RECLAMATION
Managing Water in the West
U.S. Department of the Interior
Bureau of Reclamation

Technical Service Center, Hydraulic Investigations and Laboratory Services Group, Denver, Colorado – July 2011

Scanning Sonar - Underwater Imaging and Bathymetry System

Are you tired of not "seeing" the whole picture of your underwater infrastructure? Reclamation's TSC now has the capability to image underwater structures even under poor visibility and without having to completely shut down dam or powerplant releases. These images are collected from shore or by boat and can be used to document facility condition or direct divers while underwater.

The Technical Service Center now has a state-of-the-art Scanning Sonar System that can image underwater structures in clear or low visibility water and produce images and 3-dimensional (x,y,z) survey data with amazing detail. This technology is well suited for assisting divers with inspections, search and recovery, and monitoring underwater construction. In addition, bathymetry applications include canal and embankment dam inspections, contour mapping, hydraulic structure inspections for damage or invasive mussel infestation, as-built surveys, fish screen inspections, and scour hole mapping (shape and volume).

What Is a Scanning Sonar?

Sonar stands for SOund NAvigation and Ranging. Active sonar systems send sound waves through the water and records the reflected sound waves. An image is made using reflected acoustic signal strength to provide information about the reflectors.

The TSC has a single-axis profiling sonar system which includes the Kongsberg MS1000 software and a 1071-Series Sonar that is designed to produce the highest resolution scanning sonar images at a frequency of 675 kHz. The sonar transducer is equipped with a stepper motor which rotates the transducer at angles as small as 0.225°. The system operates in two modes: 1) sonar imaging and 2) profiling (point measurements). The imaging mode uses a fan beam with 30° wide beam angle and the profiling mode uses a narrow, 1.7° wide conical beam. The dual-transducer sonar allows for collection data using both modes from a single deployment.

Acoustic Images

Acoustic images are collected by submerging the instrument and rotating the acoustic fan beam over the area of interest. Multiple set-ups are required to image large structures. The instrument has an acoustic range of up to 500 ft and can be used in any depth you can throw at it (it was designed for deep ocean applications). The image resolution depends on range and sampling configuration High resolution configurations can detect offsets greater than $1/10^{th}$ of a foot and measure distances to within ±1 inch. Sample images are included with this brochure.

Acoustic Profiling Surveys

Similar to laser scanning, sonar surveys can be used to create a three dimensional model of an underwater structure. With this data distances, areas, and volumes can be estimated. This technology will allow Reclamation facility managers to "see" their structures before having to dive on them. All data collected below the waterline can be tied into the project datum using RTK GPS.

Who Can Benefit?

Any project manager that has underwater infrastructure which requires periodic inspections or surveys. Furthermore, sonar is an efficient means for search and recovery operations when something is lost underwater.

Where Have We Applied This Solution?

The first project was completed in July 2011. A survey was conducted for a new river outlet works intake structure at Cutter Dam in New Mexico. The sonar was used to measure sediment accumulation and to confirm the existing intake structure was in good condition and that no debris had accumulated on the trash racks. A sample report is available upon request.

Contact Information

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Bubbler Line Survey to Identify Damaged Sections and Missing Anchors, Babine Lake, BC

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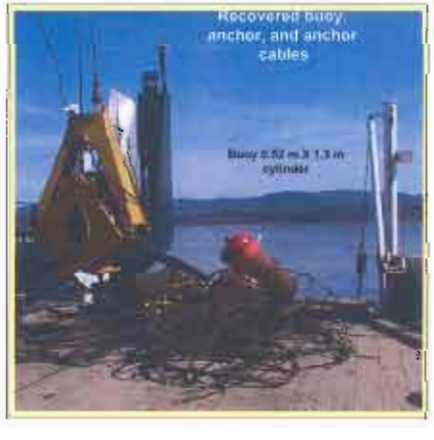
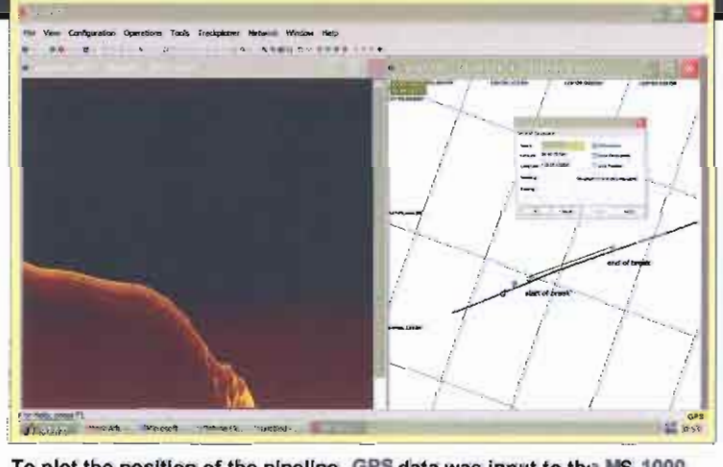


