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New techniques in Echoview for fisheries acoustic data analysis

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Introduction

Acoustics is widely used in marine and inland fisheries research and management. In June 2002 ICES (Council for the Exploration of the Sea) held a symposium titled " Acoustics in Fisheries and Aquatic Ecology " in Montpellier, France. There were several topics to be presented such as ecology marine waters, combination of methods, target strength (TS) method and results, TS modeling, survey design, behavior, avoidance, technology, and identification. Characteristics of behavior of fish and plankton were studied in various circumstances. Different acoustic systems such as lidar, multibeam sonar, and echo sounder were combined to investigate fish schools. Target Strength was measured from egg of fish to deepwater fish by single frequency, broad band and multi-frequency techniques. Calibration of multibeam sonar and 3D structure of school were examined for quantification and visualization. Acoustic identification methods were applied not only fish and plankton but also aquatic vegetation and gelatinous species using broad band, video, and muti-frequency (Anonymous, 2002). New techniques, hardware and software make use and application of acoustics more accurate, easier, and broader than before. Even if different equipments are used in different and/or similar environments, it is important to be able to directly compare data and results. After all it is very effective to work with data from all commonly used acoustic instruments such as echo sounder and sonar and to access the analysis methods. Commercial software, Echoview, is able to handle data from all major echo sounders and is compatible with a range of acoustic data formats.

Acoustic observation and assessment of marine organisms is highly influenced by fish behavior, target size, species classification, and acoustic system as well as bottom classification, and scattering properties (Cooke *al el.*, 2002). Recently multibeam sonar has been using to fisheries acoustics for quantification of school and 3D visualization.

In this study, we describe new techniques of acoustic data analysis using Echoview, which is powerful and user-friendly commercial software, such as biomass assessment, species identification, 3D display of school and sea bottom and seabed classification.

Biomass assessment

Not only fish school and but also plankton have been tried to assess their biomass in sea and rivers. Echo integration method has been using to estimate biomass in fisheries acoustics (Simmonds *al el.*, 1992). The most important part of analysis for stock assessment is scrutiny and quality data for correct biomass. Therefore, while analyzing acoustic data, it is important to see what you are doing and check data quality at every step of the analysis. The process of integration becomes easy and fast for accurate assessment due to advanced functions in Echoview. For example integration cells and defined polygons of interesting school as well as by surface and bottom referenced layers can be integrated for biomass. An echo sounder displays the sounder detected bottom, however, it new sea bottom line can be defined and edited in order to optimize. Bad data from all kinds of noise, such environment, vessel, other echosounders can be removed easily, as can echoes of unwanted organisms. In situ single target can be detected for TS analysis. Analyzed data can be exported to different software for further processing and analysis. Moreover calibrated data can be modified by new calibration parameters, so that even wrong calibration can be corrected. By combining results from multi-frequency and school detection processing with data such as the allocated species-composition, biomass assessment can be estimated efficiently and precisely. Figure 1 shows a typical echogram in Echoview.

