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Final Report
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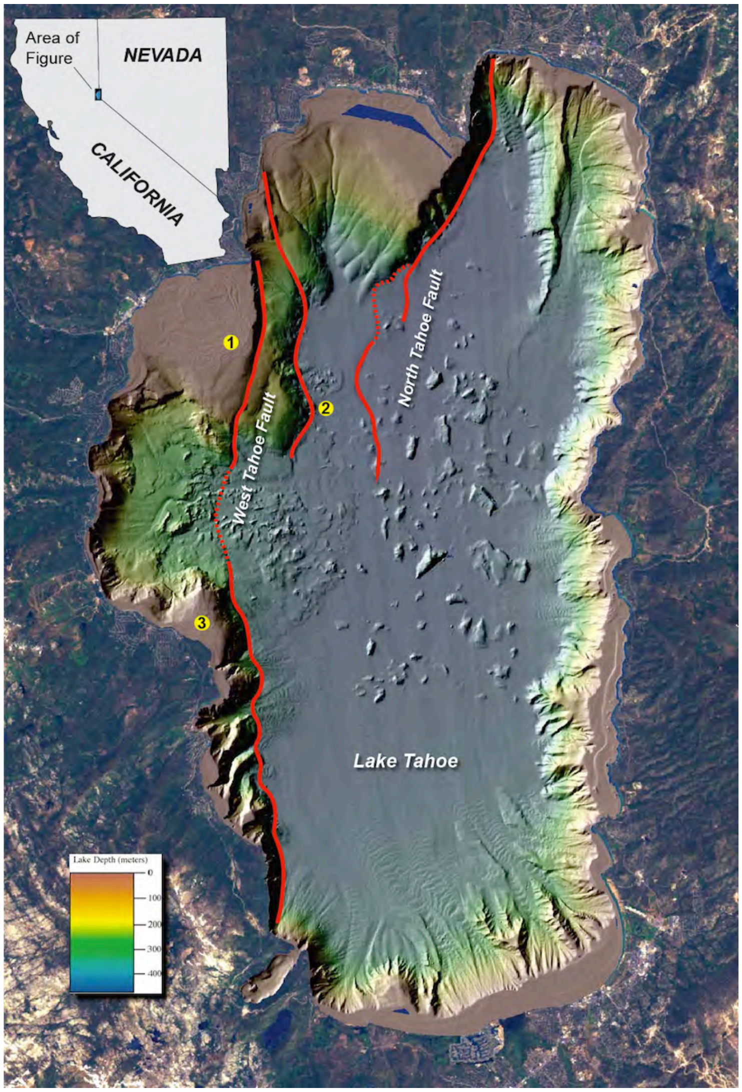

Lidar bathymetry (US-ACE) + Landsat (provided by Gordon Seitz – CGS)

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Background

This report summarizes outcomes from testing of instrumentation for use in the Antarctic field operations of WISSARD (Whillans Ice Stream Subglacial Access research Drilling) by Northern Illinois University (NIU). NIU contracted out instrumentation design and construction to DOER Marine of Alameda, California and Tahoe barge operations to Tahoe Marine and Excavating. In addition, by collaborating with Gordon Seitz of the California Geological Survey (CGS), the project was designed to try and fill gaps in knowledge of the evolution of Lake Tahoe Basin, and add to understanding of seismic, seiche, and landslide hazard potential in the basin. Gordon Seitz is also closely studying the West Tahoe Fault on shore, south of the offshore sites targeted in the lake. Results of that study have yet to be released.

The original plan of one operational period in Lake Tahoe had to be modified due to manufacturing issues and consequently involved two periods over two years. This required an extension of time on completion for this contract that was granted by the Commission without an increase in budget. All additional costs for the two deployments were borne by NIU. The first operational period was conducted in August 2012 and the second was in July 2013.

A suite of samplers was tested and used to sample Lake Tahoe during the first period in 2012 that included (i) Instrumentation Packages for Sub-Ice Exploration (IPSIEs) (Fig. 1), (ii) a hydraulic percussion corer, (iii) a multicorer, and (iv) a multipurpose winch with smart cable umbilical. The IPSIEs measure and sample a wide range of water properties, the percussion and multicorers are for collecting sediment core samples, and the winch and cable are for deploying and commanding all of the instruments, as well as enabling the instruments to transmit real-time data to the surface while deployed. The second operational period in 2013 was specifically dedicated to testing the Sub-Ice ROVer (SIR) (Fig. 2), a remotely operated vehicle (ROV) with 3km of umbilical tether designed for deployment through a borehole melted in Antarctic ice, but which can also descend and explore the full depths of Lake Tahoe.

