Chapter 4

The Use of Echosounding Equipment in Limnology and Ecology Classes

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THE USE OF ECHOSOUNDING EQUIPMENT IN LIMNOLOGY AND ECOLOGY CLASSES

INTRODUCTION: Chart recording echosounders of the kind now widely used for sportfishing in lakes are valuable for describing the spatial and temporal distribution of fish, zooplankton and rooted aquatic plants. The equipment employs high-frequency sound, typically near 200 kHz, for use in shallow, freshwater lakes. Sound of this frequency is reflected by objects in the size range of cladocera and copepoda (0.5 - 5mm diameter), which are typically the predominant freshwater zooplankton (McNaught 1968, 1969). Of course, larger objects, such as fish, also reflect these frequencies.

The instrument we will demonstrate is a Lowrance X-16 computer sonar. It features a high resolution printout (125 lines per inch), variable pulse length (30 to 2,000 us) and dual transducers (8 or 20 degree beam angle). It operates off of a 12 volt battery and may be purchased through the manufacturer, at an educational institution discount, for about $575.00, Depending on the accessories you choose.

The shortest sonic pulses (30 us) emitted by the the Lowrance X-16 echosounder can discriminate between objects that are separated from each other by a vertical distance of 2.5 cm. Echotraces can be recorded from objects in all depths beneath the water surface, or a range of intermediate depths can be selected and traces from objects only in this increment recorded. The operating characteristics are controlled by a microprocessor so that different

combinations of depth range, chart speed, acoustic pulse duration, and other characteristics can be selected rapidly with a keyboard. These features enable the equipment to provide much information that is not detected by conventional sampling with nets. The technique can be used quantitatively and obviates many of the problems associated with traditional sampling, such as: active net avoidance by and patchy distribution of zooplankton, working with hazardous preservatives, and tedious and time consuming counting of samples. The echograms obtained are concise graphic records that show instantaneously how populations of zooplankton and pelagic fishes are distributed with respect to each other, to features of underwater topography, and to areas occupied by rooted aquatic plants. Depths for conventional sampling can be selected judiciously based on this information.

Zooplankton are typically distributed heterogeneously, and the density of echotraces varies correspondingly along the depth-scale of an echogram. Scattering layers, depths where zooplankton are abundant, often are conspicuous features which appear as bands of high density tracings. The depth limits of scattering layers sometimes coincide with layers of water that can be distinguished from each other on the basis of temperature and concentrations of dissolved substances, but some scattering layers are not closely related to water strata. Depths of scattering layers often change somewhat during a day as zooplankton migrate vertically (Northcote, 1964). Therefore, boundaries of scattering layers generally represent instantaneous depth distributions of different zooplankters. Environmental conditions at these boundaries thus appear to be of critical importance for the physiology and behavior of zooplankton.

WORKSHOP DEMONSTRATION: We will use this workshop to demonstrate the use of echosounders in obtaining information about a number of physical and biological parameters in Lake Minnetonka, and to discuss several other possible applications for class or individual student projects.

Lake Minnetonka is a large lake consisting of a group of interconnected "kettle hole" basins situated in glacial drift in eastern Hinnesota, about 20 miles west of Minneapolis. The lake became an important vacation and tourist area in the late 19th century, and subsequently became a commuter suburb of Minneapolis in the 1950's. Lake Minnetonka has been the subject of extensive limnological study, largely because planktonic algae became very abundant due to increased sewage effluent to the lake that diminished the lake's recreational value (Megard, 1977). Sewage diversion in the early 1970's resulted in an amelioration of this concern, and in much of the lake algae are now much less abundant. It is the home of the Gray Freshwater Institute, which is associated with the University of Minnesota.

The demonstration will be done in Crystal Bay (see map), which has an area of $3.4 * 10^{6}$ m^{2}, a mean depth of 8.5 m and a maximum depth of about 30 m. The procedure we will follow is given below:

1) Two complete transects of the bay at constant boat speed and echosounder settings will be made. This will:

a) provide a sketch of the morphometry of the basin.

b) demonstrate how this equipment can be used to survey rooted aquatic macrophytes.

c) determine the depth of the mixed layer and any horizontal irregularities that might be present due to internal seiches.

d) indicate that this technique can not only locate individual fish, but also be used to survey fish populations and their distribution.

e) indicate depths at which scattering layers exist, and which are therefore of interest to sample more extensively with traditional techniques.

f) indicate a location in the basin in which to do the more extensive sampling.

g) If meteorological conditions permit, these transects may also allow the demonstration of Langmuir circulation and the concentration of zooplankton in regions of current convergence.

