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Acoustic Mapping of Aquatic Vegetation in Lakes: An Example from Northwest Arkansas

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Lake Wedington Recreation Area is located in Washington County in northwest Arkansas (Fig. 1). The lake is accessible in the Ozark National Forest 17.7 km west of Fayetteville, on State Highway 16. The normal pool of Lake Wedington lies at an elevation of 342 m (1,121 ft; Fig. 1) and has a maximum depth of approximately 12 m (Fig. 2; Table 1). In 1937, an artificial dam was constructed across the drainage leading to the Illinois River to create Lake Wedington. The lake has been drained occasionally throughout its history as a means of controlling aquatic macrophytes, composed primarily of aquatic algae and an aquatic vascular plant, *Potamogeton natans* (floating-leaf pondweed; Lindman, 1901; Owen, 1952; Fig. 3). Two previous studies of Lake Wedington were completed in 1952 (Allman, 1952; Owen, 1952). Allman (1952) focused on the relationship between water chemistry and spring phytoplankton blooms using temperature, dissolved oxygen, pH, and nitrate. Owen (1952) provided a number of morphometric measures of the lake and also reported water quality parameters similar to those of Allman (1952) from July 1950 to June 1951. Most recently, Polly (2001) conducted a detailed bathymetric and sedimentation survey of Lake Wedington utilizing a dual frequency (28 and 200 kHz) echo sounding system. The acoustic mapping system deployed by Polly (2001) is typically utilized to discriminate bedrock and lacustrine sediment fill, providing detailed maps of bathymetry (Fig. 2) and sediment thickness (Polly and Boss, 2000; Polly, 2001). However, this short note reports on the observation of distinctive yet anomalous acoustic signatures on a number of echo sounder profiles from the Polly (2001) survey, and the correlation of these acoustic anomalies with dense growths of aquatic plants. As such, results presented here provide a novel and potentially cost-effective method for lake managers to map distributions of aquatic plants.

Polly's (2001) survey of bathymetry and sediment thickness of Lake Wedington was conducted during June 2000 as a research project for her M.S. degree in Geosciences. Lake elevation at the time of the survey was 342 m. The survey utilized a Knudsen Engineering, Ltd. Model 320 B/P Dual Frequency (28 and 200 kHz) Echo Sounding System deployed from an 8-m pontoon boat maintained by the Department of Geosciences at the University of Arkansas – Fayetteville for limnological research. During lake surveys, the boat travels at approximately 2 m/s. The transducer of the echo sounding system transmits acoustic energy to the lake bottom from which it reflects to be detected again by the transducer. The two-way travel time (i.e. time for sound to travel from the transducer to the lake floor and back to the transducer) of the acoustic impulse is recorded by the system and converted to depth according to the following relationship:

$$D = \frac{t}{2}\ v$$

where D = depth (m), t = two-way travel time (s), and v = p-wave velocity (m/s) (Robinson and Coruh, 1988). In order to solve this equation, the p-wave velocity through water must be known. This velocity will vary with water temperature, but because Lake Wedington is relatively shallow, choosing an average velocity for the entire water column (despite temperature changes) results in minimal error (<0.15 m, or <1.25%, in the deepest part of the lake). For this study, the echo sounding system was calibrated in known water depth at the lake's boat dock and the p-wave velocity was determined to be 1,480 m/s, a typical value obtained in fresh water (Robinson and Coruh, 1988). The echo sounder emitted and recorded six pulses every second. These data were averaged to obtain one sounding for each second of the lake survey, resulting in 15,324 soundings throughout the lake basin.

Table 1. Morphometric parameters of Lake Wedington derived from bathymetric survey and GIS analyses.

Parameter	Units
Fetch	1,000 m
Area	279,243 m^2 (69 acres)
Maximum Depth	12.4 m
Mean Depth	6.0 m
Shoreline Length	4,192 m
Volume of Lake	1,675,458 m^3
Watershed Area	10,198,440 m^2