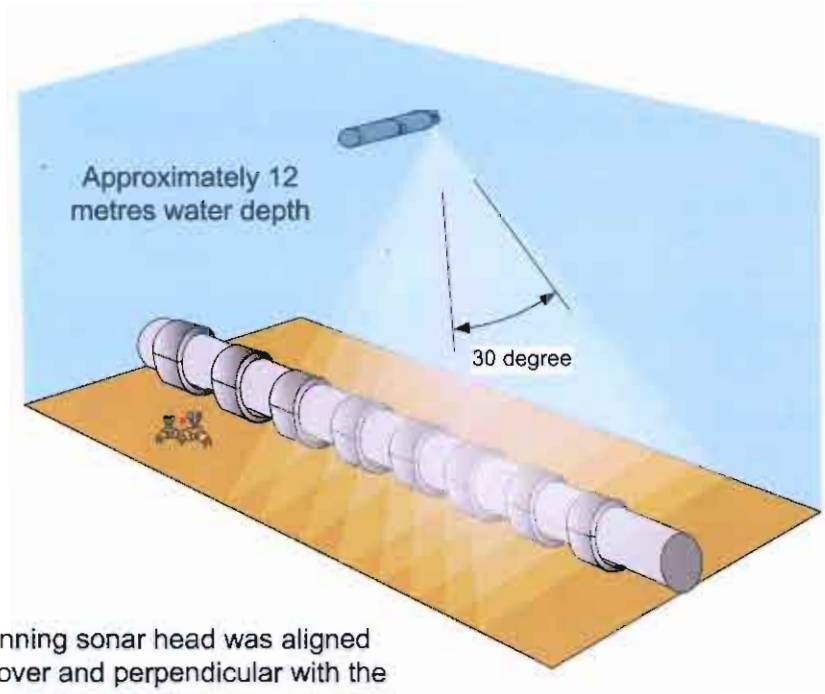


To plot the position of the pipeline, GPS data was input to the MS 1000 *TRACKPLOTTER* software module; both the sonar and navigation windows were displayed and used to view the condition of the bubbler line, and mark the geographic coordinates of damaged pipeline sections.

To keep ice from forming in the winter (permitting year-round ferry service from one side of the lake to the other) a submerged bubbler line was installed between 30 – 40 metres below the surface of Babine Lake, BC, Canada. Knowing that a section of the line was damaged, the Customer asked that a survey be completed to locate the damage and other potential areas of missing anchors and/or buoys.

A 200 kHz altimeter (10° x 10° beam) and a 675 kHz (0.9° x 30° fan beam) high resolution scanning sonar head were used to profile the lakebed and identify the bubbler line. The scanning sonar head was mounted such that the wide axis of the fan beam was perpendicular to the direction of the vessel. This allowed the line and buoys to be visible even when the boat was slightly off the alignment of the bubbler.

