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COMPUTERIZED SYSTEM FOR ACOUSTIC BIOMASS ESTIMATION

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Abstract—Specialised multiprocessor system for amplification, processing/integration/and plotting echo signals for acoustic biomass estimation is described. The system includes two independent frequency input channels and allows direct connection to transducers of conventional fisheries echo sounders. Via data interface the system is connected to internal PC for collecting, logging and postprocessing acoustic as well as navigational, oceanographical and other data.

1- INTRODUCTION

Marked success in development and practical use of the acoustic method in estimating biomass has been achieved in last two decades. This method is based on sound scattering by biological objects insonified by pulse signals from echo sounders with carrier frequency within 20-200 kHz. After amplification with TVG echo signals are squared and integrated for a series of pings in several depth layers. The integrator readings are proportional to volume \( S_V \) or surface \( S_S \) back scattering strength of the layer.

To calculate density of concentration it is necessary to calibrate echo sounder and integrator (usually a standard metal sphere is used) and to determine the target strength / TS / of surveyed objects. Measurements of TS in situ is a vital requirement for accurate density estimation. Density evaluation is only one of many important tasks of studying biological objects in their environment. Some of them can be investigated with acoustic methods:
- species identification on statistical parameters of echo signals;
- TS measurements to estimate density and size distribution;
- biomass calculations by species and sizes;
- mapping density fields of surveyed region;
- comparative analysis of density and oceanographical parameters fields for ascertaining statistical regressions and monitoring the state of surveyed objects.

Specially designed computerized system for these tasks is described in the paper.

2- SYSTEM TECHNICAL DESCRIPTION

The multiprocessor computing system collects, processes and plots acoustic as well as navigational and ocean environmental data from appropriate vessel instruments in real time. Particular tasks of the system are:
Primary real time analogue and digital processing echo signals
from biological objects and bottom;
logging and secondary digital processing of acoustic, ship
location, oceanographic and other data with plotting log sheets,
maps and other output documents, estimating biomass with confiden-
ce intervals, etc. These tasks are mainly realized off line and
require expanded hard- and software.
Primary processing of echo signals includes analogue TVG amplifi-
cation, envelope digitizing in two independent frequency channels.
Digital real time processing consists of thresholding, squaring
and integrating samples of the envelope in each depth layer for a
series of transmissions under control by log signals and automatic
bottom tracking within window with bottom signal discrimination by
pulse length and level.
The real time system includes /See Fig./:
-analog processing and ADC boards (3) for connection to echo sounder
transducers (1);
echo signals digital integration unit (4);
it-Unit for operative presentations of graphic and symbolic informa-
tion (5) with colour display (6);
interfaces for input from external devices (2): log, gyro, oceanogra-
phic instruments and satellite navigation receiver as well as
standard interface for PC (9) and printer (8);
special keyboard with numerical panel and functional keys (7).

The result of operation of real time system is log sheet - a print-
out of SS in each depth layer with reference information: time, ship
position, mile number, depth, layer depth and width, threshold, etc.
Acoustic data from the real time units 3,4 through the standard
interfaces are also transferred to periphery PC IBM XT/AT or compati-
ble (9) for logging, second level of time processing and
plotting survey results.

Below are listed the main features of the system.

Technical base. The system is based on 4 microprocessors with a
functional keyboard, colour display and standard printer.

Processing modes. The main mode is "Integration", the others are
"Calibration", "Test", "Envelope load in PC" and "Dialogue".

Simultaneous operation at two frequencies. The frequencies are deter-
mined by customers. Soviet most widely used commercial echo sounder
operates at 20 and 136 kHz.

Dynamic range: -60 dB; processing without saturation.
ADC: 10 bits, sampling frequency: -24 kHz.
Distance resolution: 2.5 cm.
Digital threshold: individual for each integration layer, set by an
operator from the keyboard.

Number of layers: 10 pelagic, one bottom lock layer.

Bottom tracking: automatic scanning, looking and tracking bottom
signal with adaptive time window.

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**Fig.** Generalized block-diagram of computerized system.

TVG - digitally controlled, microprocessor based; 20logR+2αR and
40logR+2αR functions for multiple and single targets; α is set by
an operator. TVG accuracy is 0.5 dB.

Data presentation: a) Log sheet/print-out; b) Colour display; echo
signals intensities, integration layers marks, depth, etc. c) Results
Dimensions and weight. The system is installed in two standard racks about 1200 mm high; total weight is about 50 kg.

3- SECONDARY PROCESSING OF DATA.

The system provides TS measurements in situ by inputting digitized envelope to PC. When measurements are made with standard transducers it is necessary to remove directivity factor of antenna. System software includes time discrimination of echo signals, single fish selection and TS distribution computing by Craig-Forbes method. It is possible to connect the system to two echo sounders with different beams to realize the two-beam method.

The estimation of real confidence intervals of biomass and construction of density fields requires the change of techniques of collection and processing survey data. The new data collection procedure implies replacing integration by a mile for integration by a transmission. The system accumulates these data, calculates its mean, variance and other statistical parameters and prints results on a log sheet. On the basis of these values and variance of TS which is determined by distribution measured in situ, biomass confidence intervals for each transect or stratum are calculated. After that total biomass with confidence intervals can be computed with due regard of the autocorrelation of density values along the transects.

Density measurements along the transects makes it possible to use a special reconstruction techniques for random fields. Such fields are of interest when studying distribution and behaviour of surveyed objects. By analysing density fields together with fields of oceanographical parameters such as temperature, salinity, dissolved oxygen, etc. one can find out interconnections between density and environmental parameters. At present such analysis is mainly made by heuristic methods, but in meteorology objective methods of statistical analysis and comparison of fields of different parameters are used. To use these methods the system software includes programs for field reconstruction with polynomial and spline-approximation. The system allows for data transfer from oceanographic instruments to reconstruct and plot fields of hydrological parameters and study their correlation with density fields.

4- DISCUSSION.

Realized in our system combination of specialized computing device with PC has ensured the solution of the most important tasks of primary and secondary processing of acoustic signals and other survey data. Inputting to PC the echo signal envelope simultaneously with integration makes it possible to measure TS distribution in situ and carry out different processing, for instance, species identification. Logging in PC of data on density, control catches, measurements of TS and oceanological parameters makes it possible to calculate biomass by species and size with confidence intervals, plot fields of density and different environmental parameters, fulfill their statistical processing and analysis.

The system is a combination of a digital integrator with appropriate analogue processing and printer with interfaced PC which raises the reliability of the system and allows PC to be used in survey for other computing tasks. This technical decision seems more expedient than using PC with special constructed additional board as digital integrator and two-beam processor for TS measuring as implemented in BioSonics ESP/2. Firstly, in last configuration a special scientific echo sounder with appropriate analogue processing is required. Secondly, simultaneous integration and TS measurement is impossible. Thirdly, when logging in PC navigational and oceanographical data, the integration or TS measuring is interrupted.
Thus, in spite of a more sophisticated structure and higher cost our system is characterized by wider functional facilities especially when it is connected to conventional fisheries echo sounder. In this case there is no need in expensive installation of scientific echo sounder. In view of the above it is planned to equip with these systems all Soviet fishing research vessels.

REFERENCES