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ADVANCES IN BERGEN ECHO INTEGRATOR

by

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ABSTRACT

The Bergen Echo Integrator (BEI) is a software system designed for convenient postprocessing of echo sounder data. BEI is realized in international standards and is essentially machine independent. Development of BEI for analysis of such diverse scatterers as plankton, pelagic fish, bottom fish and bottom itself is reviewed. The system design is described and the latest advances are discussed. Among these: a more flexible database, an improved man-machine interface, an easier procedure for accessing data and a system for mapping the data. General operating procedures are described for extraction of information while scrutinizing acoustical data.

I. INTRODUCTION

A major application of echo sounder data is the estimation of fish stocks to establish fishing quotas. Echo integration in combination with trawling is the most widely used of several techniques to perform this estimation.[1,2] It proceeds in the following way:

Absolute measurements of the acoustical density is collected by a ship cruising with a calibrated hull-mounted or towed transducer. The density is commonly expressed either trough the mean volume backscattering coefficient, or the integral of the volume coefficient over depth (the so-called area or column backscattering coefficient).[3] The area backscattering coefficient has units of square meters of backscattering cross section per unit of surveyed area measured in BEI square meter per square nautical mile (m^2/nm^2). The number density is determined by dividing the area backscattering coefficient by the mean backscattering cross section of the object fish.

The Bergen solution to the problem of echo integration owes its origin to the work of G. Vestnes and Dragesund and Olsen,[4] as assisted by I. Hoff. The Institute of Marine Research (IMR) based its first digital echo integrator on the Norsk Data ND-1 computer.[5] The next generation of echo integrators was implemented in a machine language running on a ND-10 computer that went out of production in 1979.

In 1987 IMR decided to replace its echo integrator. By the cooperation with experts at Christian Michelsens Research (CMR),[a] IMR decided to gamble on recent developments in data processing and graphic display techniques that appeared to be attaining standard-status. The decision was taken to free the echo integrator from hardware. The software standards selected were the UNIX operating system,[6] C programming language,[7] X Window system,[8,9] Structured Query Language (SQL) for relational databases,[10] and Transport Control Protocol/Internet Protocol (TCP/IP).[11]

The Bergen Echo Integrator was documented by Foote, Knudsen, Korneliussen, Nordbø and Røang in 1991[12] and is reviewed here.

II. SYSTEM DESIGN

Efficient user interpretation of echograms is based on knowledge of experienced scientists. As a consequence, the man-machine interface should reflect both the user requirements and accepted software design principles.

Requirements imposed by users on the system are the following: (1) ample capacity for processing, displaying and manipulating data from echo sounder preprocessor and other units indicated in Fig.1; (2) machine independence; (3) programming in a high-level language; (4) modular construction; (5) database; (6) Ethernet local-area network (LAN); (7) full documentation; and (8) user friendliness.

(2), (3) and (4) are fulfilled with the use of UNIX, C and X. When the BEI project started ANSI C was not yet defined and a proper version of X was not available. The Ingres database version of SQL and the SUN version of UNIX were selected. In BEI we have only used functions seeming a part of a future standard. Even if BEI is converging to the defined standards, BEI is still not more than 'essentially' machine independent.