HIGH RESOLUTION SCANNING SONAR USED TO DETAIL PIPELINE AND CHECK CONDITION OF CONCRETE SADDLE WEIGHTS



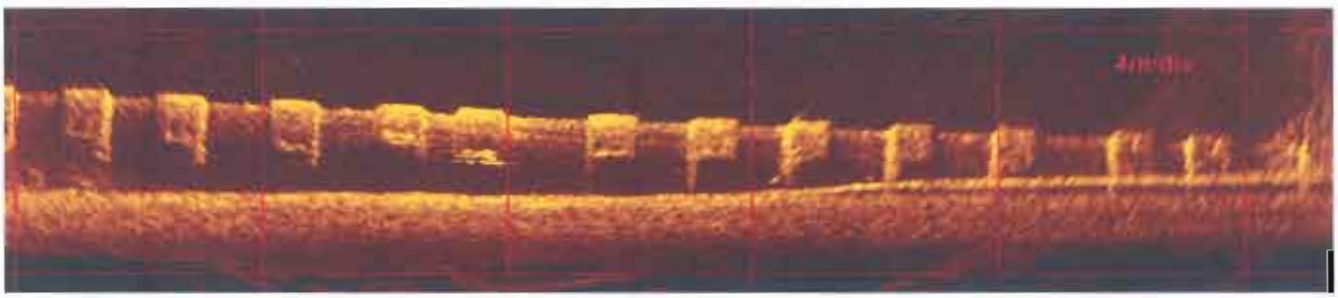
The scanning sonar head was aligned directly over and perpendicular with the pipe so that the scan geometry was maintained as shown.

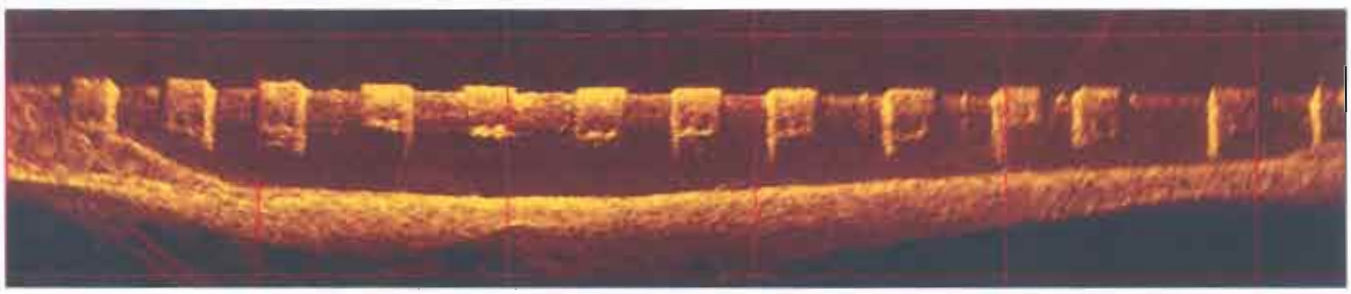
Sonar Requirements

- MS 1000 PC-based Sonar Program and computer
- High Resolution, 675 kHz sonar head with Fan transducer
- Deployment cable
- Over-the-side mount

Additional Equipment

- DGPS
- 3-axis sensor
- Compass





Images courtesy ***Peter Diving, Russia***

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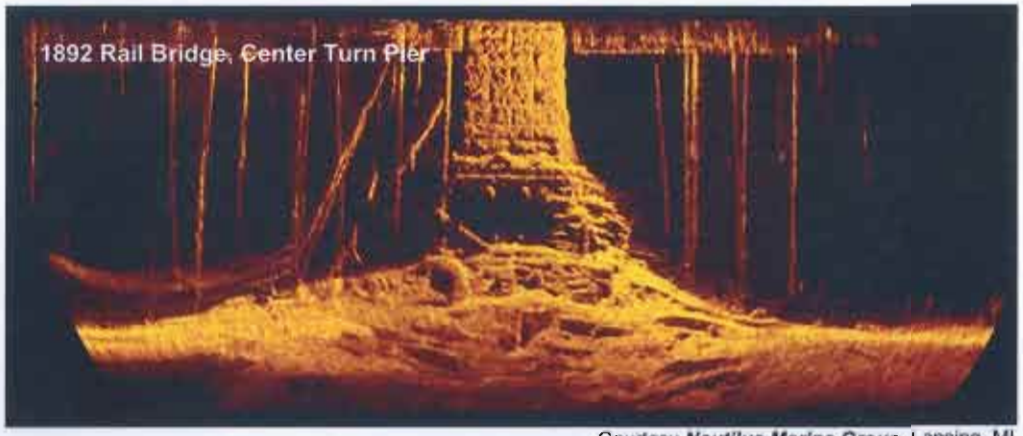
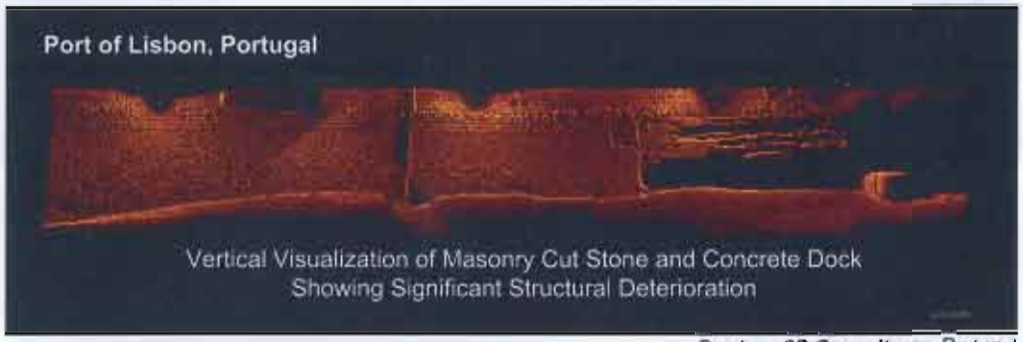
Scanning Sonar Used to Identify Scour, and Structural Deterioration of Bridge Piers and Docks

