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High Resolution Acoustic Survey Techniques and Coring Operations Upper Klamath Lake and Lake of the Woods, Oregon

BY

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High Resolution Acoustic Survey Techniques and Coring Operations

Upper Klamath Lake and Lake of the Woods, Oregon

The U.S. Geological Survey, Global Change and Climate History Program Team performed two high resolution geophysical surveys on Upper Klamath Lake and Lake of the Woods, Klamath County, Oregon, in July and again in September, 1996. The field programs had two primary objectives. The first objective was to survey both lakes using acoustic high resolution geophysical tools to help characterize bottom types and to locate potential core sites. The second objective was to perform the actual coring operations using a (free fall) gravity corer, and a (push type) Livingstone Corer. This report outlines the methodologies, operational issues, problems, and solutions incurred both in the high resolution geophysical surveys of the lakes and the coring operations. (fig.1)

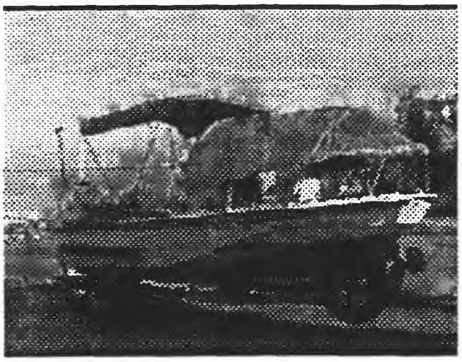

Fig.1

Survey Boat

Two U.S. Geological Survey teams converged in Ft. Klamath to perform the field experiments. Personnel (David Nichols and Steve Colman) from the Coastal and Marine Geology Center, Woods Hole, Ma. provided the equipment, scientific, and technical expertise for acoustic and gravity coring operations, and those from the Global Change and Climate History Team from Denver, CO. (R. Reynolds, J. Rosenbaum, and G. Skipp) provided equipment and expertise for the Livingstone Corer as well as watershed sediment sampling. Steve Colman, USGS Woods Hole, Ma. was the overall project chief.

Upper Klamath Lake (fig.2.1) fills a tectonic depression at the boundary between the Cascade Range and the Basin-and-Range Province. The lake is very shallow (about 2.5m average depth) and hypereutrophic, with massive summer algal blooms. Wind stress (N. W. dominant) commonly induces resuspension and mixing of bottom sediments, which are diatomaceous and water rich.