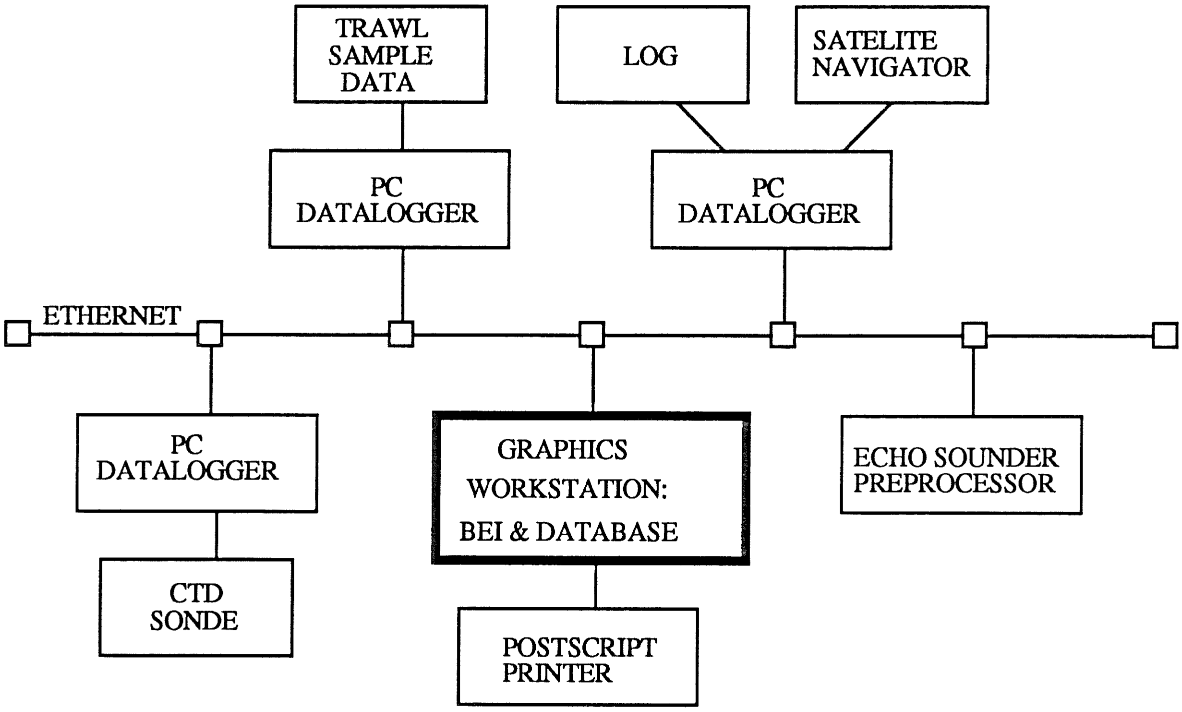

Fig. 1. Data network for research vessels.

A. DATA FLOW

The data flow was considered as first step in the design. An overview of the data flow is showed in Fig.2. The echo sounder postprocessor is p.t. an SIMRAD EK500 capable of operating up to 3 different frequencies simultaneously. Each BEI echo sounder log process logs all data from an echo sounder postprocessor. Using more than one log process it is possible to log data from more than 3 transducers. All acoustical data are stored in high volume files covering 5 nautical miles. The positions are also stored directly in the database. Other types of data are logged by separate log processes.

The windows are interacting with the database and the files trough the processing module during the scrutinizing process. The interpreted data are stored in the database and may be sent to hardcopy devices like postscript printers using the report generator window.