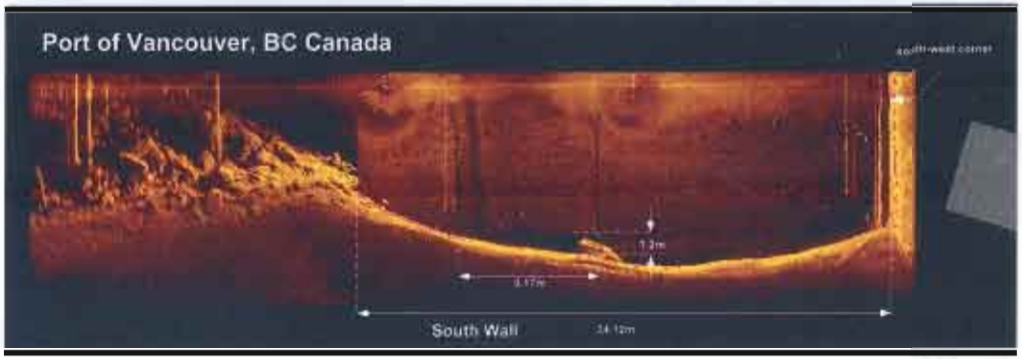
Courtesy ***Peter Diving***, Russia



Courtesy ***Nautilus Marine Group***, Lansing, MI



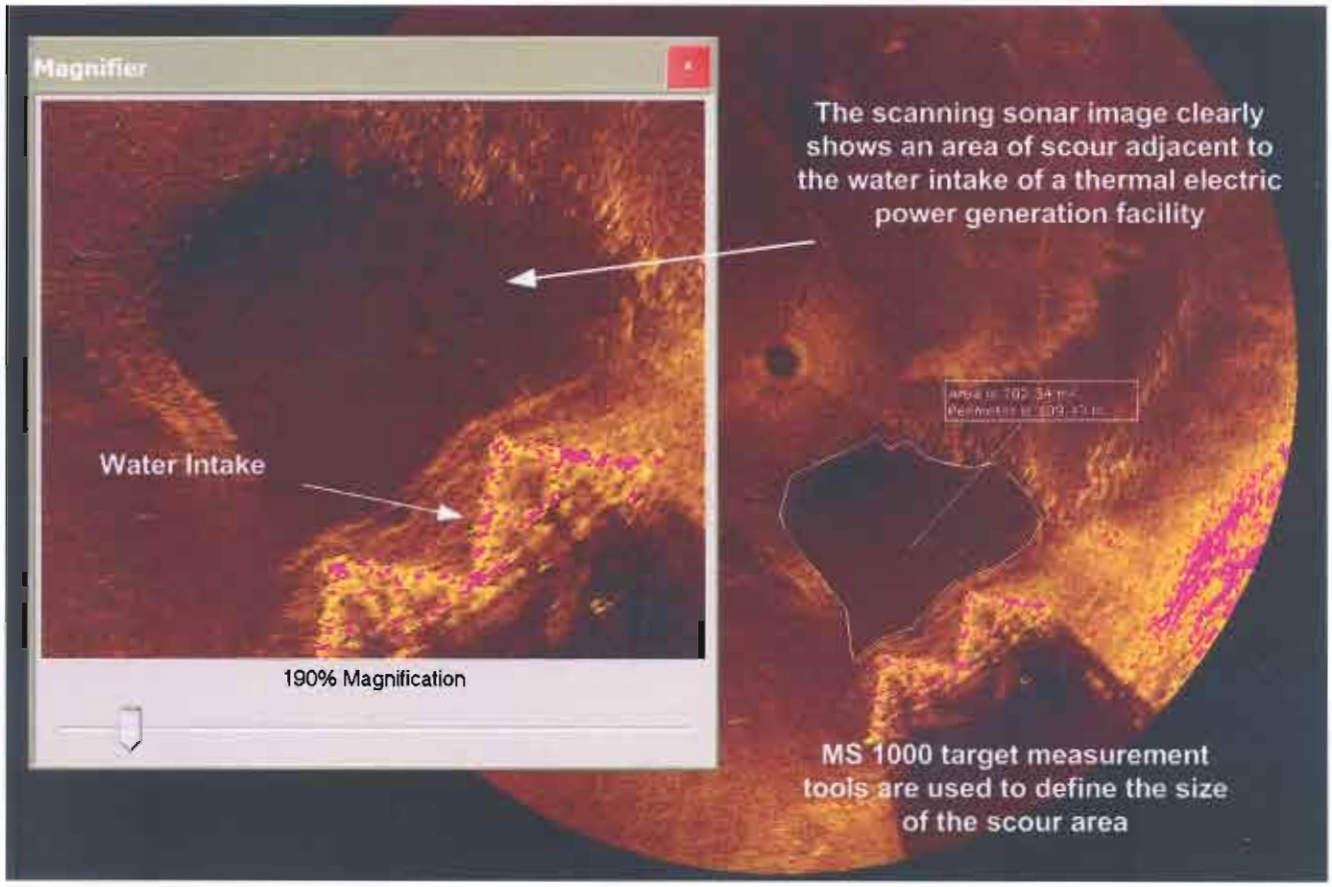
Courtesy ***3P-Consultores***, Portugal



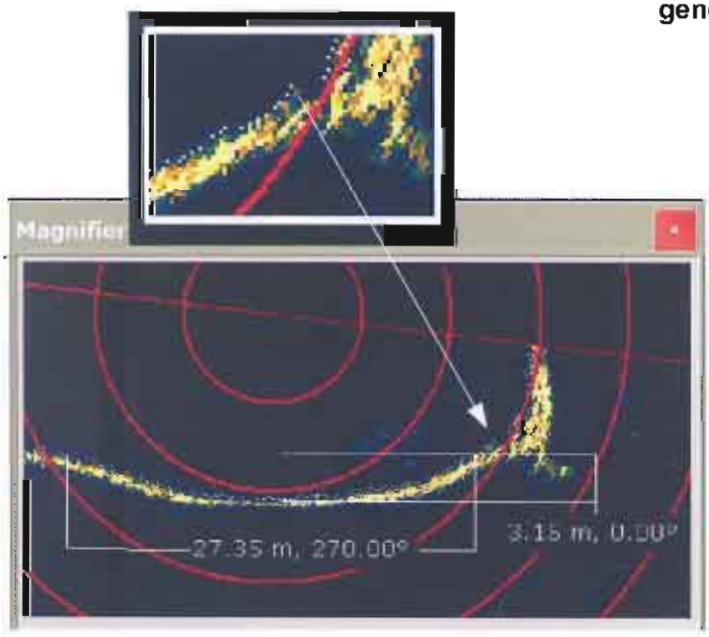
Data Collection by ***Kongsberg Mesotech Ltd.***, Port Coquitlam, BC, Canada

Data Collected Using MS 1000 and 675 kHz High Resolution Scanning Sonar Head with 30 Degree Fan Beam Transducer

Scanning Sonar Utilized for Scour Survey



Imaging data defines the area where acoustic profiles must be generated to ensure adequate coverage



Profiling Data

Profile points are generated from the first acoustic return. These are output in both proprietary, and XYZ formats along with all data from attached sensors to be modeled using a 3-D terrain mapping program

Sonar Equipment Requirements:

