in the ADZ can be improved by incorporating bottom habitat features such as depth and sediment particle size, as well as pelagic habitat features such as water temperature, light level, and current velocity. We also obtain predictions for trawl efficiency parameters such as EFH, density-dependent trawl efficiency, and proportionality coefficients for trawl and acoustic data by modeling bottom-trawl catches as a function of acoustic measurements and the environmentally dependent ADZ correction. This method is applied to walleye pollock in the eastern Bering Sea to quantify expected biases associated with each survey method and the dependence of the biases on environmental variables. The catchabilities of acoustic and bottom-trawl survey methods are dependent on
environmental variables, and the sampling biases are not stationary in time and space as is commonly assumed for survey data. Applying models that combine both bottom-trawl and acoustic data can mitigate these problems for stock assessment as well as spatial dynamics studies.

Keywords: acoustic-trawl survey, bottom-trawl survey, acoustic dead zone, bottom-trawl blind zone, effective fishing height, catchability.

Contact author: Stan Kotwicki, Research Fisheries Biologist, NOAA, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Bldg 4, Seattle, Washington 98115, USA [tel: +1 206 526 6614, e-mail: stan.kotwicki@noaa.gov].

ICES CM 2012/B:03

High-resolution acoustic indices of Atlantic herring (Clupea harengus) paving the way for inclusion of migration patterns in management considerations of herring in ICES Divisions IIIa and SD 22-24

Karl-Johan Stæhr and Lotte Worsøe Clausen

Herring catches in the Western Baltic, Kattegat and Skagerrak consist of a mixture of stocks; the two predominant stocks are the spring-spawning Western Baltic herring stock and the North Sea autumn-spawning herring (NSAS), and the mixing follows an age- and season-dependent pattern with high variability. The management is currently based on a single TAC and all catches are split into stock components prior to the single stock-assessment process. Given the complexity, knowledge of the magnitude of the mixing would improve the ability to perform sound forecasts of the herring stocks in the area. Thus a high-resolution stock-segregated survey index is highly warranted. Since 1991, DTU-Aqua have been acoustically monitoring herring in Skagerrak and Kattegat, ICES Division IIIa, as a part of the international acoustic survey for herring in the North Sea and adjacent waters. For the years 2006–2011 the two major herring stocks have been separated in the abundance estimate based on a combination of otolith microstructure and otolith shape. The abundance estimates by ICES rectangles have been used to describe the yearly geographical distribution of the herring stocks separately by age groups, mean length, and mean weight during June–July. This time-series (2006–2011) when analysed as a whole, gives a general picture of the distribution of the two herring stocks in Skagerrak and Kattegat during June–July and can ultimately be used as input to a description of the migration pattern for the two herring stocks.

Keywords: acoustic monitoring, herring, migration, Skagerrak, stock separation.

Contact author: Karl-Johan Stæhr, National Institute of Aquatic Resource, DTU-Aqua, Technical University of Denmark, PO Box 101, Nordøen Forskerpark, DK-9850 Hirtshals, Denmark [e-mail: authorkjs@aqua.dtu.dk].

ICES CM 2012/B:04

Determining herring habitat quality from acoustically derived zooplankton abundance in the northern North Sea

M. M. Sascha Fassler, Lorna R. Teal, Susan M. Lusseau, and Piet Ruardij

Acoustic fish surveys commonly collect data at a frequency range of 18–200 kHz. This is done primarily to facilitate target species identification and distinction from other fish based on differences in frequency-dependent scattering properties. Indeed, acoustic data contain qualitative and quantitative information on various trophic levels within an ecosystem, ranging from plankton to larger predators. Generally, however, backscatter information coming from plankton or other non-target fish species is discarded during the process of producing estimates of abundance and biomass of the target species. We applied a bi-frequency algorithm to multi-frequency data collected in the northern North Sea during acoustic surveys for herring from 2002 to 2012. This algorithm has previously been used on data from the Bay of Biscay and waters off
Peru to identify acoustic backscatter coming from macrozooplankton. Here, the same method allowed production of high-resolution maps of distributions, abundances, and biomass of macrozooplankton in the northern North Sea. These estimates were compared to outputs of the European Regional Seas Ecosystem Model (ERSEM) to determine whether the two approaches are in agreement with each other. Forage fish species such as herring feed directly on macrozooplankton, which are mainly composed of copepods and euphausiids. Knowledge about the location and abundance of food (macrozooplankton) and environmental conditions (temperature) may be used to identify preferable habitat for herring. A Dynamic Energy Budget (DEB) model was used to estimate food intake requirements of herring, given prey abundance and temperature, and consequently map the quality of the habitat in the survey area.