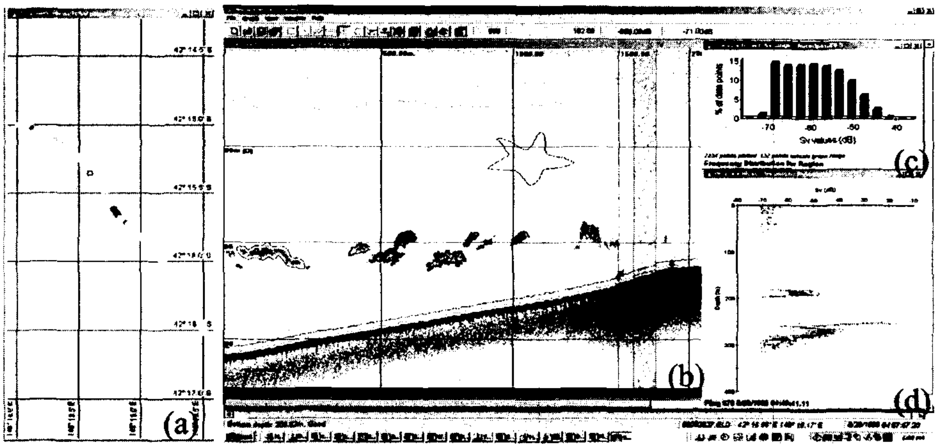

Figure 1. An example of echogram. SV cruise track (a). it shows SV on the cruise track. dark brown, which is middle of track and has high SV, is included echo of sea bottom. Schools were detected using school detection algorithms in orange box in echogram (b). it is typical echogram. Region, which can be school and any kind interesting area, can made by users very easily. See the star mark in (b). The line has sea bottom in violet parallelogram, so that very high SV in dark brown shows on the cruise track (a). It means that it is simple to find out the strong signal such as of sea bottom. SV distribution graph by any part of echogram (c). Ping graph by depth (d).

Schools Detection

An approach to distinguish between species is used by features such as morphological, bathymetric, and energetic characteristics (Haralabous *al el.*, 1996, Lawson *al el.*, 2001). Behavioral studies of school distribution and schooling behavior is facilitated by detecting schools in acoustic data and can be used to examine schools at the high level of temporal and spatial resolution inherent to acoustic data. The detection and integration of individual schools should allow school-by-school estimates of biomass, which may represent an improvement over estimates of biomass based on mean biomass per EDSU (Elementary Sampling Distance Unit).

Fish tracking

The technique of detecting, tracking and counting fish uses to calculate biomass, distribution, flux, and indicative parameters for behavioral studies and species identification. α–β Fish Tracker implements a fixed coefficient filtering method (Blackman, 1986) is used in Echoview. The sensitivity of the tracker to unpredicted changes in position and velocity is controlled by the Alpha and Beta gains respectively. The filtering process selects out single targets as candidates for appending to a track. Fish tracks can be graphed in 2D and 3D. Information from fish tracking includes swimming speed, direction of travel, mean TS and track tortuosity. 3D positions of fish tracks can be plotted relative to the acoustic beam.

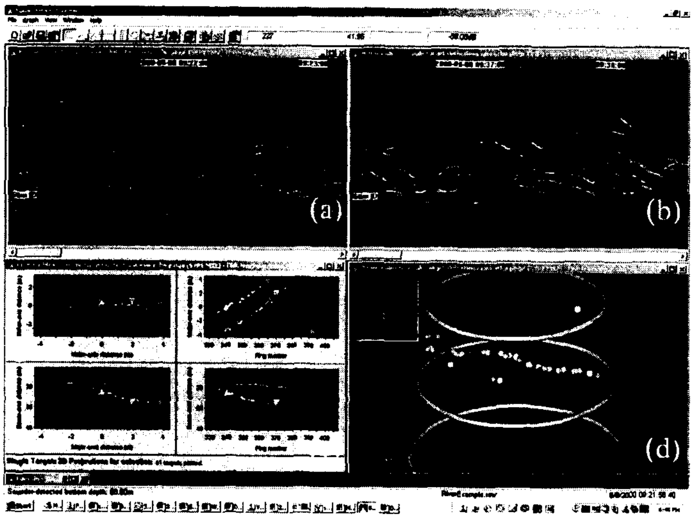

Figure 2. Fish tracking echogram. Echogram before fish tracking (a), after fish tracking (b), 2D result of fish tracking such as minor-axis distance and major-axis distance, major-axis distance and ping number, beam axis distance and major-axis distance, beam axis distance and ping number (c). 3D result (d) can provide where fish echo is in the beam.