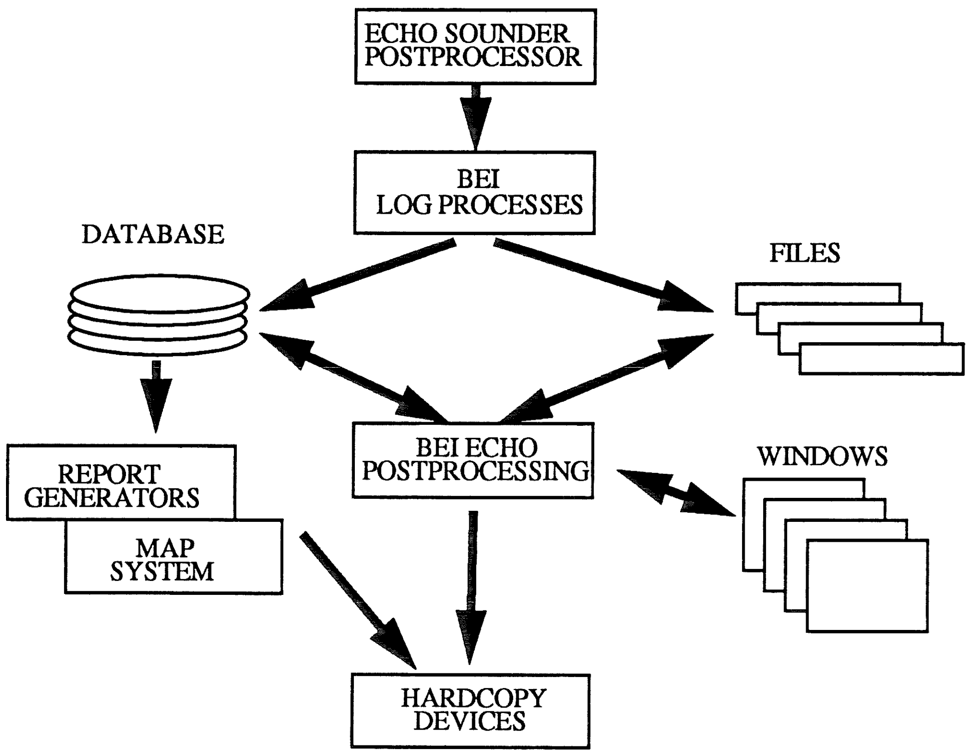

Fig. 2. Data flow model

B. DATABASE

At the end of 1990 the current revision of the database model was very flexible with respect to spatial resolution of data. The cost of a slower storing speed compared to earlier datamodels. This became a major concern when Ingres changed its internal architecture from system version 5 to 6.

The storage speed was increased dramatically at high resolutions by writing data to ASCII files and copying into the database. Storing times on a Sun Sparcstation IPX for a typical situation with 2-3 species per channel down to 500 meters:

Table 1: Database storage

Thickness of bottom-referenced channels (meter)	Thickness of surface-referenced channel (meter)	Horizontal resolution (nautical miles)	Storage time (seconds)
2	50	5	2.5
2	50	1	4
2	50	0.1	12
2	10	0.1	30
2	1	0.1	190

An echogram is a 5 nautical mile block of echo sounder data identified by codes for nation, ship, survey, frequency, transceiver, date and time. The echogram files are uniquely identified by the content of the database. This close connection makes the rawdata files an extension of the database.

Bottomdepth and the position are stored in the echogram files for each ping. From 1992 positions are stored in the database according to the horizontal resolution (not only one per echogram as earlier). Restoring of scrutinized echograms into the database can therefore give higher resolutions of positions and its associated date, time and bottomdepth.

In addition to acoustical and oceanographical data (CTD, nutrient, light, ...), the database is modelled to hold data from biological sampling. However, the fish station database tables turned out to be to static for practical scientific use. This problem reached a solution since IMR in 1991 initiated a project to model all data collected or used by IMR. The BEI database model was handled over to this project with the intention of letting the new model be version 3 of the BEI database. This new model is presented on ICES statutory meeting 1993 by R. Korneliussen and others.

C. GRAPHICAL USER INTERFACE

The graphical user interface consist of the database control window called the Configuration Window, the scrutinize control window named SurveyGrid, the data windows and the presentation windows. Fig. 3. shows the interconnections of the graphical user interfaces and stored data.

