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THE LARGE SCALE SURVEY SYSTEM - LSSS

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Abstract

Acoustic methods are widely used for estimating fish abundance. Currently the Institute of Marine Research (IMR) uses the Bergen Echo Integrator (BEI) to analyse the acoustic data. Development of BEI started in 1987, and although it still fills its purpose it has become increasingly difficult to maintain and expand. An evaluation of existing post-processing systems for acoustic data concluded that present software systems do not meet the future demands of IMR. Therefore IMR decided to develop a new post-processing system, the Large Scale Survey System (LSSS). LSSS is described here.

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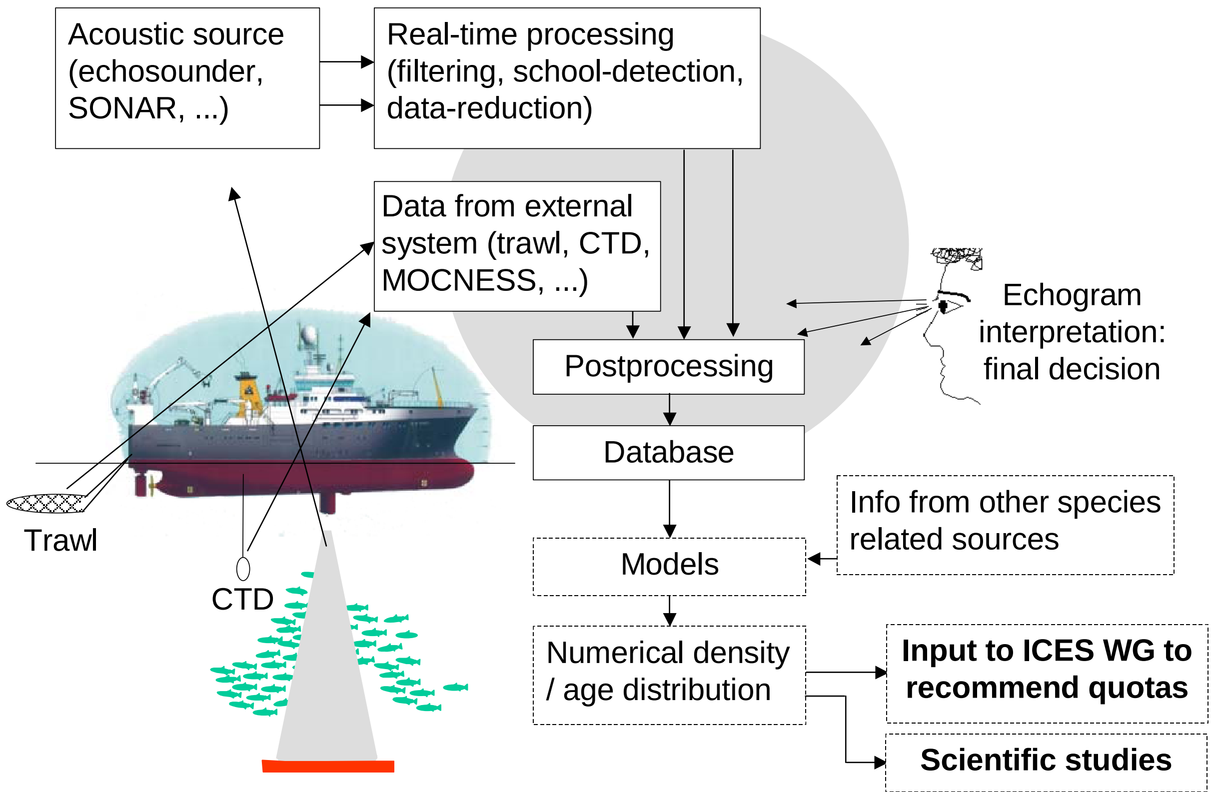
Introduction