Engineering Testing

As a result of the engineering testing of all instruments during the 2012 test (see location 1 on cover image), some modifications were made for easier and more efficient equipment handling and data/communication issues. These instruments were used in Antarctica during a successful campaign in 2012-13.

For the SIR during the 2013 testing (see location 3 on cover image), the sub-bottom profiler (CHIRP seismic reflection) and multibeam swath topography units were successfully deployed, however, the manipulator arm was left off the SIR for this initial test to save weight on board while testing SIR maneuverability. There were no electrical, structural or communication failures and all but the thrusters performed exceptionally in the range of mechanical operations. The power that the SIR has for maneuverability exceeds all expectations and thus it has shown that it can easily haul out 2km of umbilical as it roves at depth. DOER continues to run tests on the thrusters in their Alameda shop and components are being purchased to complete the solution to their problems.

Science Outcomes

Water column profiles in the lake are comparable to those collected over many years by the Tahoe Environmental Research Center (TERC) (Fig. 3). The data show that our instrumentation is working appropriately and will record correct data in deeper waters of the Lake in conjunction with SIR studies.

Our corers provided sediment samples from the upper layers of lake floor sediment, the undisturbed sediment-water interface, and the bottom lake water (Figs. 4 and 5). We also collected a cobble-sized piece of gravel. Sites sampled on the shallow water shelves on the west side of Lake Tahoe have highly consolidated sediment that we consider to be till from the Last Glacial Maximum underlying a thin cover of very gravel-rich (granules to boulders) biogenic mud. The corers showed that they would be able to collect samples from deeper waters of the lake if required. The till was very stiff and actually damaged two of the corers, which have since been repaired.

A “regular” DOER ROV was used during the August 2012 testing to observe how well the instruments operated while deployed. Once testing was complete that ROV was used to investigate the West Tahoe Fault near the shallow water testing sites as an assessment of possible findings that could be obtained by SIR (see location 2 on cover image). It descended down the fault scarp to lake bottom at 1150 feet (Fig. 6) and imagery was spectacular. It clearly demonstrated the high potential of using SIR in the future, with is greater capabilities.

As we did not test the SIR at depths below 100 feet, because of the thruster issues that are currently being solved, we did not accomplish any scientific investigations with SIR during this initial deployment. However, our testing did show that SIR will be capable of performing at depth in the lake to collect unique imagery, high-resolution topography using multibeam instruments, and high-resolution sub-bottom profiles of key areas around fault lines and sites of interest to the CGS.