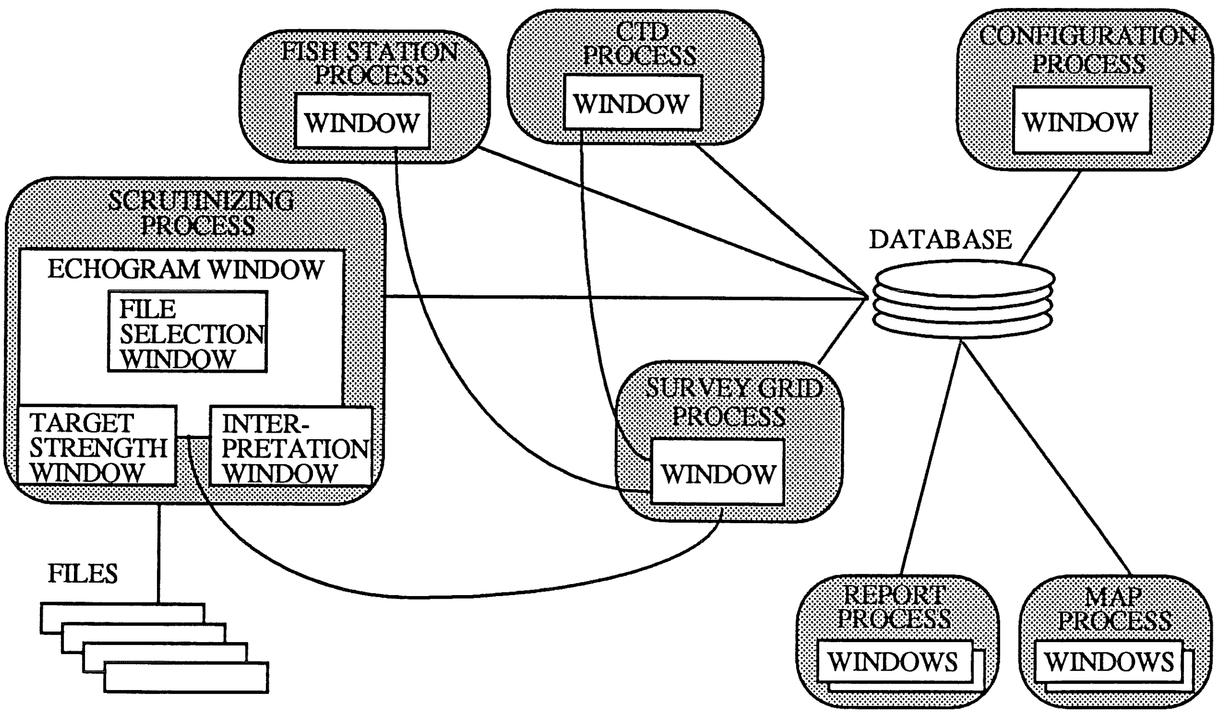

Fig.3. Interconnections of the graphical user interfaces and stored data.

1. Log Activity Window

The Log Activity Window displays the available disk space and gives a warning if data is not received or if available disk space is less than a specified limit. Old scrutinized rawdata files found in the 'waste' directory are deleted if possible to keep the available disk space above the given limit. The current form of the Log Activity Window is made after 1991.

2. Configuration Window

The Configuration Window is used to set key data in the database and to set and get informations about cruises. In almost all tables in the database nation, ship, and cruise number are used to associate data.

The thickness of both pelagic or surface-referenced channels and bottom-referenced channels are specified through the Configuration Window. The window is also used to set default parameters used by other windows. The Report Window will e.g. use default nation, ship and cruise each time it is executed, but all these parameters may be changed in the Report Window.

Advances since 1991

The Configuration Window is even easier to use since Ref. 12 was published in 1991. The inherent security is improved. The window can be started with 3 options: view only, change of common parameters allowed and change all allowed.

3. Survey Grid Window

The Survey Grid Window displays the location of the cruise data stations. Among these are stations where echosounder-, trawl-, oceanographic-, and other data are collected. Data from a station selected by the operator will be displayed in the corresponding window if it has been started.

Advances

The Survey Grid Window turned out not to be very useful both because of great errors in many of the positions received in certain areas, sometimes as much as 30^0, and because of complicated or overlapping cruise lines. Improving the digital filter removing erroneous positions during the logging process and adding a new filter replacing erroneous positions read from the database with interpolated positions have reduced the position error problem. The possibility of limiting the displayed cruise lines both in time and aerial dimension have made the Survey Grid Window a useful tool during the scrutinizing process.

4. Echogram Window

The Echogram Window is viewed in Fig. 4. The Echogram Window consist of four different sub-windows; those of the main echogram, expanded bottom, color map and zoom. The first two sub-windows are displayed with markers specifying depth range, vessel log, and layer limits. New layers can be inserted, moved, deleted, or redrawn at will.