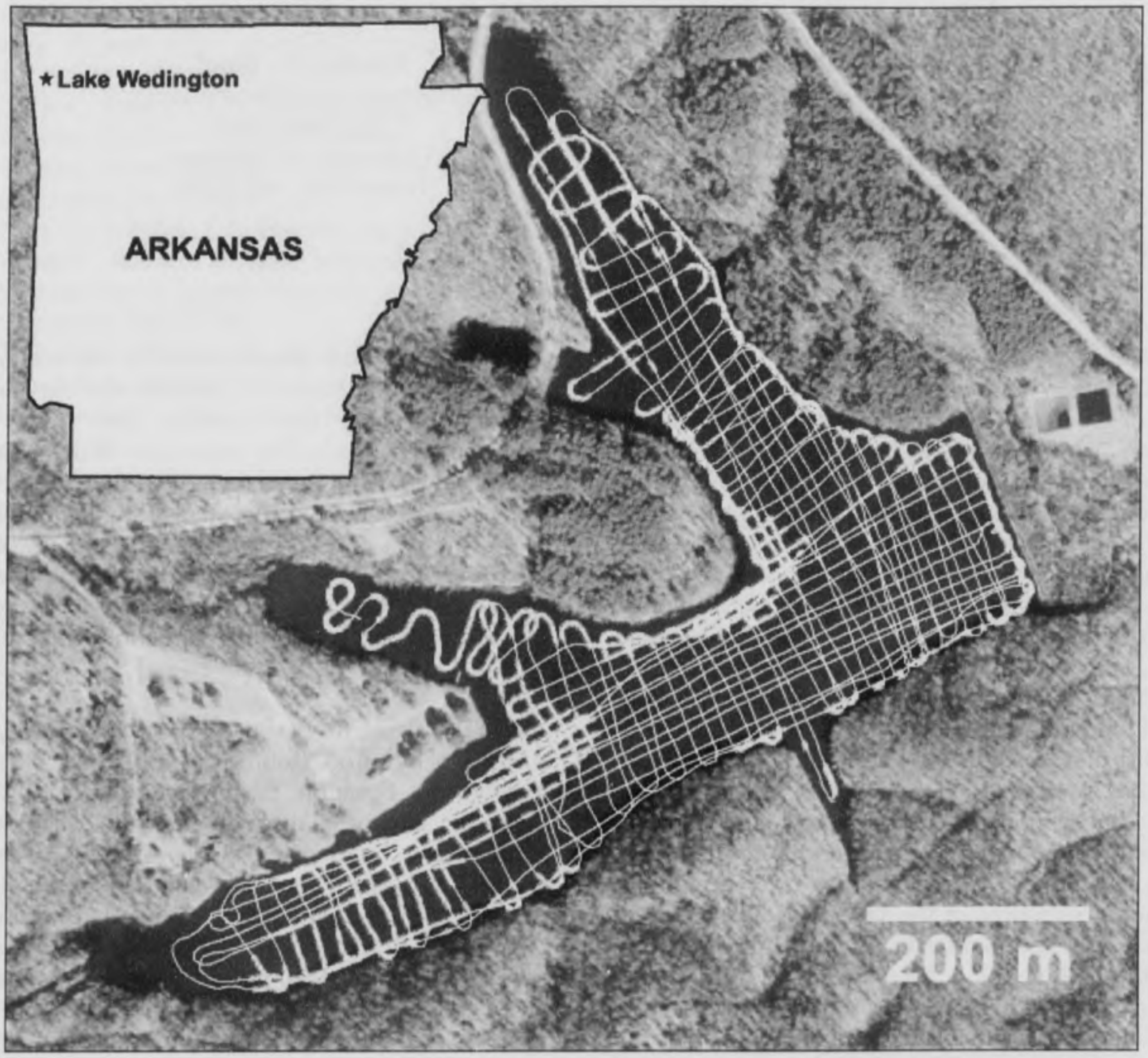

Fig. 1 Illustration showing location of Lake Wedington in northwest AR superimposed on aerial photograph of Lake Wedington and showing echo sounder survey track lines (white lines) and portions of track lines exhibiting anomalous acoustic signatures (bold white lines). Prominent road curving along north shore of Lake Wedington is AR State Highway 16.

Accurate positioning of the echo sounding survey within the lake basin was obtained using a Trimble Pathfinder Pro XRS Global Positioning System (GPS). Data obtained using this receiver were differentially corrected using the differential GPS radio beacon in Sallisaw, Oklahoma to provide location data with 2 to 3 m horizontal accuracy. Positions were automatically logged from the GPS receiver every five seconds during the survey. Following the survey, GPS data were interpolated to provide geographic coordinates (latitude and longitude) for each second of the survey, and these interpolated data were merged with echo sounder data and used to generate the bathymetric map (Fig. 2).