2) A sampling location will be chosen (traditionally, the deepest spot in the lake is used) and we will double anchor to provide a stationary platform on which to work. The following measurements will then be made:

a) a remote sensing thermistor (available from Fisher for $400.00) will be used to construct a vertical temperature profile.

b) An oxygen meter (available from Fisher for about $500.00) will be used to construct a vertical oxygen profile. Oxygen may be measured less expensively and easily by the Winkler titration method (American Public Health Assoc. 1985)

c) A three-liter Van Dorn water sampler (Wildco, $300.00) will be used to collect water samples at designated depths. The samples will be filtered on board using a hand-held vacuum pump/filtration system (Fisher, $45.00) and 0.45um glass-fiber filters. The chlorophyll samples thus obtained will be visually examined, but it is a simple procedure to measure the chlorophyll quantitatively (Am. Pub. Health Assoc. 1985).

d) A Schindler trap (Wildco, $300.00) will be used to sample zooplankton at designated depths. Zooplankton nets could be substituted; they are more laborious but much less expensive. The samples will be inspected visually and if time permits, microscopically.

3) We will return to the Gray Institute to examine and discuss our results. Correlations between the echotracings, temperature, oxygen, chlorophyll and zooplankton profiles will be examined, and a summary figure constructed.

OTHER APPLICATIONS SUITABLE FOR CLASS PROJECTS: The echosounder is a versatile tool, and may be easily adapted to a variety of ecological and limnological studies. A few are mentioned below:

a) Surveys and estimates of fish, zooplankton, and macrophyte distribution and abundance.

b) Monitoring of the amplitude and timing of zooplankton diel vertical migration.

c) Demonstration of correlations between zooplankton and other biologically significant parameters, such as: phosphorus (which zooplankton are thought to recycle and secrete), chlorophyll (which zooplankton eat), and oxygen and carbon dioxide (which zooplankton consume and generate respectively).

REFERENCES

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Megard, R.O. 1977. Phytoplankton, phosphorus, and sewage effluents in Lake Minnetonka. EPA-600/3-77-086. North American Project– A Study of U.S. Water Bodies. E.P.A. Corvallis, Oregon.

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Figure 1. Acoustic scattering layers in Elk Lake during mid–morning, 21 July 1986, recorded along a transect marked with dashed line on the lake map. Top echogram recorded during a traverse from shallow to deep water, and bottom echogram recorded during the return to shallow water. Note scales for depths on the right and scales for temperature (^{o}C) and dissolved oxygen (mg liter^{-1}) on the left. Echosounder operating characteristics: Top echogram, 8^{o} transducer, 200 usec sonic pulse duration, sensitivity 2, grayline 1; bottom echogram, 8^{o} transducer, 50 usec sonic pulse duration, sensitivity 7, grayline off.