The Expanded Bottom Window displays a specified bottom area, usually 5 meters below and 10 meters above the bottom detected by the echoprocessor. The detected bottom is marked by a line that can be corrected during the scrutinizing process and ends up with the bottom used by BEI.

Different colormaps are available. The commonly used colormap marks strong backscattering with a dark warm color (dark red) and weak scatterers with light cold colors (light blue) in accordance with accepted scientific principles for color usage. The Color Window is also used to set noise level; the weakest echo used in the calculations. Echoes below the noise level are marked with white.

Advances

The only visible change in the Echogram Window is the redirection of the error messages from standard output to windows. This improvement is provided by H. Nes at Simrad Subsea.

38 kHz echogram. Scrutinized as mainly herring in school. Cod below curved layer limitation.

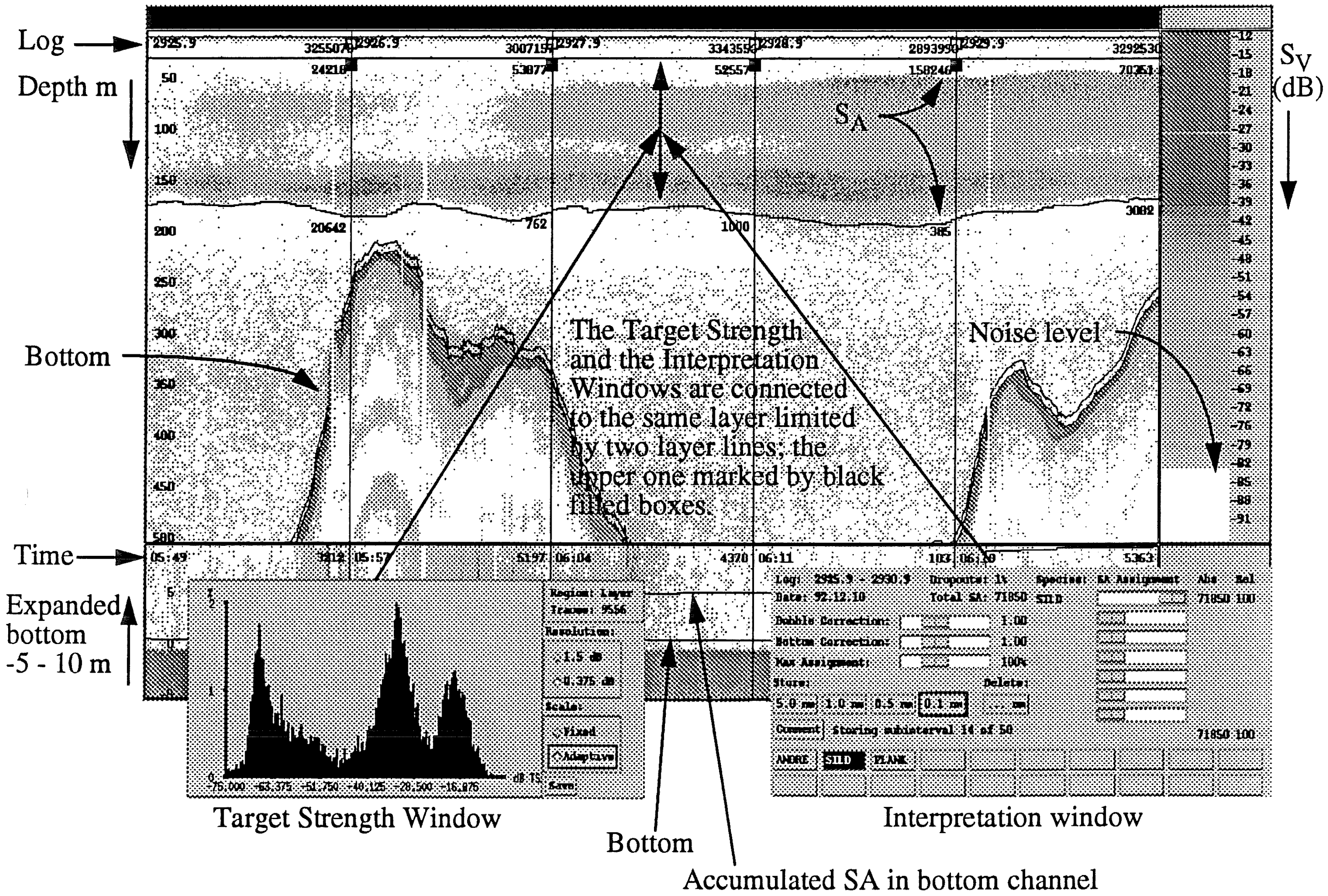

Fig. 4. The Echogram-, Interpretation and Target Strength Windows.

5. *Interpretation Window*

The Interpretation Window shown in Fig. 4 is used by the scientist during the scrutinizing process as a notebook for his observations. The basic data are extracted from either of two kinds of regions; either a rectangular box of operator-set-and controlled limits or a horizontal layer indicated by the operator using the same. The scrutinized data are stored in the database with the horizontal resolution indicated on the pressed Store-Button.

Advances

Different resolutions give very different storage time. H. Nes at Simrad Subsea has provided function to display the database storing activity.

Scientists often wants to add a comment to the scrutinized data. Comments are connected to the data trough the Comment Sub-Window popping up when the comment-button is pressed. Commonly used comments are: 'Trawling', 'Bad weather', 'Uncertain scrutinizing'.

6. *Target Strength Window*

Target strengths corresponding to resolved single-fish echoes are collected in a histogram that is displayed in this window. The basic data are the same as for the Interpretation Window.

Advances