Fish habitat (Seabed classification)

Fishermen have used changes in appearance of the sea bottom echo to identify fish-habitat association. Advances in single beam and multibeam acoustics have increased the ability of researchers to classify seabed habitats in objective and quantitative ways (Cooke *al el.*, 2002; Komatsu *al el.*, 2002). Accordingly, it can be defined and automated the calculation of different indices from seabed backscatter and used them to classify bottom habitat or substrate type of the seabed. It can display seabed echo parameters such as hardness and roughness on a cruise-track plot and a table. In order to verify seabed classification methods in the field, monitor results in real time by acquire video or benthic grab samples for independent classifications can be compared. Export of data to other commercial seabed classification packages such as Quester Tangent's Echo Impact software is possible.

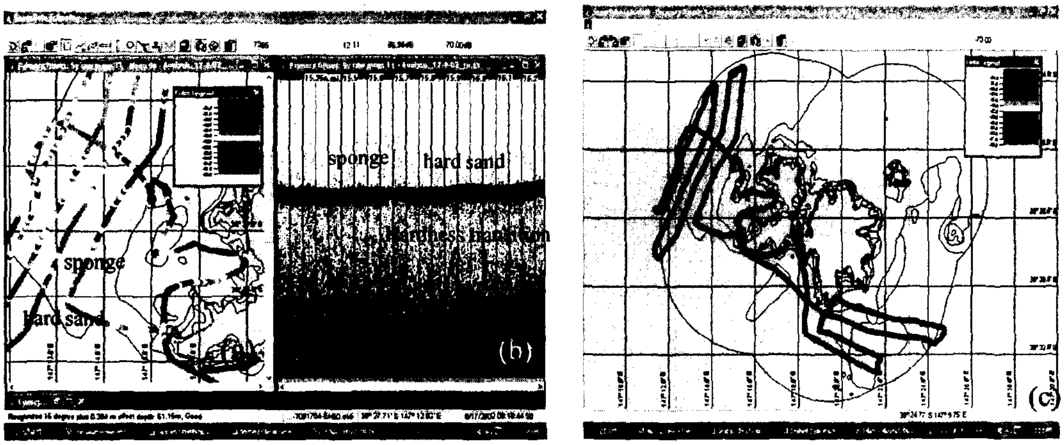

Figure 3. Hardness and Roughness for seabed classification. Hardness SV cruise track map (a) and its echogram (b). The pink color of hardness SV shows the sponge of seabed, green one hard sand (a). Hardness is calculated from the second echo of sea bottom line as shown arrow (b). See the difference between sponge of second echoes and hard sand of that. Roughness SV cruise track map (c). Acoustic data was collected near Deal Island, the Kent Group of Islands, Bass Strait, Australia at 120 kHz single beam.

Species classification

Investigations into the acoustic identification of schools to species, which substantially increases the accuracy of the process of partitioning measurements of back-scattered energy among species. This constitutes an important improvement over species-allocation based solely on trawling and/or visual scrutiny, and ultimately allows fishers to capture only schools of target species in those fisheries, thus allowing limited by-catch.

The method of acoustic species identification can be largely grouped as following. Frequency characteristics method is based on a single fish and school scattering by a wide band or multiple frequencies (Conti and Demer, 2002; kang *et al.*, 2002). Distribution characteristics method is founded on the morphologic and bathymetric characteristics of school (Lawson *al el.*, 2001). Signal characteristics method is originated in the characteristics of signal such as the envelope of school echoes (Rose and Leggett, 1988; Scalabrin *al el.*, 1996). Acoustic result method is based on the information obtained an echo sounder such as SV, TS, and swimming speed by analysis of echo trace (Richard *et al.*, 1991). Consequently, it has increased to study on the relationship species and environment such as water temperature, current, geographical seabed, and habit (Cooke *al el.*, 2002; Komatsu *al el.*, 2002).

One of the most popular techniques is ΔMVBS method based on frequency characteristics method, and is called dB difference. dB difference method have adopted to identify Antarctic krill
in CCAMLAR (Convention on the Conservation of Antarctic Marine Living Resources).