Keywords: North Sea, herring, dynamic energy budget, ecophysiology, habitat quality, ERSEM.

Contact author: Sascha Fässler, Wageningen Institute for Marine Resources and Ecosystem Studies (IMARES), PO Box 68, 1790 AB IJmuiden, The Netherlands [e-mail: sascha.fassler@wur.nl].

---

**ICES CM2012/B:05**

**Going pelagic: how abiotic conditions force demersal Baltic cod into open water, and how this affects assessment**

Matthias Schaber, Hans-Harald Hinrichsen, and Joachim Gröger

Hydroacoustic measurements were applied to resolve seasonal distribution patterns of adult cod (*Gadus morhua*) in a physically challenging environment of the central Baltic Sea. Sampling was conducted biannually from 2006 to 2009 during the beginning and peak of the eastern Baltic cod spawning season on hydroacoustic transects covering the Bornholm Basin. Individual cod were identified using hydroacoustic single-target detection in combination with a fish-tracking algorithm. Distribution patterns of individual cod were related to ambient *in-situ* environmental conditions to identify possible abiotic driving mechanisms. Results showed a clear effect of salinity and ambient oxygen concentration marking the upper and lower boundaries of favourable cod habitats. Deteriorating oxygen levels in deep layers of the Bornholm Basin over the years investigated led to a seasonal upward movement of cod resulting in an increasingly pelagic distribution of large fractions of the local population. The results presented in this study highlight a significant shortcoming of the assessment survey design established for this species, as the observed shift in (vertical) distribution is not taken into account during the regularly conducted bottom-trawl surveys generating abundance indices, thus introducing a potential bias into a dataseried used to tune the ICES standard stock assessment of this species.

Keywords: Bornholm Basin, environmental habitat thresholds, hydroacoustic single-fish detection, seasonal distribution patterns.

Contact author: Matthias Schaber, Johann Heinrich von Thünen-Institute, Institute of Sea Fisheries, Palmaille 9, 22767 Hamburg, Germany [tel: +49 (0)40 38905 173, fax: +49 (0)40 38905 264, e-mail: matthias.schaber@iti.bund.de].

---

**ICES CM 2012/B:06**

**Acoustic assessment of the effect of anchovy on bluefin tuna school structure: implications for acoustic estimation of tuna abundance and of predation of anchovy**

Nicolas Goñi, Igor Arregui, Guillermo Boyra, Iñigo Onandia and Haritz Arrizabalaga

Juvenile Atlantic bluefin tunas perform feeding migrations every summer to the Bay of Biscay, where juvenile anchovy constitutes their quasi-exclusive prey in the second half of the summer. Uncertainties regarding the stock abundance of bluefin tuna and their predation impacts on juvenile anchovy raised the need to develop reliable abundance indices for bluefin tuna in the Bay of Biscay. Due to the behaviour of this large pelagic predator (patchy distribution, fast
displacements, possible influences of feeding strategy on schooling behaviour), the possibility of acoustic surveys directed to bluefin tuna was assessed by an experimental survey. A set of three vertically and horizontally oriented echosounders was installed on board a baitboat targeting bluefin tuna in the Bay of Biscay during July and August 2011. The radius, volume, and density of each aggregation detected were calculated through a processing method combining information from vertical and horizontal echograms. The influence of anchovy abundance on tuna school structure (shape, volume, density) was tested on a large temporal scale and on a small temporal and spatial scale. The ratio between tuna catch rate and calculated abundance was also tested versus meteorological conditions and anchovy abundance. Our main result is a shift in school characteristics between July and August, schools being larger and denser in August than in July. This shift coincides with the local presence of juvenile anchovy in August (versus absence in July). The possibility of a transect-based acoustic survey directed to bluefin tuna is discussed according to the global results.

Keywords: acoustics, bluefin tuna, Bay of Biscay, feeding behaviour.

Contact author: Nicolas Goñi, AZTI-Tecnalia, Marine Research Division; Herrera kaia portualdea z/g, 20110 Pasaia (Gipuzkoa), Spain [e-mail: ngoni@azti.es].