It is possible to store the basic data to ASCII files. This has turned out to be a useful function for special target strength research projects.

7. *File Selection Window*

This window provides an alternative means of selecting acoustical data, e.g. when navigation data are lacking.

Advances

Amount scrutinized data stored in the database is viewed.

8. *Punch Window*

This is a new window that will be available on all institute ships from 1994. Acoustical raw data are sometimes not available from BEI. The problem may be caused by the network, the echoprocessor or the workstation. This has not been a big problem. Data from the echoprocessor printouts are sometimes used in addition to the database data to estimate the fish stock size. Re-estimation using new methods on the database data some years later is then not directly comparable with the original estimations. The Punch Window together with the Echogram/Interpretation/TS windows complete the scrutinizing system.

9. Fish Station Window

The Fish Station Window is used to display trawl catches or other fishing operations. The window is almost never used. (See the database discussion).

10. STD Window

This window displays the dependencies of salinity and temperature of depth, as measured by an CTD-sonde.

Advances

The window is redesigned to be able to show parameters derived by the CTD data, e.g. speed of sound. Other types of data, e.g. nutrients, can also be displayed.

11. Report Window

The Report Window is the man-machine interface used to generate reports and was not implemented in 1991. The design for retrieving of data is optimized to be fast. Tests have shown that a bad design can be hundreds of times slower than a good one. The Report Window and the data flow are illustrated in Fig. 5. At (4) -> (5), all retrieved data are delivered to the users in arrays of records. The user selects a subset of these data to be printed out. For simple reports, a single print statement is all that is needed. At this stage 9 different report types may be generated in one operation pressing the Scatter-Button. Each type of report can be printed in 0.1 - 5 nautical miles resolution simultaneously if the data are stored with 0.1 nm horizontal resolution in the database.

