Electronic Processing of Acoustical Data for Fishery Research[1]

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A system for processing acoustical data is described. Acoustical data are recorded on magnetic tape in analog form in the field. The data are converted to digital form and analyzed with the aid of a digital computer. The system provides investigators with considerably more information than is available from paper records now in common use.

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ACOUSTICAL techniques are being used increasingly for the study of fish behavior (Narver 1970; Finnell and Reed 1969) and for estimation of the size of fish stocks (Cushing 1968). Usually, acoustical returns from fish are recorded on paper charts and then counted. Counting fish targets is a subjective and tedious process and, consequently, several electronic devices have been developed to estimate target densities. An example is the echo integrator that was developed by Lahore and Lytle (1970.) These devices have been used successfully in the field (Thorne and Woodey 1970), but they are expensive and add to the complexities of field work. Another approach to estimating target densities is described in this paper: acoustical data are recorded on magnetic tape and are automatically processed by means of a digital computer.

Returning signals from a Simrad ER 4 or EK 38A echo sounder are recorded by a Sony 560 D tape recorder in analog form onto a standard four-track magnetic tape. Echo signals are recorded on one channel, and a timing pulse is recorded on the other channel as a pulse of sound is emitted by the sounder. The echo signal is recorded as a 6-kHz sine wave, 100% amplitude modulated by the returning echo from the sounder. The operator of the sounder records a vocal log at the beginning of each set of soundings onto the tape.

The data are converted from analog to digital form by a unique analog-to-digital converter that the Department of Atmospheric Sciences of the University of Washington constructed. We developed electronic circuitry to reduce the data to a more efficient form during the digitizing process.

Figure 1 illustrates the nature of the signal from the time that it is emitted by the sounder until it has been converted to digital form. The signal from the tape recorder is passed through a full-wave rectifier. This device can be expressed mathematically by the equation

$$V_{out} = |V_{in}|, \quad (1)$$

where V_{out} = output voltage, and V_{in} = input voltage. Then the timing pulse is subtracted from the signal so that all information is stored in one series of data. It is simple to distinguish the negative timing pulse from the remainder of the data. Next, the signal is passed through a 1-kHz, low-pass filter. We choose a 1-kHz cut-off frequency because the length of the pulse of sound transmitted by the sounder is about 1 mv-sec, thus there should be no significant variations at frequencies higher than 1 kHz left in the return signal.

Much of the signal contains data that are not interesting to us. We are never interested in echos returning from depths greater than 100 m. In many instances, only the upper 30–40 m are of interest. We developed a timing gate to eliminate the unnecessary data. This device allows us to reduce the amount of data by more than 80%. Since returns from adjacent pulses of sound are highly correlated, it is not always necessary to sample every pulse to obtain desired results. Therefore, we developed a device to allow us to sample every first, second, third, or fourth pulse. The data are digitized then at a 2-kHz rate and recorded in binary form on magnetic tape.

A computer program was written in the Fortran language for a Control Data Corporation 6400 computer to perform preliminary analyses of the data. Since an enormous amount of data is involved (an average of 18,000 observations per minute

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of sounding), particular attention was devoted toward developing an efficient program. The data are packed five observations per 60-bit computer word. Most of the calculations are made in integer mode.

Several calculations are made by this program. During the digitizing process, a record of data is created without movement of the analog tape. This group of data represents the noise level of the system. The average noise level is calculated and subtracted from each observation. Changes in gain of the digitizing system are estimated from the timing pulse. The gain is standardized by multiplication of each observation by a standard value divided by the minimum value of the timing pulse within a specified time interval. The user is allowed to supply a TVG (time varying gain) function, which corrects for increased attenuation of the signal with depth. Voltage and voltage squared are summed at user-specified intervals of time and depth. Statistical frequency distributions of target strengths are produced at specified intervals of time, target strength, and depth.

The calculations made by this program represent a minimal analysis of the data. We anticipate that the availability of acoustical returns from fish targets in digital form will facilitate the development of methods of target classification. Figure 2 is a three-dimensional plot of returns from a target in Iliamna Lake, Alaska. There is considerably more information available to investigators than would be available from paper recordings now in common use.

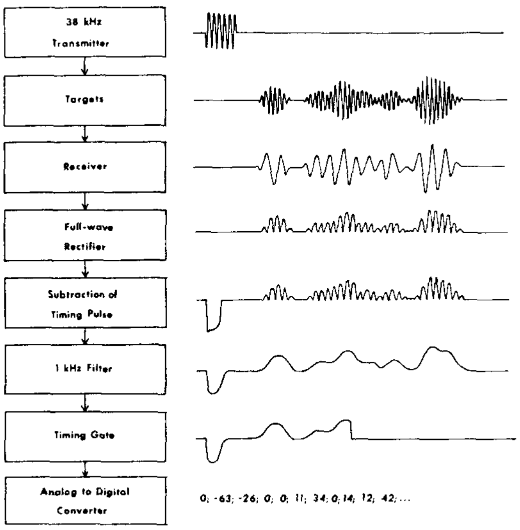

FIG. 1. Flow chart of acoustic signal from emission by sounder to conversion to digital form.

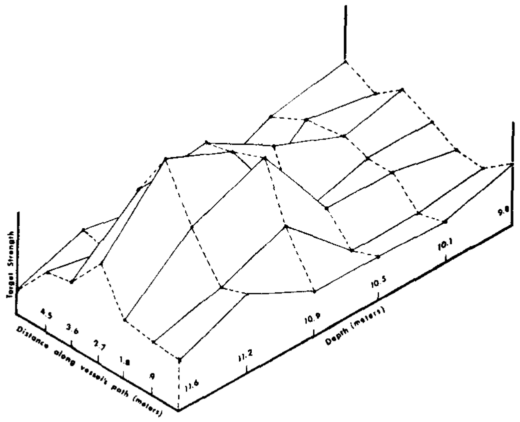

FIG. 2. Three-dimensional plot of echo returns from a target in Iliamna Lake, Alaska.

A detailed description of the electronic circuitry and computer software may be obtained from the Fisheries Data Analysis Center, Fisheries Research Institute, Univeristy of Washington, Seattle, Wash. 98105, USA.

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