Various lake morphometric parameters were derived directly from survey data by importing these data to Geographic Information System (GIS) software (Table 1). In addition, a number of echo sounder profiles displayed anomalous acoustic signatures indicative of scattering of the acoustic impulse within the water column (Fig. 4). Locations of all echo sounder profiles or portions of profiles displaying this distinctive acoustic signature were displayed as an overlay on the overall map of survey tracklines (Fig. 1). The distribution of these anomalous echo profiles showed that all were associated with relatively shallow water (<5 m) along the lake margins or in the northern lake arms. Field inspection of the distribution of these profiles and visual

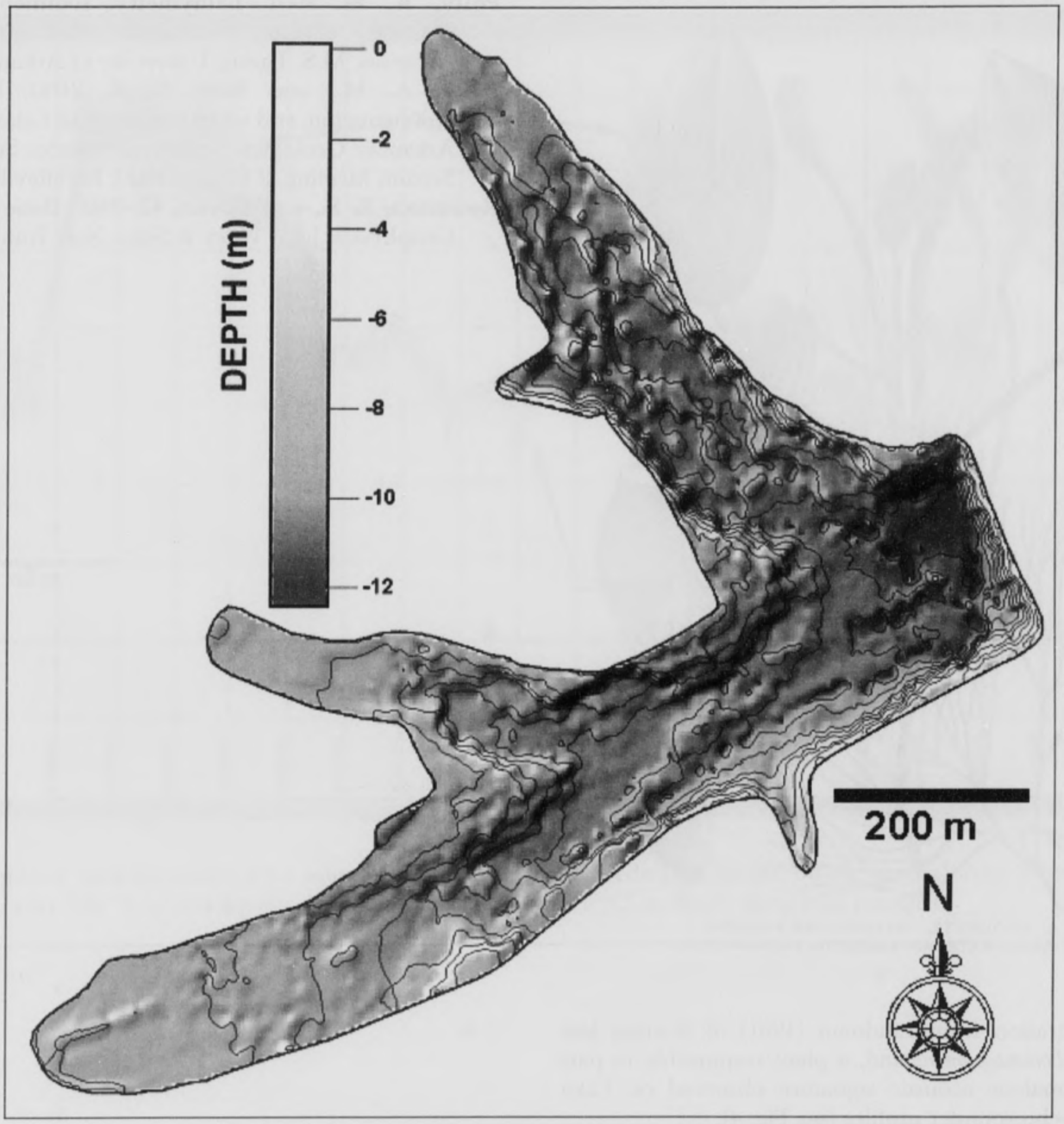

Fig. 2. Detailed bathymetric map of Lake Wedington, Washington County, Arkansas derived from dual frequency echo sounder survey of Polly (2001).

examination of the nearshore regions of the lake indicated that this signature resulted from scattering of the acoustic impulse by dense growths of aquatic vegetation.

These results indicate that the speed and efficiency of similar geophysical surveys could provide lake managers with a novel method to assess the distribution and abundance of aquatic plants throughout a lake basin. In addition, it would be possible to conduct repeat surveys several times through a growing season to determine changes in the distribution and abundance of lacustrine flora. As such, lake managers might find a powerful analytical tool in the application of acoustic geophysical methods for conducting assays of lake macroflora. Future studies will focus on quantifying the species composition of vegetation responsible for observed acoustic anomalies in Lake Wedington, and analyzing acoustic signatures that might correspond to individual plant species.