**ICES CM 2012/B:07**

**Phytoplankton abundance and productivity impacts the distribution of herring in the North Sea**

Sven Gastauer, Mark Dickey-Collas, Narangerel Davaasuren, Niels Hintzen, Thomas Brunel, and Sascha Fassler

Almost all fishery stock assessments are carried out assuming a bounded spatial distribution of the exploited resource, although fish live and hence fisheries operate, in a highly dynamic environment. An understanding of the basic underlying patterns driving the distribution of herring, one of the most important commercial pelagic species in the North Sea, is crucial to a more ecosystem-based management approach and to achieve a better understanding of herring stock dynamics. North Sea herring is a planktivorous species that feeds on phytoplankton during its earlier life stages, switching to zooplankton later on. The present study assumes that zooplankton directly tracks phytoplankton. It will be shown if and to what degree primary production in the North Sea acts as a limiting factor for the distribution and seasonal migration of herring. The presented study will provide an insight into the spatial and temporal variability of phytoplankton standing stock, the associated primary production, and its impact on the exploitation and management of herring in the North Sea. Remote sensing chlorophyll data are used in combination with fisheries-dependent (VMS data) and fisheries-independent survey data (annual herring acoustic survey) to explore the relationship between fish, fisheries, and primary production.

Keywords: acoustics, herring, North Sea, plankton.

Contact author: Sven Gastauer (IMARES), PO Box 68, Haringkade, 1 0.23, 1970AB IJmuiden, The Netherlands [mobile: +31 (0)61 005 71 03, e-mail: sven.gastauer@wur.nl].

**ICES CM 2012/B:08**

**Mesoscale eddies stimulate higher trophic level marine life—a acoustically recorded density distribution creates understanding of the impact of physical forcing**

Olav Rune Gode, Gavin Macaulay, Annette Samuelsen, and Solfrid Sætre Hjøllo

Physical forcing shapes ecosystems and an understanding of interactions between drivers and biological responses is crucial for understanding ecosystem processes and potential impacts on harvested stocks. Combining satellite information with vessel-based acoustics is a cost-efficient way to study physical–biological interactions in mesoscale eddies. Anomalies in horizontal
distribution patterns demonstrate that fish feed along eddy peripheries. Therefore eddies also have an effect on the depth distribution patterns of fish species in eddies. However, data also indicate that the eddy-influenced signal in the acoustic record varies from very strong to absent, possibly because of eddy age, eddy rotation (cyclone or anticyclone), etc. The impact of the findings and suggestions for further work are discussed.

Keywords: acoustics, biomass distribution pattern, mesoscale eddies, physical-biological coupling, satellite imaging.

Contact author: Olav Rune Godø, Institute of Marine Research, PO Box 1870, 5817-Bergen Nordnes, Norway [e-mail: nolarune@imr.no].

ICES CM 2012/B:09 Withdawn

ICES CM 2012/B:10

Assessing mackerel abundance indices extracted from opportunistically recorded acoustic data on board a bottom-trawl survey

Jeroen van der Kooij, Sven Gastauer, Sascha M.M. Fässler, Beatriz O. Roel, and David Righton

Fisheries acoustic methodologies record continuous, high-resolution data of the water column. As acquisition of acoustic data is relatively autonomous, it can provide a valuable additional resource of information during expensive research surveys, irrespective of the main focus of the fieldwork. Here we present results of a case study which utilizes acoustic data, opportunistically recorded during the international bottom-trawl surveys (IBTS) in the North Sea, to extract information on the distribution and abundance of mackerel. Information about mackerel abundance and distribution in the North Sea is important because the spatial distribution of the stock and the fishery has changed in recent years. This has led to controversial changes in exploitation policy in more northern waters. In the absence of a dedicated North Sea mackerel survey at this time of year, we used a unique dataset of opportunistically recorded data. An algorithm based on the typical backscatter properties of mackerel was applied to a five-year time-series of multifrequency (38, 120, and 200 kHz) acoustic data collected during the IBTS across the North Sea. The acoustically derived information on the distribution and abundance of mackerel in the North Sea were combined with mackerel age and length data obtained from the routine bottom trawls to investigate the population dynamics. Patterns in mackerel dynamics over this five-year time-series were compared with those based on other sources, such as the triannual mackerel egg survey, to determine whether they were in agreement with each other and to assess whether routinely collected data could provide a supplementary in-year index. Our analysis has particular value because very few fisheries-independent data exist to describe mackerel distribution during the summer, yet scientific information is crucial to underpin management decisions.

Keywords: feeding, mackerel, North Sea.