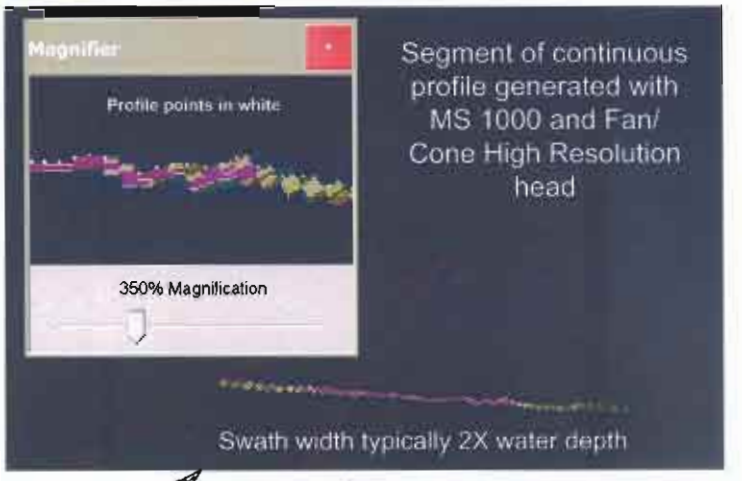
- MS 1000 PC-based Sonar Program and computer
- High Resolution, 675 kHz sonar head with Fan/Cone transducer
- Deployment cable and tripod
- Over-the-side mount when head is used in profiler mode

Additional Equipment

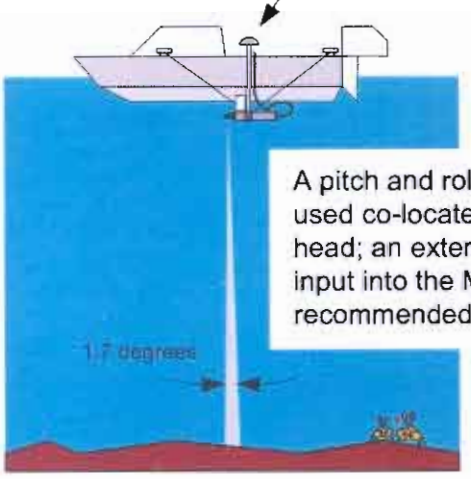
- DGPS
- 3-axis sensor
- Compass
- 3-D terrain modeling program

Scanning Sonar for Z-Swath Profile Coverage

Profile points are time-tagged recorded with position, compass and pitch and roll sensor data, and then postprocessed into an X,Y,Z file using KML's, ***BathyXYZ*** software module