Fig. 3. Illustration from Lindman (1901) of floating leaf pondweed (*Potamogeton natans*), a plant responsible in part for the anomalous acoustic signature observed on Lake Wedington echo sounder profiles (see Fig. 4).

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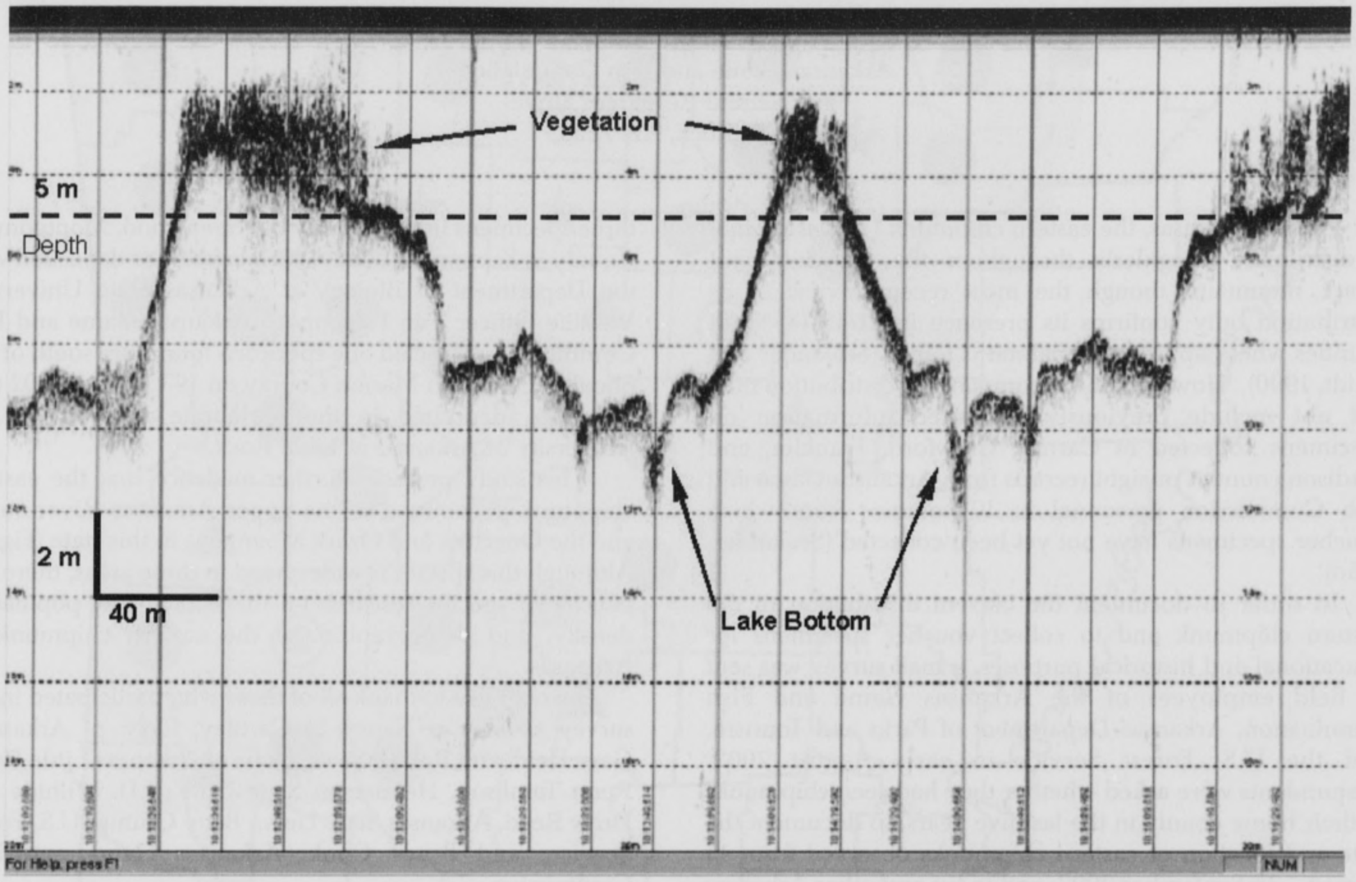

Fig. 4. Example of dual frequency echo sounder profile from Lake Wedington (depth on the vertical axis) showing acoustic signature of rocky lake floor and aquatic vegetation in shallow water (<5 m deep) along lake margins.