Contact author: Jeroen van der Kooij, Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Road, Lowestoft NR33 0HT, UK [e-mail: jeroen.vanderkooij@cefas.co.uk].
ICES CM 2012/B:11

Acoustic mapping of deep-water coral

B. Ramiro Sanchez, F. McIntyre, F. Neat, and P. G. Fernandes

Little is known about the distribution of the deep-sea cold-water coral *Lophelia pertusa* in the Northeast Atlantic, although there are several closed areas which have been designated on the Rockall Plateau to protect this habitat and the species associated with it. Acoustic surveys have made it possible to locate and map more accurately areas with the occurrence of this species. In the Norwegian fjords and the west of Scotland, acoustic surveys using multibeam echosounders have been used in shallow waters to map *Lophelia*. In deeper water more specialized lower frequency multibeam sonar units are required, which are usually only available on the larger, more sophisticated research vessels. In this study we investigate the use of low-frequency single split-beam echosounders to detect *Lophelia*. These instruments are available on many fisheries and research vessels, and have the capacity to detect the seabed in deeper waters. We conducted an acoustic survey of the seabed in the closed areas on the Rockall Plateau in conjunction with a visual survey to groundtruth the acoustic characterization of coral habitat. Preliminary results from detections of deep-sea coral habitat are presented which make use of the phase information available from the split-beam echosounder, as well as the more traditional echo amplitude and envelope statistics.

Keywords: acoustic, coral, single split-beam echosounder.

Contact author: Berta Ramiro Sanchez, University of Aberdeen, School of Biological Sciences, Zoology Building, University of Aberdeen, Tillydrone Avenue, Aberdeen AB24 2TZ, UK [e-mail: b.ramirosanchez.11@aberdeen.ac.uk].

---

ICES CM 2012/B:12

Acoustic data from fishing vessels: what indicators can be obtained that research vessels cannot provide?

François Gerlotto, Mariano Gutierrez, Erwan Josse, Anibal Aliaga, Jeremie Habasque, and Arnaud Bertrand

Large fisheries (e.g. jack mackerel in the South Pacific Ocean) are difficult to survey exhaustively through scientific surveys and the information obtained from the multiple international fisheries exploiting them are difficult to synthesize and do not always provide reliable indicators allowing correct ecosystem-based management. We propose to use direct acoustic information from fishing vessels, which is made possible nowadays because many vessels are equipped with professional echosounders similar to scientific echosounders. A study was done on the Peruvian fishery in March 2011 on a sample of acoustic data provided by the Jack mackerel fishers during the first trimester of 2011. Among the more than 150 000 data collected by the fishery we selected 25 trips made by vessels equipped with the most up-to-date echosounders, which represented 15 000 elementary distance sampling units of 0.5 nautical mile. Results showed that the acoustic information from fishing vessels is usable and could be obtained at very low cost from the fishery itself. The major findings were as follows: dimensions of fish school clusters and fishing vessels clusters were evaluated around 3 nautical miles diameter; as fishers applied an empirical density threshold below which fish was not considered exploitable, they concentrated their sampling effort on a third of the total fishing area; no clear relationship appeared between CPUE and acoustic density at small geographical scales, although a global correlation at the scale of a trip could be calculated. Finally, abundance estimates from scientific surveys could be dramatically improved when acoustic data from the fishing vessels were added.

Keywords: fisheries acoustics, fishing vessels, jack mackerel, South Pacific Ocean.

Contact author: Erwan Josse, IRD, BP 170, 29280 Plouzane, France [e-mail: erwan.josse@ird.fr].
### ICES CM 2012/B:13

**Assess spatial indicators from single-species acoustics estimates for ecosystem-based management: some possibilities from the eastern Mediterranean Sea**

M. Giannoulaki, A. Machias, P. Petigas, M. M. Pirounaki, K. Tsagarakis, and M. Woillez

Spatial indicators based on acoustic surveys for anchovy and sardine, the two main target species in the Mediterranean, are used to describe species spatial distribution in relation to biomass variation. A series of spatial indicators (i.e. positive area, spreading area, equivalent area, inertia) was examined in two areas of the Aegean Sea (eastern Mediterranean) during summer (i.e. spawning period for anchovy and recruitment period for sardine). A significant relationship was found between the biomass and the spreading and equivalent area index for both species. In contrast to anchovy, sardine showed a highly aggregative behaviour in the study area, presenting biomass values that were not related to the positive area occupied by the population. Going a step further, the same relationship was examined using one-year lag difference in order to explore whether a spatial indicator could be used as an index to assess the status of the stock in the following year. Thus, during summer, which is the spawning period of anchovy, higher values of the equivalent and the spreading area, implying less heterogeneous distribution, can lead to lower biomass values in the next year. With regard to sardine, during the summer period—which largely coincides with the recruitment period of the species—the only significant relationship found was between inertia and the biomass of the next year. This denotes that higher inertia values and subsequently less aggregated population is likely to result in lower biomass in the following year. Thus the spatial behaviour of a population can be reflected in different spatial indices depending on the species and life stage.