Acoustic methods are widely used for estimating fish abundance and echo integration at one frequency, supported by biological sampling, is the general method used (MacLennan, 1990). Scrutiny of acoustic data is generally done by analysing and correcting echograms in digital format using a dedicated post-processing system, e.g. BEI (Foote et al., 1991; Korneliussen, 1993, Korneliussen, 2002), BI500 (Anon. 1993a; 1993b), EP500 (Lindem et al., 1993), Echoview (Anon. 1999), Sonar 4, 5, 6, MOVIES+ or ECHO. Within these systems, echogram recordings are subject to manipulation, thresholding, error-checking and noise removal. During the scrutinising process it is possible to rearrange and control new depth layers, within which the fish density is to be estimated. A team of experienced operators interprets acoustic data by drawing lines and encircling schools on the echogram screen. Supported by data from biological and oceanographic measurements this process allows them to separate, isolate, and allocate the different acoustic structures to species and groups of scatterers. In most surveys, identification and separation of one or two targeted species is the main goal, while the rest of the recordings may be of less importance. The work-flow for scrutinising acoustic data at Institute of Marine Research (IMR) shown in Figure 1 is applicable to many other institutions as well.

IMR is responsible for research and monitoring marine resources in the large Norwegian waters. In addition to renting vessels for these investigations, IMR runs 4 sea-going research-vessels and 2 coastal vessels. Currently, the system that best fits the needs of IMR for post-processing acoustic data is BEI. These needs are mainly a high quality of the scrutinised data, but also the limited available time to scrutinise the acoustic data to the optimal quality. However, development of BEI started in 1987, and although it still fills its purpose it has become increasingly difficult to maintain and expand. An evaluation of existing post-processing systems for acoustic data concluded that present software systems do not meet the future demands of IMR. Therefore IMR decided to develop a new post-processing system, the Large Scale Survey System (LSSS).



Essential: • *combination of acoustic data with size distribution from biological samples*
• *scientists (not the system) take the final decision*

Figure 1. Abundance estimation of fish at IMR

Within acoustic surveying methodology there is an incessant call for improvement, in order to reduce ambiguity in the interpretation of acoustic data and thereby reduce the uncertainty of acoustic abundance estimates. Species identification was addressed by MacLennan and Holliday (1996) as "the grand challenge of fisheries and plankton acoustics". Considerable potential for improvement may be derived from the echogram interpretation process as shown by Mathisen et al., 1974; Korsbrekke and Misund, 1993; Misund, 1997. An enhancement of the echogram interpretation process is desirable by utilising multi-frequency information for species discrimination. Concurrently collected multi-frequency data, combined with an improved knowledge of the backscattering properties of the observed animals, a typical species mix, and the size distribution, may be used to characterize acoustic returns, thereby improving the scrutinising process.

For improvements under practical survey conditions, tools must be directly available to the operator of the post-processing system for analysing combined multi-frequency echograms and sequences of single frequency [*s(f)*] echograms. Most of the available systems were originally intended for either *s(f)* analysis, or sequential analysis of several frequencies, although a few examples designed for combined analysis of two frequencies have appeared. In the BEI system, layer lines and parameters for scrutiny, which are selected during *s(f)* analysis, can be transferred readily between echograms along the survey track and across frequencies (Korneliussen, 2002). BEI can also combine the information in near real-time, for direct presentation to the operator. The main problem with BEI is the increased effort during the years to implement new features.

Material and methods - LSSS system design

The new system was given the name Large Scale Survey System to emphasise that it will be used on large-scale surveys at sea to process large amounts of acoustic data. LSSS should be a production system for underway processing of survey data. It should meet the requirements to ”ecosystem approach”, which inherently means that several species will be investigated simultaneously. LSSS should be able to handle the full resolution of the raw acoustic data, and to handle data in different files seemlessly. LSSS is also required to be expandable by users.