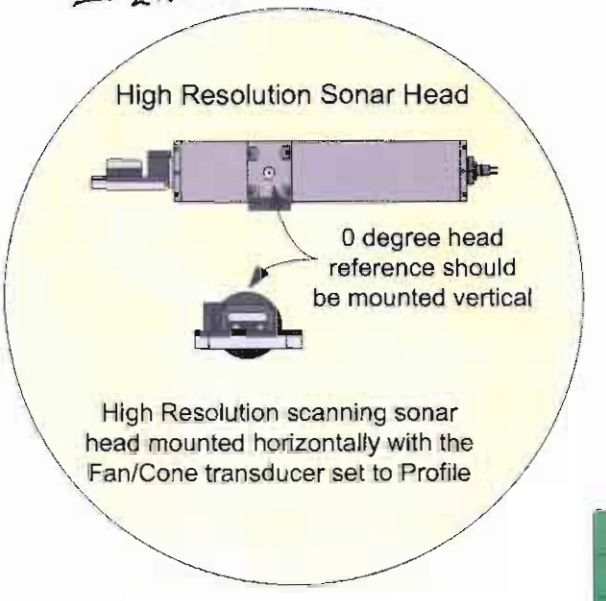


Mount RTKGPS receiver directly above the sonar transducer

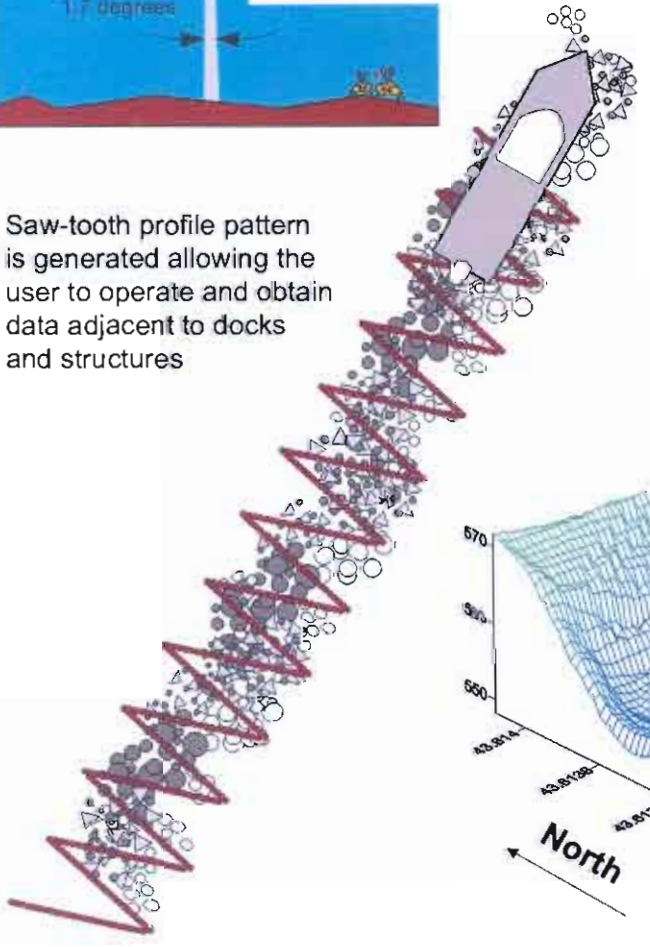


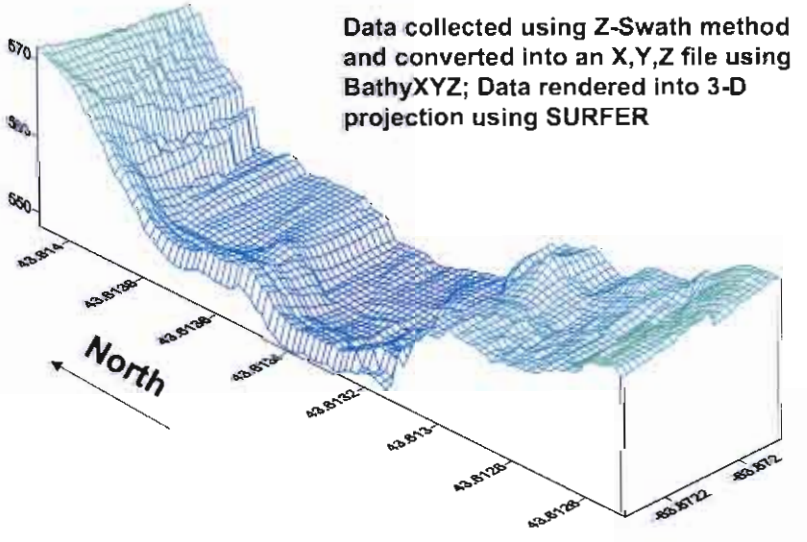
A pitch and roll sensor must be used co-located with the sonar head; an external compass input into the MS 1000 is recommended

2X DEPTH



Saw-tooth profile pattern is generated allowing the user to operate and obtain data adjacent to docks and structures





Data collected using Z-Swath method and converted into an X,Y,Z file using BathyXYZ; Data rendered into 3-D projection using SURFER