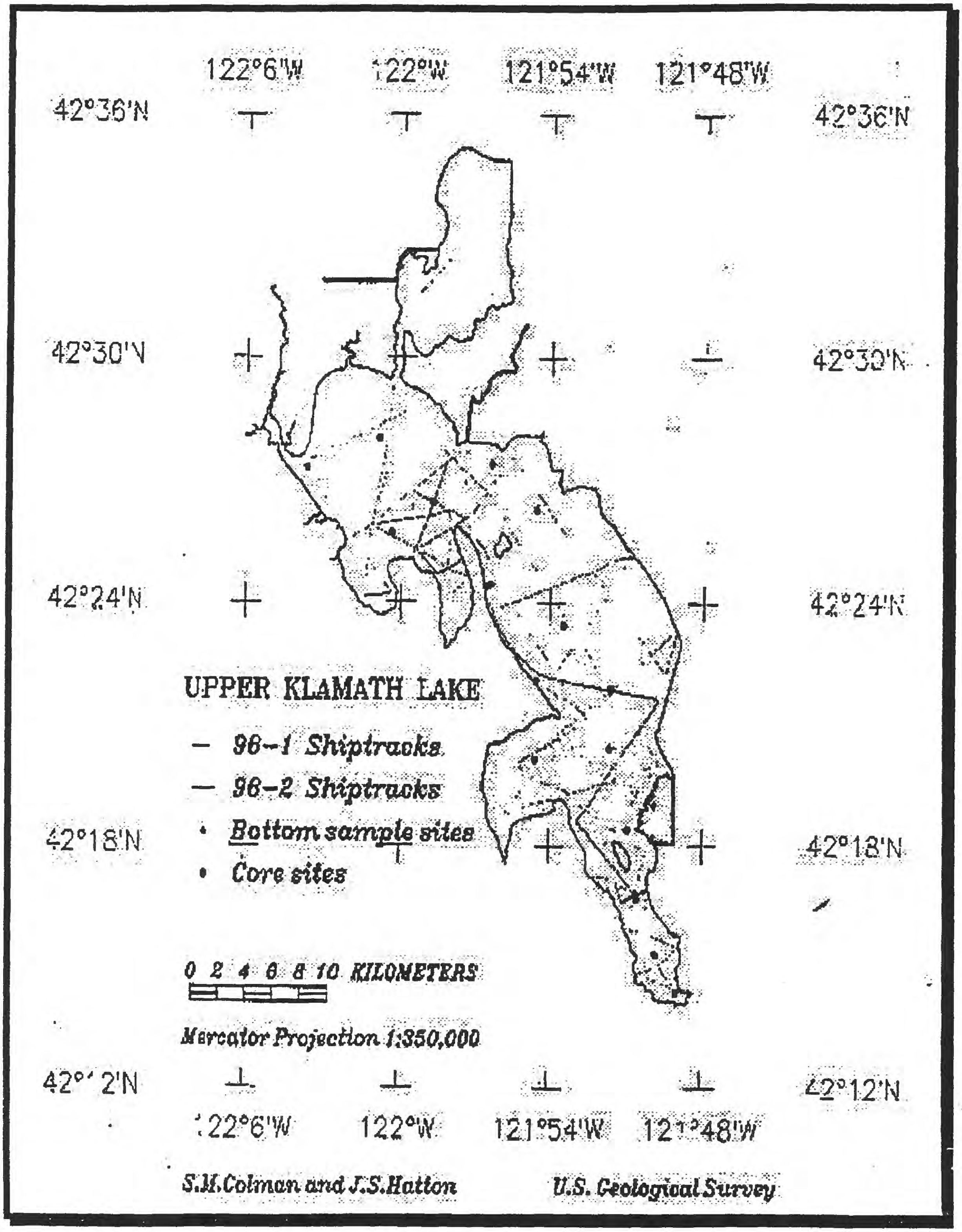

Figure 2.1 Upper Klamath Lake

Lake of the Woods (fig. 3.1) is a nearby glacial lake located in the Cascade Range immediately West of the Klamath Valley and about 250m higher. It is smaller than Upper Klamath Lake, deeper (ca.16m maximum), and clearer (no Summer algal bloom).