The objectives of the LSSS project are merged into a set of main specifications and system requirements of LSSS: the present IMR survey work-procedures should be kept; LSSS should have improved geographical referencing; there should be enhanced quality of scrutinised data by allowing day to day evaluation. LSSS is required to have a dynamic and scalable design, and to use the standard programming tools Java and JDBC. Acoustic categorisation (“species identification”) through multi-frequency analysis (i.e. the multi-frequency toolbox “KORONA” should be included).

These specifications have merged into the following key-features of which some are listed below:

1. Flexible, configurable survey setup designed to meet work processes in organizations of various size
2. Handles very large surveys, primarily limited by computer disk space
3. Handles multi-frequency data (LSSS have been thoroughly tested with 6 frequencies ranging from 18 kHz to 364 kHz)
4. Advanced pre-processing with noise removal, filtering, categorisation training, and automatic school detection
5. Data loading with step-wise refinement, allowing users to start interpretation immediately while remaining data are being loaded in parallel
6. Data loading with “look ahead” functionality, often implying that the next data to be interpreted exists in internal memory when the interpreter is ready
7. Interpretation by means of a very flexible drawing tool, allowing users to draw continuous free-form lines (for layers), and arbitrarily shaped closed contours (for schools)
8. Prepared for automatic school categorisation (this functionality will be included during 2006)
9. Modular design, making it easy and efficient to extend system functionality

Figure 1 indicates some real-time processing of the data. In LSSS the real-time processing is done by KORONA. Figure 2 shows how the LSSS real-time modules are set up in KORONA.