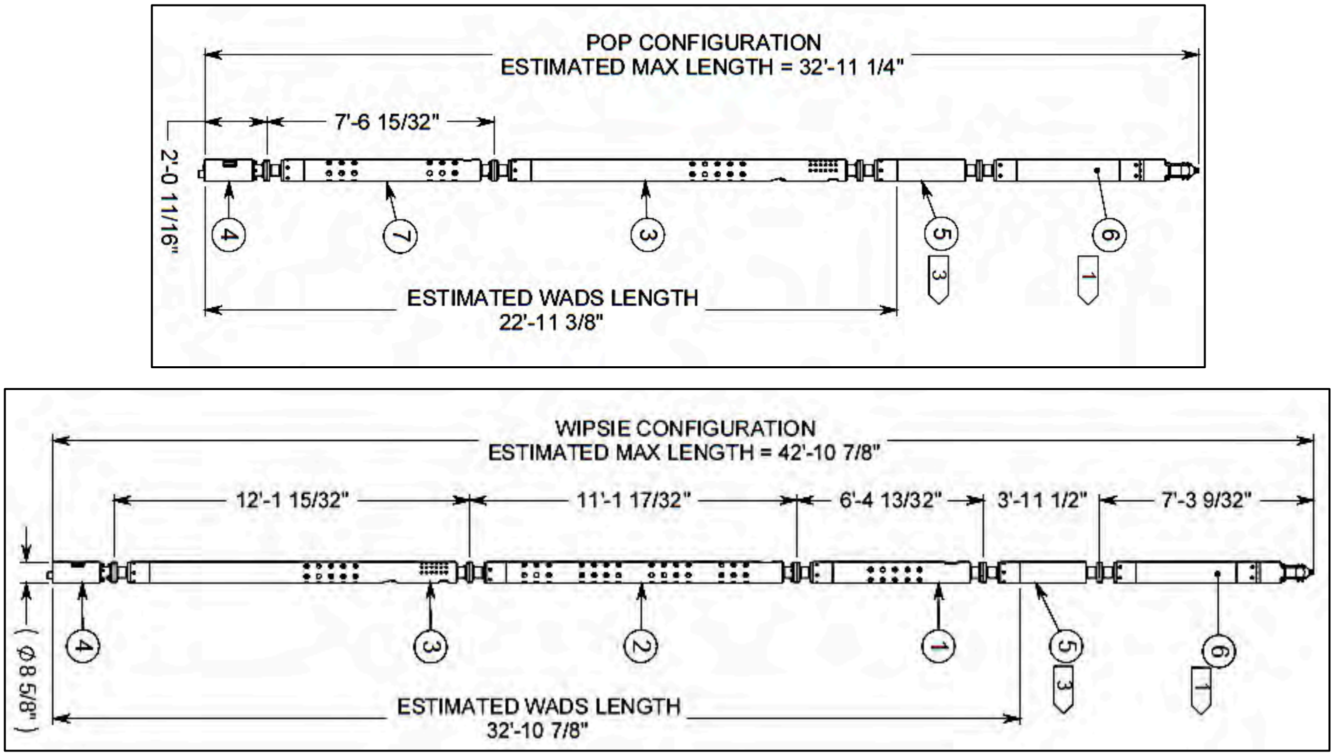

Figure 1: Engineering schematic layout of the POP (Physical Oceanography Package) and the WIPSIE (Water chemistry Instrument Package for Sub-Ice Exploration) of the IPSIE sensors: 1- Contros nutrient stage (HydroC - CO_2, CH_4), 2- Envirotech nutrient stage (PO_4, SiO_4, NH_4, NO_3), 3- Envirotech water-bag sampler stage, 4- Bottom stage (down- and side-looking cameras with LED lights, Wetlab fluorometer and optical-backscatter (FLNTU), Contros electromagnetic current meter, Tritech altimeter), 5- WaDS pump stage, 6- lifting power and telemetry stage, 7- Physical properties stage (Seabird CTD and dissolve oxygen sensor, LISST Deep particle-size analyzer, Wetlab CStar transmissometer, Nortek Aquadopp Doppler current meter).

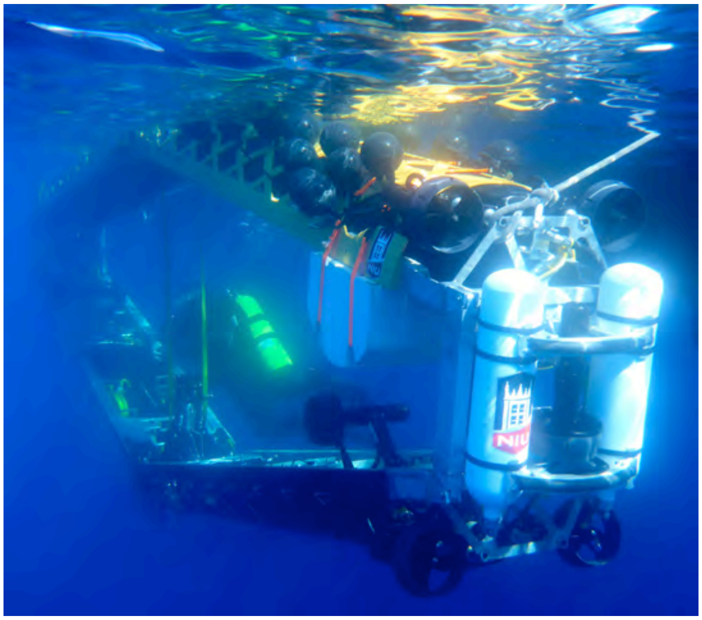

Figure 2: SIR going through its underwater transformation in July 2013 (image: Reed Scherer).