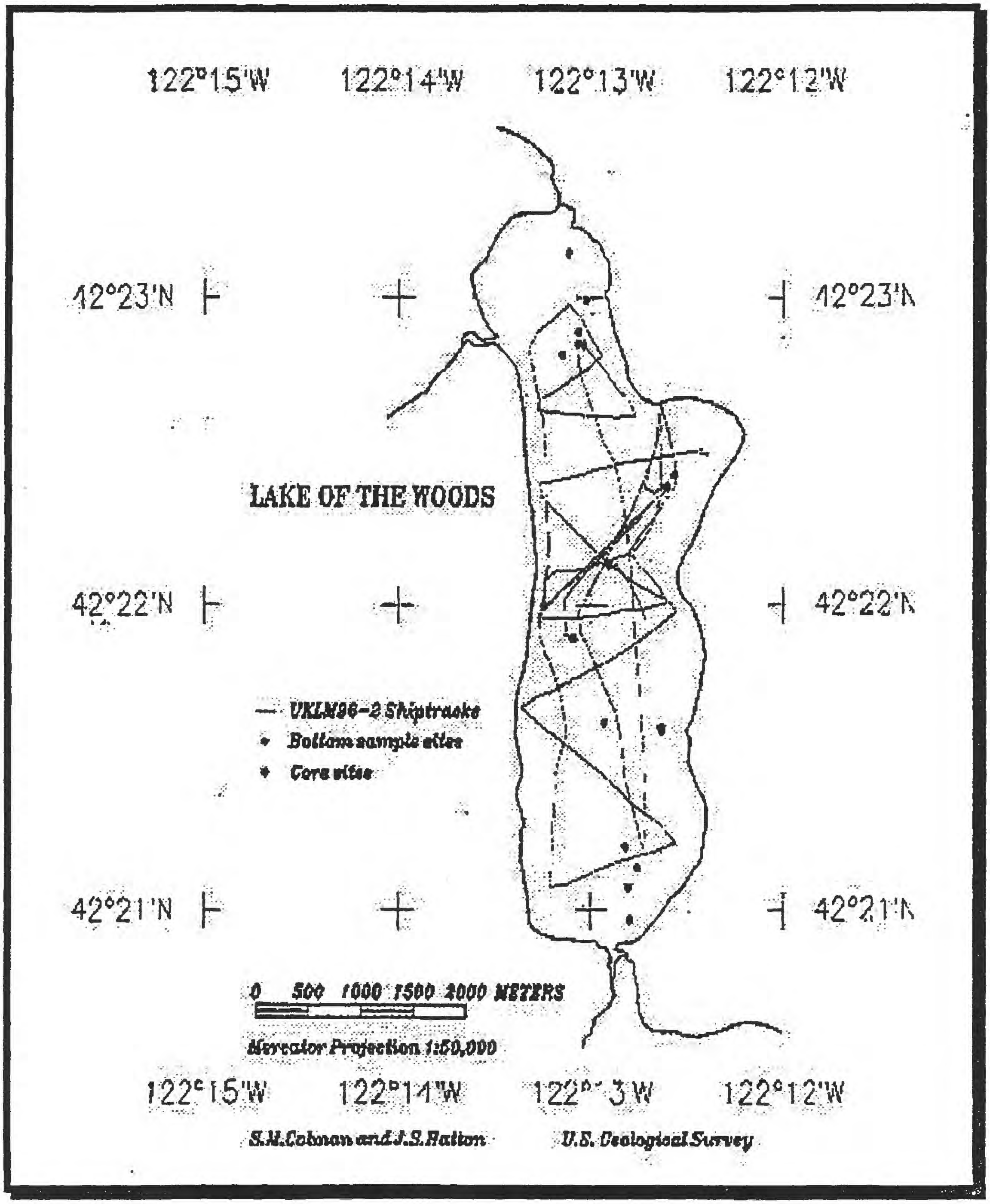

Figure 3.1 Lake of the Woods

Acoustic Surveys:

During the two field programs in Upper Klamath Lake and Lake of the Woods, approximately 200km of high resolution geophysical data were collected to determine core locations and to help quantify bottom types. A 19' Boston Whaler was used as the geophysical platform due to it's shallow draft and it's work boat specifications. Examples of seismic profiles from Upper Klamath Lake (fig. 4.1) and Lake of the Woods (fig. 5.1) show the difference of bottom types in these two lakes and their effect on the seismic signal.