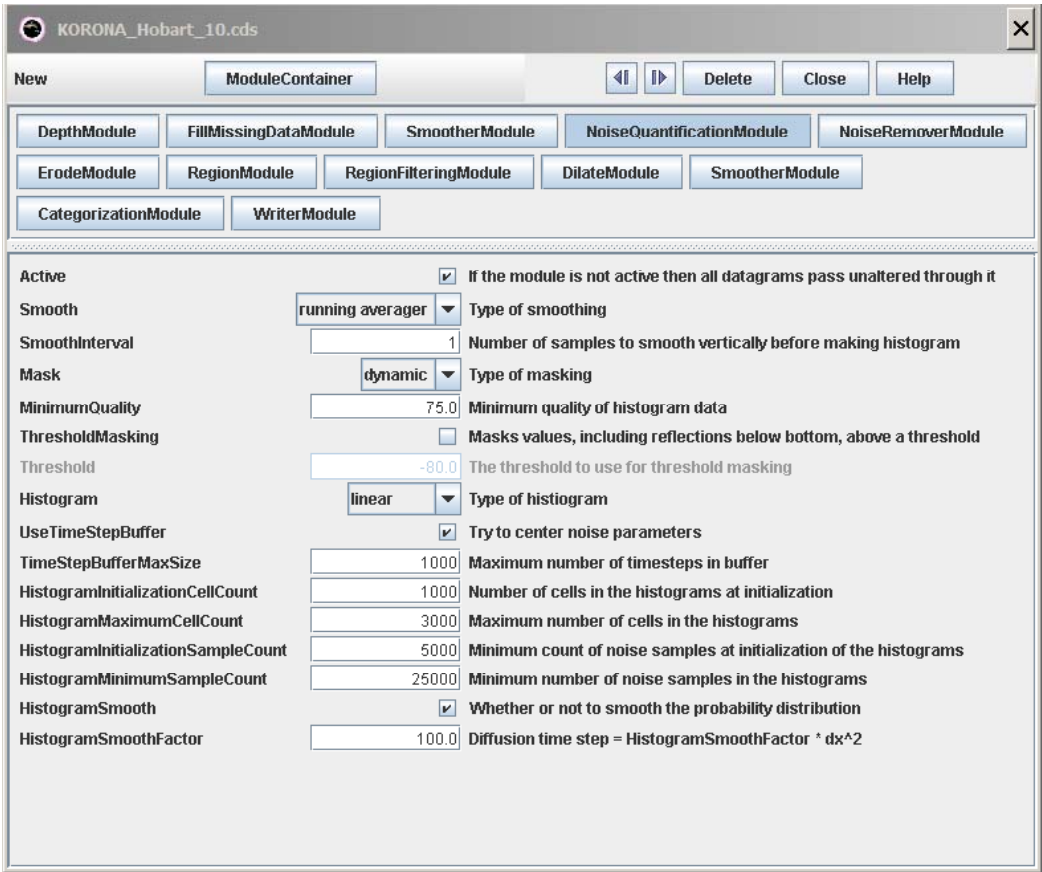


Figure 2. Setup of the LSSS real-time system (KORONA).

Results

Figure 3 shows the main view of LSSS. The figure illustrates the main features of LSSS. The two largest sub-windows are the surface-referenced and the bottom-referenced echogram windows. Dark warm (i.e. dark red) colours show strong backscatter, and light cold (i.e. light blue) colours show weak backscatter. Increasing distance is shown horizontally and increasing depth vertically. The sub-windows below the bottom-referenced echogram window are some of the auxiliary windows used during the interpretation process.

Figure 4 shows some results from the LSSS real-time processing. In the largest window, a synthetic echogram is shown. Each colour now shows different acoustic categories. Orange is mackerel, dark green is siphonophores and pink is herring. Note that mackerel and herring are found in both distinct schools, and in mixed schools. The techniques for distinguishing between the acoustic categories are similar to those described by Korneliussen and Ona in 2002 and 2003. The middle lower window shows two acoustic features plotted against each other, and how these separates the acoustic categories that are visualised in the synthetic echogram. The lower right window is an echogram at 38 kHz, but noise-corrected and smoothed.

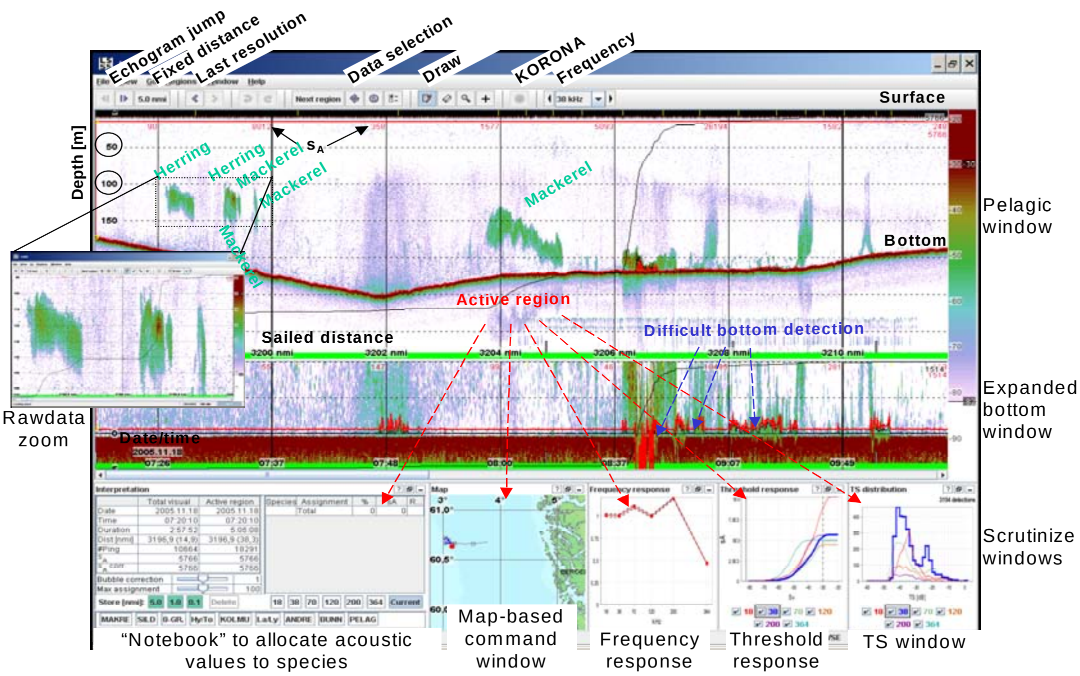


Figure 3.