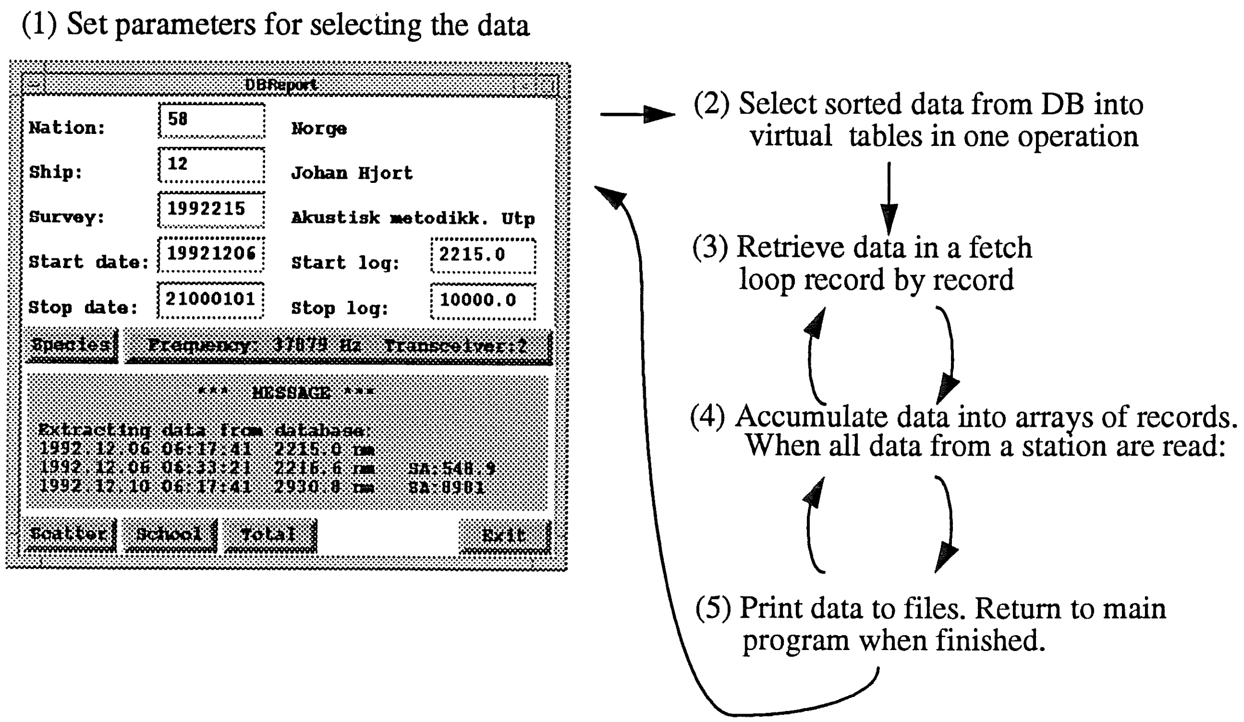

Fig. 5. The Report Window and the data flow from the DB to files.

III. SCRUTINIZING PROCEDURES

A commonly used scrutinizing procedure is as follows:

- Start the needed windows, e.g. Scrutinize, SurveyGrid and STD. Select data.
- Set bottom expanded window inactive in case of bad bottom detection.
- Set noise level and color scale.
- Use Interpretation Window to set factors for bubble and bottom correction. Stored in database: $S_A K_{bubble}$ for surface referenced channels and $S_A K_{bubble} K_{bottom}$ for bottom referenced channels.
- Correct detected bottom line.
- Draw layer lines.
- Use school boxes if necessary.
- Allocate S_A integral to species in upper layer. Consider: time, depth, color / noise level, target strength, zoom, trawl catches, salinity-temperature-depth measurements
- Move on to next layer and repeat.
- Store scrutinized data.
- Get next echogram using SurveyGrid or FileSelection Window.

IV. THE MAP SYSTEM BEI/Map

The Map System is developed in cooperation with IMR, CMR and Simrad Subsea. User requirements and essential parts of the man-machine interface are specified by IMR. The program design and the programming is made by Per Erik Nordbø at CMR. Simrad Subsea will start industrializing the system during 1993.

First step using BEI/Map is to manually correct cruise lines or to remove lines not significant for presentation. Corrected cruise lines and its associated data can either be exported to files readable from commercial graphical systems or be presented in 3 different maps, all with coastlines available:

- Cruise lines with symbols for data stations.
- Averaged S_A within a specified aerial grid.
- S_A isoline contour map

High resolution coastlines from all of the world is provided as a part of the system.

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