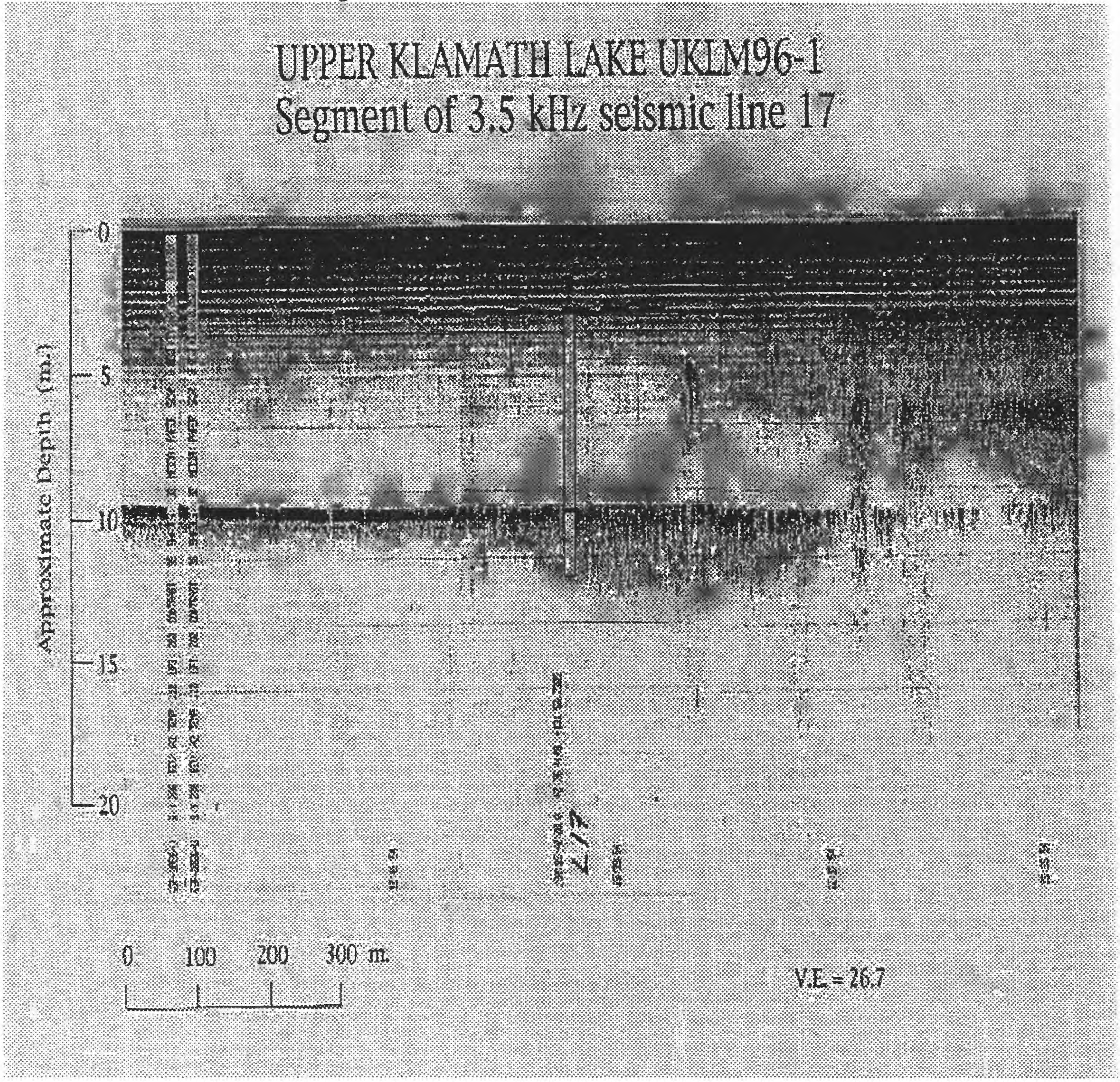

Figure 4.1 Upper Klamath Profile

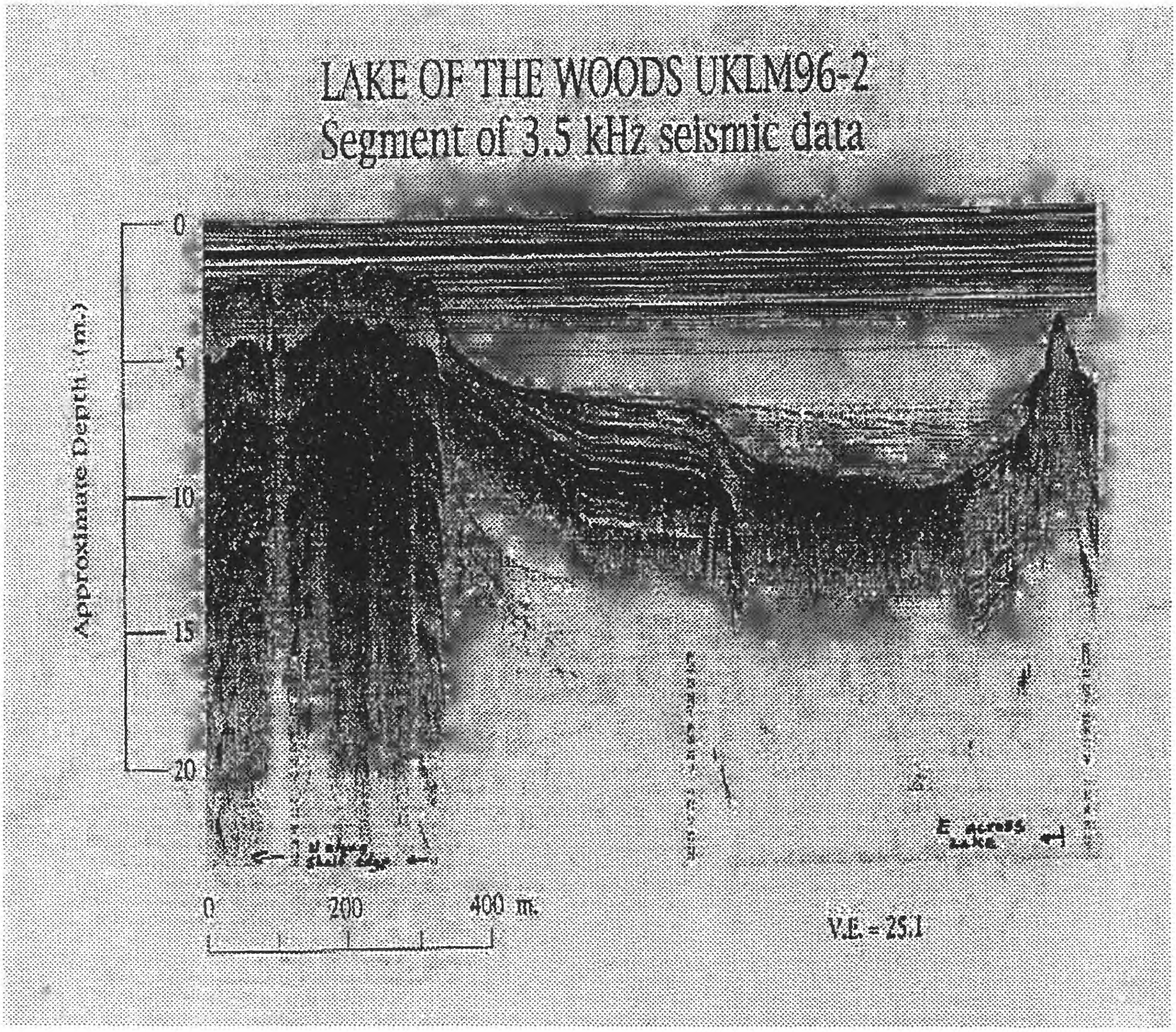

Figure 5.1 Lake of the Woods Profile

Data Acquisition Systems:

A. ORE 140 Transceiver, 4 ea. 3.5 khz transducers on side mount

B. Odem Dual Frequency Digital Fathometer (200/24 khz)

C. Data Marine 200 khz Fathometer

D. Triton Technologies SIU Interface Unit

E. Rockwell International (Plugger) Pcode GPS Receiver

F. Sony 2 Channel Dat Recorder

G. Honda 3.5 khz Power Plant

H. EPC 1086 Thermal Plotter

I. USGS Integrated Navigation Computer with Digital Depth Input

Equipment used for this field program was chosen with portability and physical size as major criteria. When working on small boats it is critical that weight and mass are kept to a minimum. Boston Whalers are a known work horse in the industry and provide the scientist and associated personnel a safe and reliable platform for experiments.

Logistics and Methodology:

The equipment was shipped overland to the Klamath Indian Tribes fish hatchery in Chiloquen, Oregon. It was then mobilized on the tribes 19' Boston Whaler. (fig. 6.1) The boat was trailed to the two work sites for operations. Power for the onboard systems was provided by a 3.5kw Honda generator. Sub-bottom 3.5 khz acoustic data and key pulse