Main view of the LSSS system

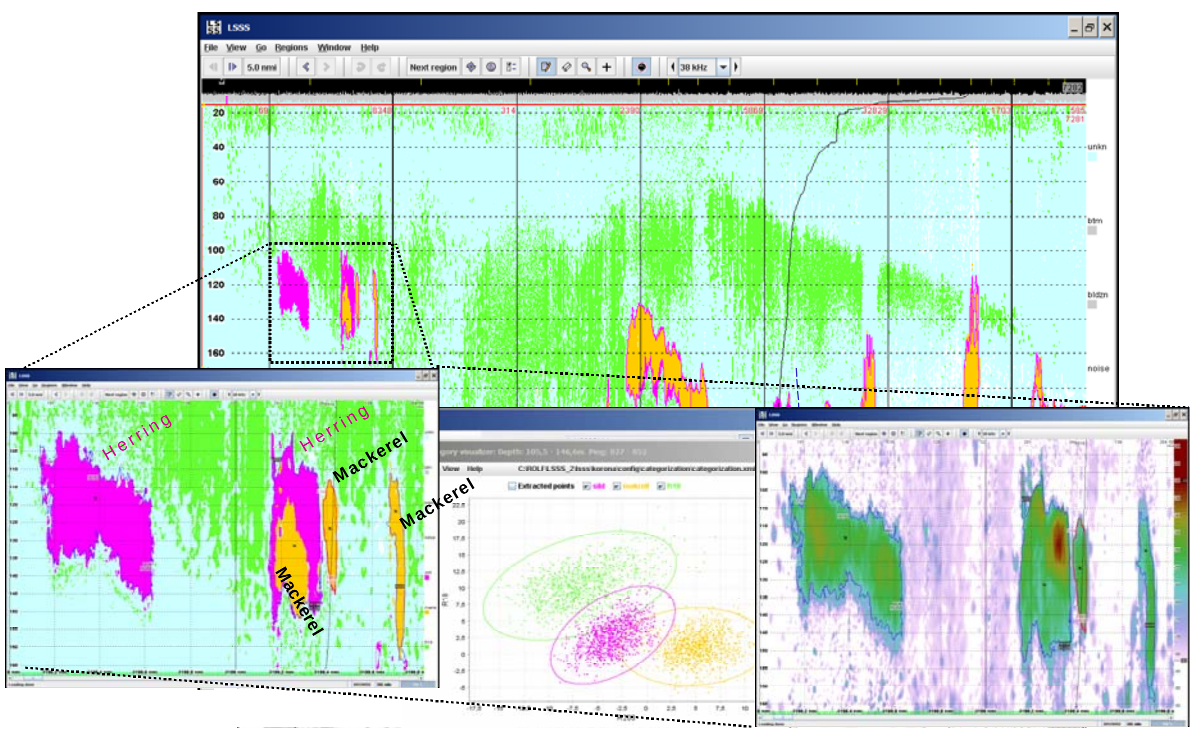


Figure 4. Results of LSSS real-time processing (formerly KORONA)

Discussion and conclusions

The testing of LSSS shows that the system is soon ready to replace BEI. The categorization system works reasonably well, and the speed of scrutinising the acoustic data to the optimal quality are even faster than BEI. Further, a Beta version of LSSS is now available for selected pilot users. IMR will start using LSSS as the main survey system from January 2007, and commercial version of LSSS is expected to be available from January 2007. There are plans for integrating data from multi-beam sonars and multi-beam echosounders.

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