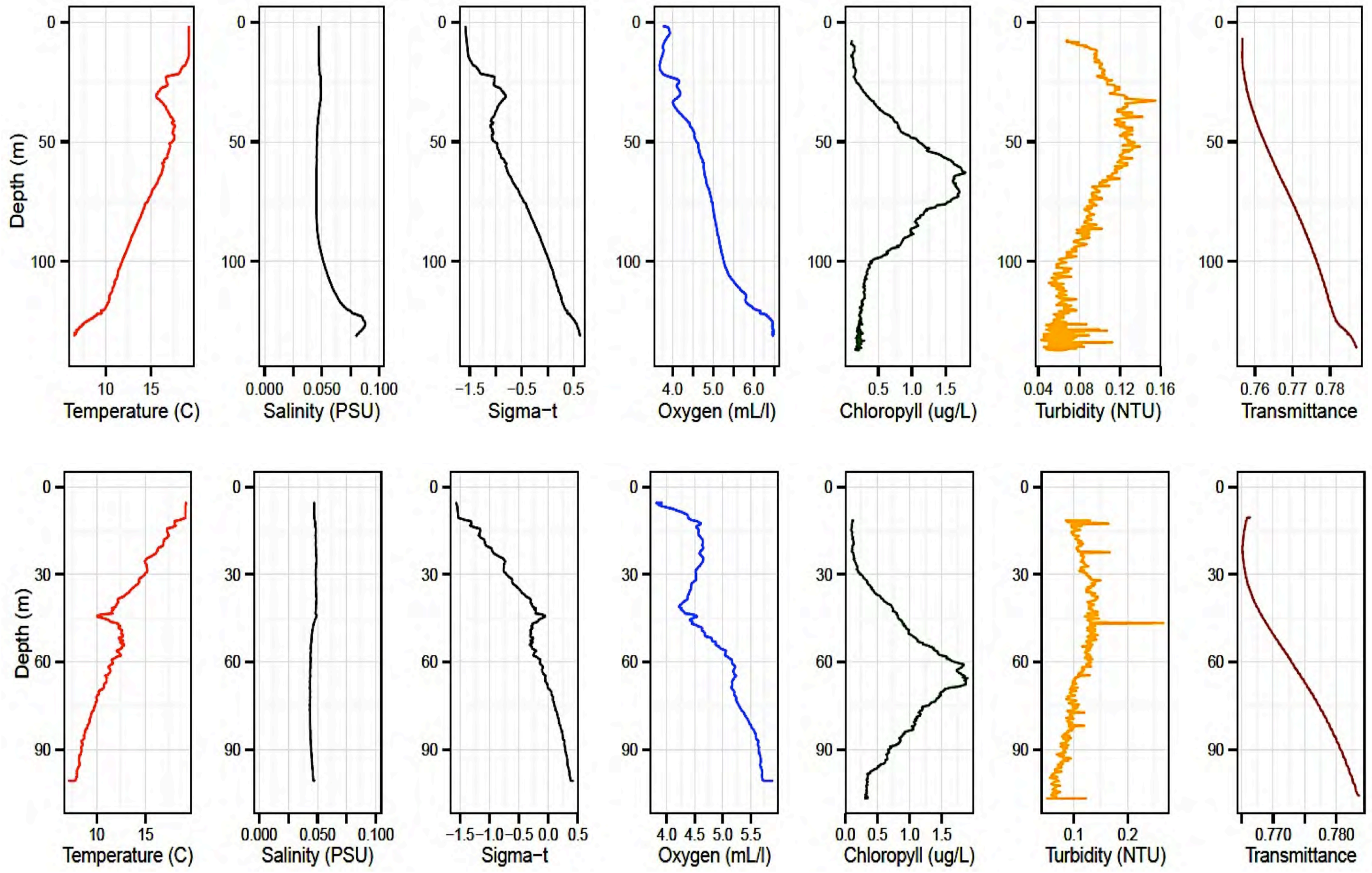

Figure 3: Descent profiles of different variables measured by the IPSIE instruments in Lake Tahoe. These data show that the instrumentation was working appropriately with one major issue that is being modified. The CTD/DO data were obtained with the instruments outside of the WaDS system and thus were affected by a delay time for water mixing into the casing during descent. The strange “kicks” in T, O and turbidity (~30m depth in top profile and ~50m depth in bottom profile) are due to turbulent mixing and bubble creation in the water as the barge was being moved (noted on our event log records and seen on the video from the downward-looking camera). Kicks in the plots at the bottom show where IPSIE came close to the lake floor. These data are comparable to those collected over many years by the TERC group.