information were merged using the Triton (SIU) box and stored on channel (A) of the DAT recorder. GPS time code was stored on channel (B). Bathymetry (200khz) data were collected and stored in the Navigation computer on 3.5 floppy every ten seconds along with Pcode GPS Data. Hard copy seismic data was annotated with Pcode position on two minute intervals.

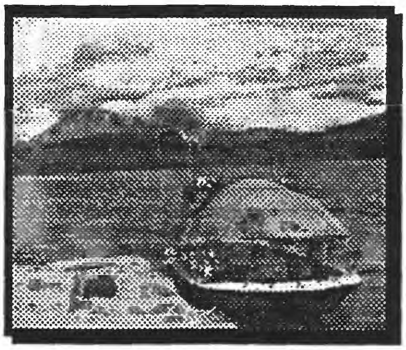

Figure 6.1

Boston Whaler

Acoustic Acquisition Techniques and Modifications:

Given the shallow water depths, which can cause ringing of the seismic signal in the water column, and highly organic bottom sediments with suspension that can disperse the seismic signal, several power levels and configurations were tried using the 3.5 khz side mount to optimize signal acquisition. (fig.7.1) Power levels from 1.2kw to 5kw max were tried with pulse widths ranging from .2ms to .5ms. After many problems were experienced trying to acquire the 3.5 khz signal using the standard four transducer array at various power levels and pulse widths a modification was made to the side mount for the September program using only two of the 3.5 khz transducers (combined mode) and the addition of a dual frequency, 24/200 khz transducer. The more directed beam of the 24 khz was a complement to the 3.5 khz signal.