Keywords: acoustics, anchovy, sardine, spatial indicators.

Contact author: Marianna Giannoulaki, Hellenic Centre for Marine Research, Greece [e-mail: marianna@hcmr.gr].

### ICES CM 2012/B:14

**Extraction of zooplankton echoes in mixed aggregations**

Rolf J. Korneliussen, Egil Ona, and Hector Pena

When echoes from several organisms occur in the same acoustic pulse volume, as is the case in many fjord and oceanic layers, multifrequency analysis can seldom be directly used for target separation. A much stronger separator is sometimes needed for extrication of strong and weak targets. If a layer with zooplankton is contaminated by fish larva, small or large swimbladdered fish, the layer frequency response is always dominated by the strong scatterer, often disguising much more abundant zooplankton information. New thresholding and filtering methods enable a more accurate separation of the two dominating scatterers, enlivening the backscattering response from individual groups. New separator echograms may then further be used for standard single-target category abundance estimation.

Keywords: acoustics, mixed aggregations, zooplankton.

Contact author: Rolf J. Korneliussen, Institute of Marine Research, Bergen, Norway [e-mail: rolf@imr.no].
Oceanographic and physiological conditioning of the hydroacoustic survey results in the Canary upwelling region

A. Sorokin, N. Barkova, N. Timoshenko, and G. Chernega

The hypothesis that acoustic biomass estimations in the Canary upwelling region are strongly dependent on oceanographic conditions was examined. Based on a long-term survey data, it was found that sardine shoals shifted northwards off the usual grounds in the years with positive temperature anomalies. The largest fish moved closer to the shore. Its availability for the survey as well as biomass assessment decreased. A contradicting growth of artisanal catches accompanied such situations, which is possible with high biomass levels. The areas around Cap Blanc abandoned by sardines became occupied by Sardinella, which in other years is stationed in shallow waters and is less available for surveys. Significant changes in individual weight which is determined by physiological condition affected biomass level of sardines. The relationship between those conditions and hydrological parameters was shown.

Keywords: availability for the survey, biomass, habitat conditions, indices, upwelling region.

Contact author: Andrey Sorokin, Atlantic Scientific Research Institute of Marine, Kaliningrad, Russia [tel. +7 905 245 45 11 or +7 911 459 29 07, e-mail: sorokin.and@gmail.com].

Density dependence in spatial behaviour of anchovy and sardine across Mediterranean systems


A spatial indicator—the spreading area index—is used to describe anchovy and sardine spatial distribution in relation to biomass variation and to look for ecosystem differences within the Mediterranean basin. Specifically, the variation in the spreading area index in relation to biomass was examined for different areas of the Mediterranean Sea (i.e. Aegean Sea, western Adriatic Sea, Strait of Sicily, Gulf of Lion, and Spanish Mediterranean waters). In order to capture the spatial variability of the population at different levels of fish density, acoustic survey data for the years of highest, lowest, and intermediate abundance were used. In a subsequent step standardized values of spreading area and biomass were estimated to allow comparisons. Results showed pronounced area differences. A significant relationship was revealed in the case of anchovy for areas with extended continental shelf (i.e. Aegean Sea, Adriatic Sea, and Gulf of Lion), indicating an increase in biomass with an increase in the spreading area. No relationship was found for areas dominated by narrow continental shelf and strong currents (i.e. Spanish Mediterranean waters and the Strait of Sicily). With regard to sardine, an increase in biomass was followed by an increase in the spreading area when estimates from the Aegean Sea, the Adriatic Sea, and the Strait of Sicily were considered together. The relationship was even more

---

**ICES CM 2012/B:15**  Withdrawn

**ICES CM 2012/B:16**  Poster

**ICES CM 2012/B:17**  Withdrawn

**ICES CM 2012/B:18**  Withdrawn

**ICES CM 2012/B:19**  Poster
pronounced when analysis was limited to the Aegean Sea and the Strait of Sicily. No relationship was found for the Spanish Mediterranean waters and the Gulf of Lion. This clearly implies that spatial indicators should be integrated into ecosystem management, taking into account that they can be area- or ecosystem-dependent.

Keywords: anchovy, Mediterranean Sea, sardine, spreading area index.

Contact author: Marianna Giannoulaki, affiliation: Hellenic Centre for Marine Research, Greece [e-mail: marianna@hcmr.gr].