Figure 4: ROV images of the percussion corer penetrating coarse sediment on the lake floor. Upper middle image shows the drop-weight stage at the top of the core barrel. Top right image is the base of a stiff till sample within the core cutter.

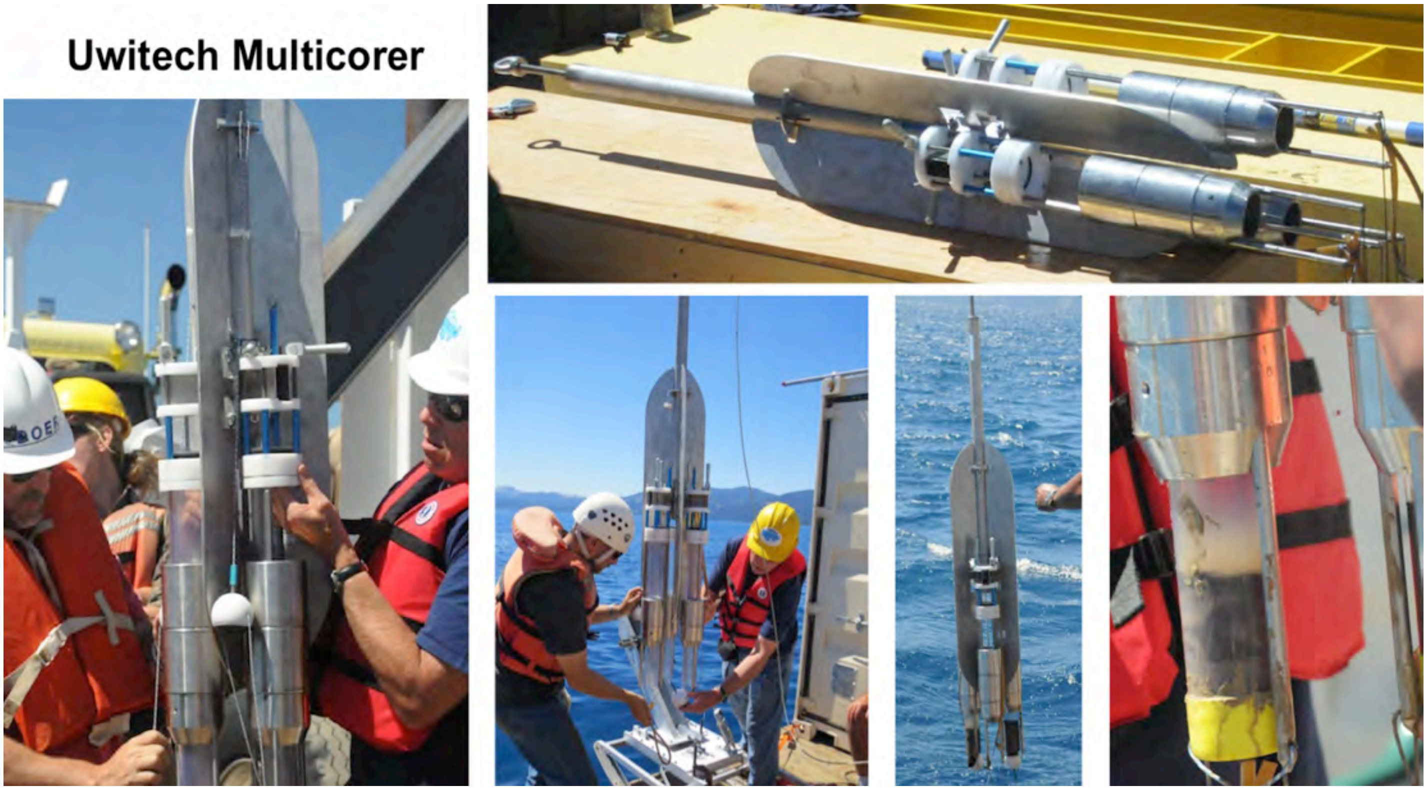

Figure 5: Uwitech multicorer that takes three replicate cores at once preserving the top-most sediment, the sediment-water interface and the water column. Two bottom right images show a sample being recovered.

Figure 6: Images of the West Tahoe Fault scarp in August 2012. Clockwise from top left: top of the scarp, two images showing bedrock exposed on the scarp face, and the lake floor at the base of the scarp at 1150 feet depth (images from DOER).