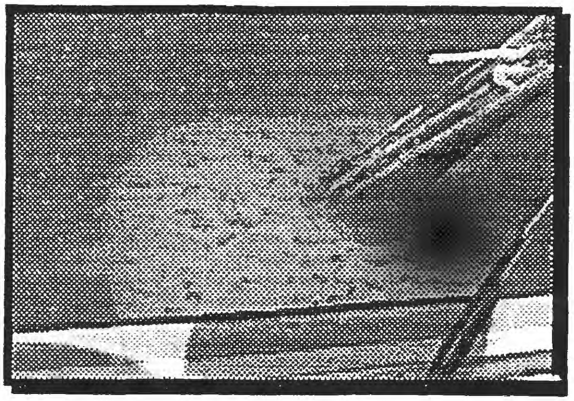

Fig. 7.1

3.5 Khz Side Mount

In much of Upper Klamath Lake, the sediment-water interface was highly reflective for the 3.5 khz signal, producing prominent ringing and no sub-bottom reflections. Locally, this strong lake-floor reflection abruptly terminated, and sub-bottom reflections from depths as much as 30m below the lake floor were obtained. The reason for the bimodal acoustic nature of the lake floor is not known. Sediment cores revealed that in most cases, the sediment-water interface is sharp and well defined, although the sediment is so water-rich that the contact is less like a solid-water interface than one between two immiscible liquids. The strong lake floor reflection does not appear to be related to biogenic gas (methane) in that it is a single strong reflection with many multiples,rather than one followed by the diffuse later returns characteristic of gas.

Similar strong lake floor reflections were observed on shallow shelves in Lake of the Woods. (fig. 7.2) There, well-developed sub-aquatic vegetation on the lake floor was observed through the clear water. The underlying sediments are soft mud containing abundant plant fragments. Interestingly, sub-bottom reflections were obtained with the 24 khz system where none were observed with the 3.5 khz system.

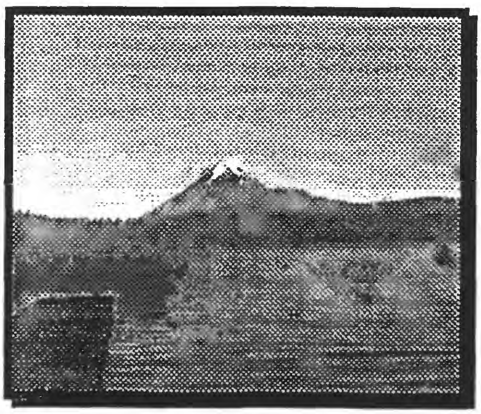

Figure 7.2

Lake of the Woods

Operations: Systems and Modifications

During coring operations in July , a 10cm diameter by 1 meter length core barrel was used on a sixty pound gravity core head. The water- rich and fluid sediment in Upper Klamath Lake washed out of the barrel on each attempt due to lack of a tight seal within the core liner. Modifications to the gravity core operations for the September program included using a Wildco 2" diameter by 4' long core barrel and a 32 pound gravity core head. This corer had a larger, better-fitting one-way valve in the core head which formed a tight seal that prevented loss of the fluid-rich sediment.

Numerous gravity cores as much as 70cm long were obtained with this corer. (fig. 2.1 and 3.1)

With the Livingstone Piston Corer, a 3m core was obtained in Lake of the Woods, (fig. 3.1) and a 9m core was obtained in Upper Klamath Lake.(fig. 2.1) The upper part of these core holes were cased, and the cores were obtained by simply pushing 1m sections of core barrel successively into the sediments.

Acknowledgments:

We would like to thank Dr. Jake Kann and the Klamath Indian Tribe for the use of their Boston Whaler and their logistical support. The Hatchery facility in Chiloquin was used as the base for operational support and for equipment mobilization. The professional atmosphere of the entire staff at the Hatchery helped make the U.S.G.S. program a success.