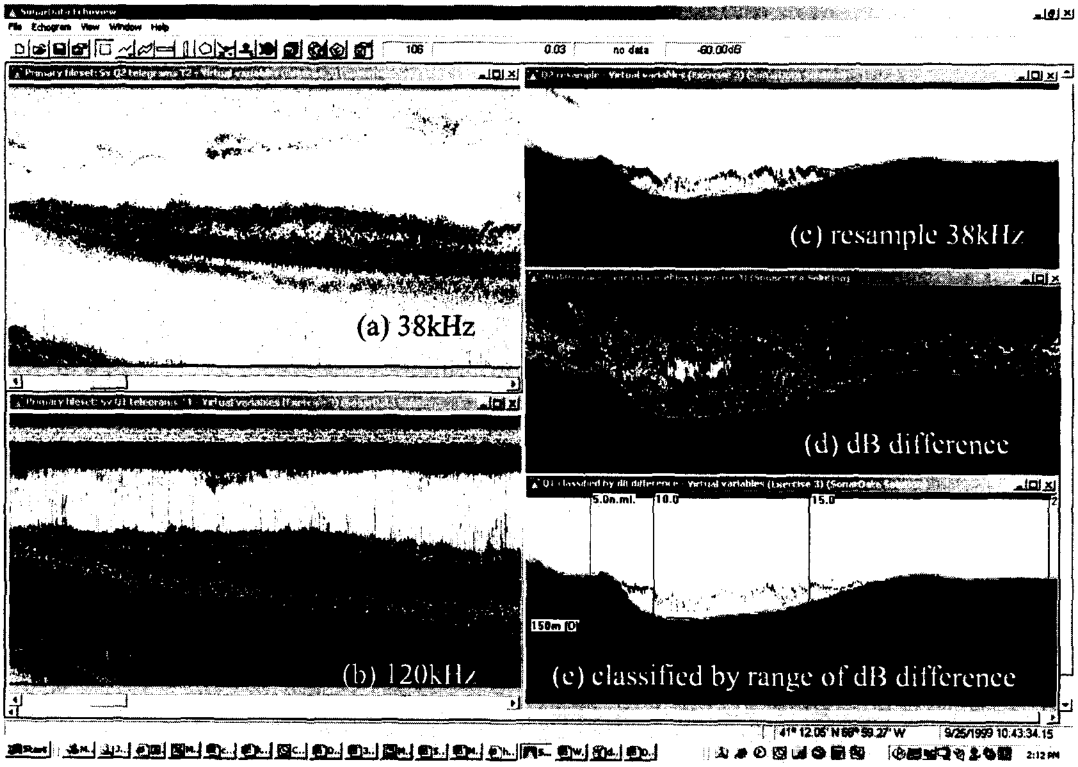

Figure 4. An example of species classification using "dB difference" technique. If marine organisms has frequency characteristics of about -6 ~ -1dB of ΔMVBS, it can be discriminated by this method. 38kHz echogram (a), 120kHz echogram (b), resample echogram by 10 pings and 2m at 38kHz, it is integration in this case (c), dB difference echogram (d). dB difference means that ΔMVBS = MVBS (mean volume backscattering strength) at 120kHz - MVBS at 38kHz. resample echogram is classified only by range of -6 ~ -1dB of ΔMVBS (e).

Multibeam sonar

Mutibeam sonar system and its data analysis are the future of acoustic surveys for fisheries application. Sonar has been used for years by the geological community to identify seabed bathymetric features, however it starts to apply for fisheries acoustics recently. It is necessary to study more about multibeam data processing, visualization method, quantification of school for the purpose of using multibeam system to fisheries acoustics. Considering 3D visualization, the technique of multibeam sonar is developed to use image processing to smooth and filter data and to define schools. Fish schools in relationship to the seabed is displayed in 3D. A set of fish school parameters is extracted for species classification. In order to improve biomass estimation, fish school volumes estimated from 3D measurement can be used. Moreover densities measured from a conventional echo sounder to calculate school-based biomass can be utilized. The bottom surface data is used for mapping survey area. In the end, vessel avoidance reaction and fish behavior can be compensated and studied from fixed and mobile transducer installations. Optimized and flexible beamforming algorithms can be used in real time, and logged raw data without loss data (Anonymous, 2003).