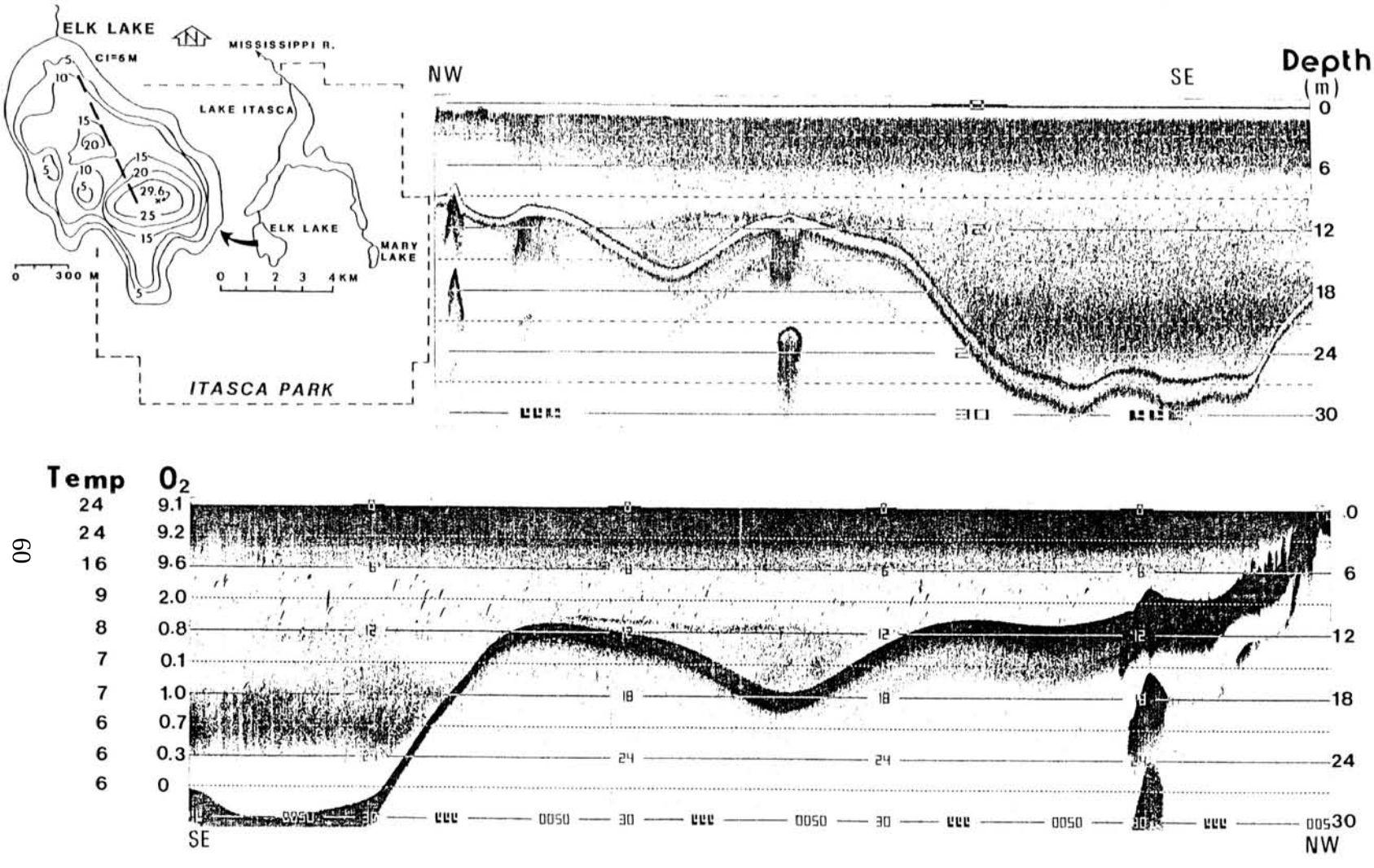

Figure 1. Acoustic scattering layers in Elk Lake, Minnesota during mid-morning, 21 July, 1986.

Figure 2. Reprinted with permission from the Minnesota Pollution Control Agency, Division of Water Quality, July, 1982.

APPENDIX

EQUIPMENT LIST FOR WORKSHOP

1) Lowrance X–16 computer sonar. $575.00 with educational discount. Talk to Charley Ramsey 1–800–331–3889. Lowrance Electronics Inc., 12000 E. Skelly Dr., Tulsa, OK 74128.

2) Remote sensing thermister. $500.00. Many offices, we use Fisher Scientific, 10230 West 70th St., Eden Prairie, MN 55344. (612) 941–5460.

3) Oxygen meter. $500.00. Fisher Scientific. See #2 above.

4) Van Dorn water sampler. $300.00. Wildco, 301 Cass St., Saginaw, MI 48602. (517) 799–8100.

5) Schindler trap. $300.00. Wildco, see #4 above.

6) Nalgene vacuum pump (hand–held). Nalgene Labware Department, Nalge Co., Box 365, Rochester, NY 14602. (716) 586–8800.