Data courtesy: ***Nautilus Marine Group***

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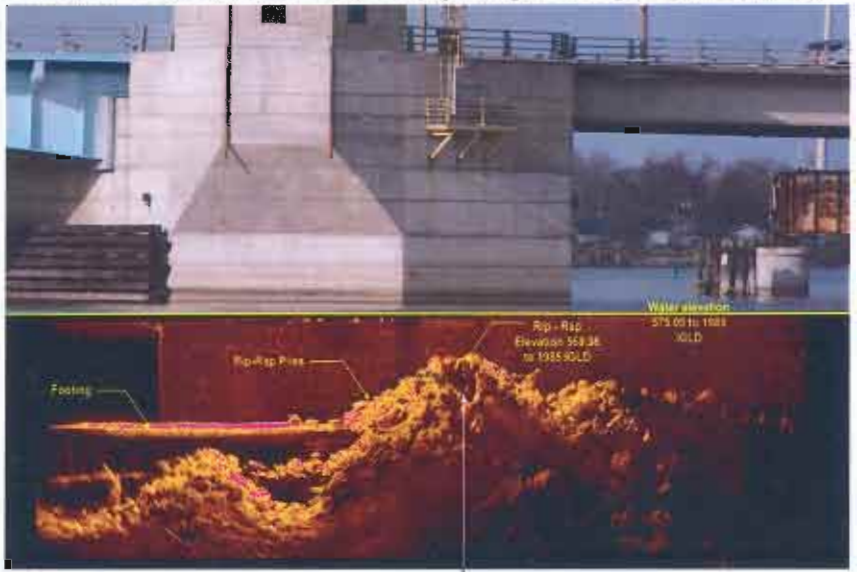
QA of RIP-RAP Placement Using Scanning Sonar

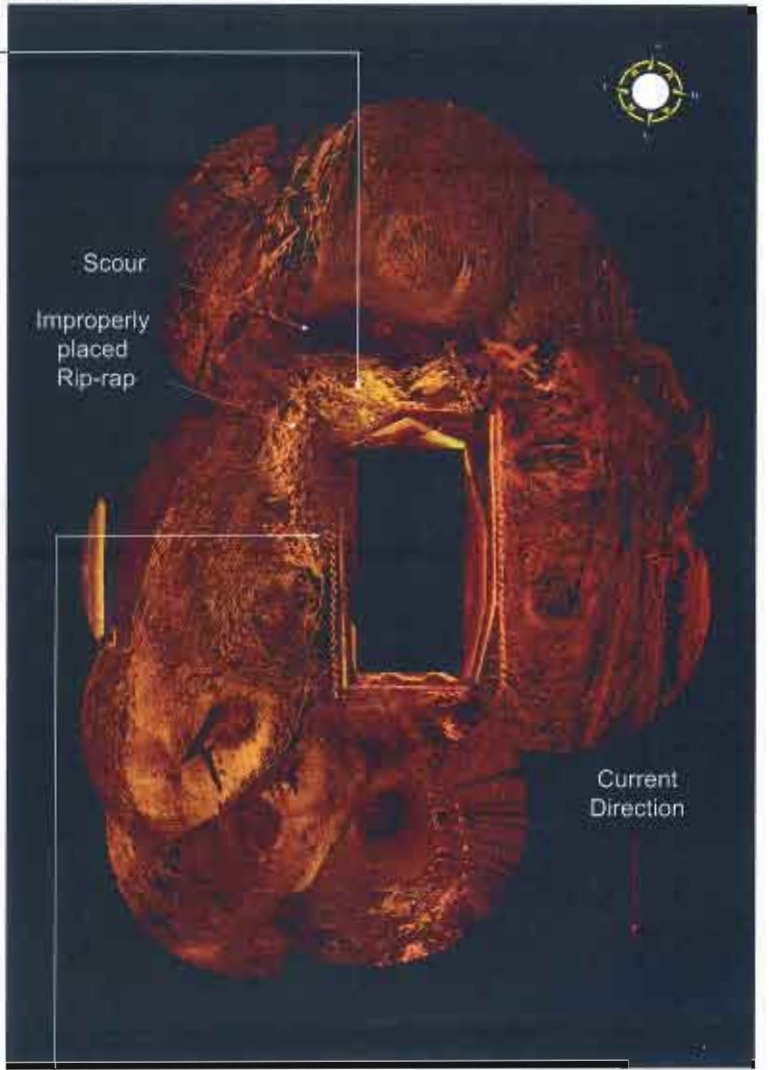
Data collection: ***Nautilus Marine Group*** (Lansing, Michigan) & ***Kongsberg Mesotech Ltd.***



Vertical Visualization Upstream View of Pier Bullnose

Vertical Visualization East Side View of Pier

Bridge Pier Plan View and River bed Mosaic



Improper placement of rip-rap increases the potential for further scour.

Rip-Rap Countermeasures was designed for 100-year flood event and to be placed no higher than top of footing elevation, and at a 1 to 3 slope out from footing.

DEBRIS DETECTION ADJACENT to DOCK AND WATER INTAKES