However multibeam sonar needs more study about quantification. Calibration tools, echo integration and fish tracking with multibeam data are being developed. Mutibeam surveys and 3D analyses will provide more precise stock assessments and new insights into fish behavior.

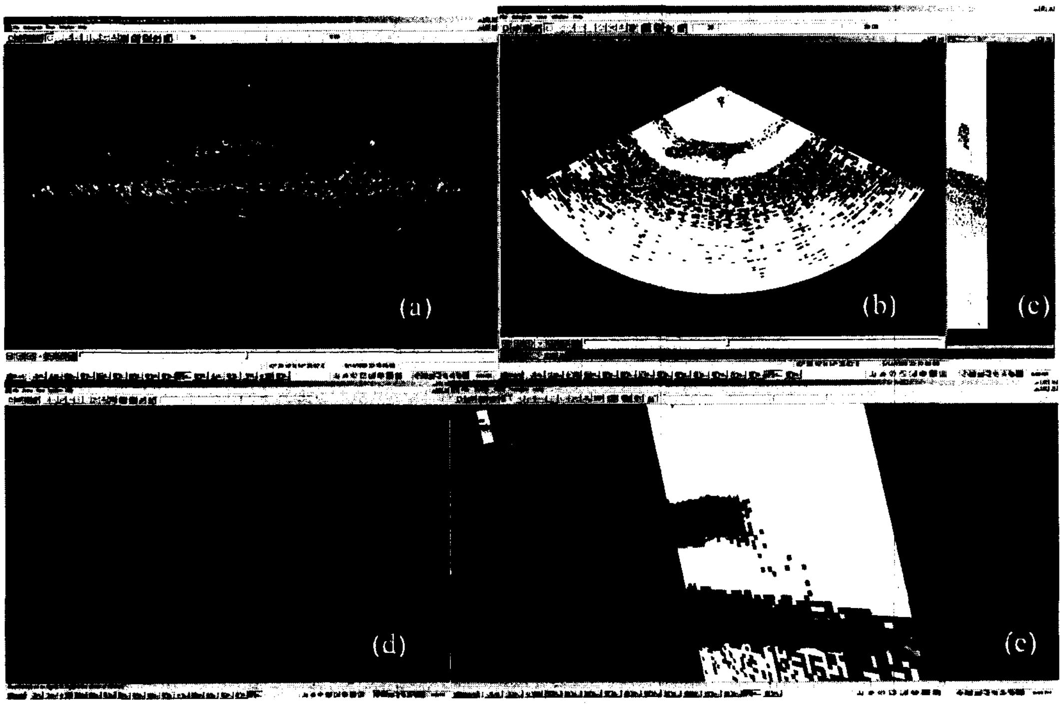

Figure 5. Multibeam sonar echograms. Magnitude beamformed pings of (a) with low threshold and of (b) with high threshold. One beam echogram, it is selected 45^{th} beam (c). One school, which has different threshold as (a) and (b) are shown like two schools with sea bottom in 3D (d). 3D one school (two objects) is added up one beam echogram as curtain (e).

Discussion

The latest techniques of fisheries acoustic data analysis was described using Echoview. Fisheries acoustic study has been developing greatly, so that new idea and innovate technique will appear more and more. Correspondingly, there are a large number of hardware to find out the ecosystem of marine organisms. However efficient series of data processing software will be required to process and interpret the large quantity of information supplied by different hardware systems.

As human being can use ears and eye for understanding, we can use acoustics to realize the life structure of marine organisms, and can display the result of acoustic data for better visualizing in 2D and 3D. We expect that more accurate acoustic data will be collected and that Echoview will continue to be developed to visualize and anlalyse all important aspects of this data.

Acknowledgment

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