New frontiers in ocean mapping

G. Costello[1], B.D. Loncarevic[2] and L. Meyer[3]
[1]*Canadian Hydrographic Service, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2, Canada*
[2]*Atlantic Geoscience Centre, Geological Survey of Canada, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2, Canada*
[3]*Ocean Mapping Group, University of New Brunswick, Fredericton, New Brunswick E3B 5A3, Canada*

Requirements for better information about the seafloor, due to the intensified use of the oceans and their increasing strategic importance, have resulted in renewed interest in high resolution ocean mapping. Our ability to respond to these demands has been made possible by the convergence of a number of technological advances: (1) accurate positioning using satellites; (2) complete bottom coverage and high resolution using multibeam sounders; (3) increased power of shipboard computing; and (4) advances in digital data processing and image presentation.

In 1992, as part of the ongoing CHS/AGC ocean mapping program, a multiparameter survey employing these new technologies on board the CSS Matthew was conducted on the inner Scotian Shelf just south of Halifax. The data collected included bathymetry (100% coverage), pseudo imagery, magnetics and gravity. During 2 months with 31 days

of data collection an area of 1000 km^2 was covered, including 11 400 km of bathymetry, 10 600 km of magnetics and 8020 km of gravity data.

Differential GPS (DGPS) positioning was used, providing 10 m accuracy; a shore based station transmitted in real time differential corrections to the ship's GPS receiver. The Simrad EM100 multibeam sounder provided 100% bottom coverage and pseudo imagery of the sea floor. The bottom coverage is 1.7 times water depth across track (80° angle), with 32 narrow beams, each about 2.5°. It operates at 95 Khz and has a depth range from 10 to 600 m. Spatial resolution (footprint of a single beam) is a function of depth; for this survey it averaged about 5 m.

Depths in the work area ranged from 50 to 200 m. Survey lines were planned to achieve at least 10% sidelap between adjacent lines, resulting in 100 m line spacing for the whole area and then interlining to 50 m in the shallower areas. Checklines, spaced at 4 km were run orthogonal to the regular lines and were used to determine the consistency of the data. A calibration procedure called a "Patch Test" was completed at regular intervals to detect and correct misalignment errors between the various sensors (transducer, motion sensor and GPS). The ship's motion (heave, roll, pitch and gyro) were continuously measured and these corrections were applied to the EM100 data. Sound velocity profiles were collected regularly and used to correct the data for speed of sound and refraction. The sounder ping rate varies with depth, but averaged about every 0.75 seconds. This meant about 2 Mb of raw data per hour; about 40 Mb per day; and about 1.2 Gb for the whole survey or about 100 million soundings. This raw data expands about ten times during processing.

During processing the raw data are corrected for sensor offsets (translations and rotations) and tides and then "cleaned". During cleaning within the HIPS processing package erroneous navigation and depth data are flagged using automatic and interactive software tools. The data set is then ready for further visualization and image presentation or for loading into a database. There are several software packages available that accept XYZ data points, then grid or bin the data and generate two- or three-dimensional images enhanced with colour or grey shading and illumination algorithms. By varying these parameters we can generate any number of images for interpretation that enhance particular features of the data set.

Presently, accurate measurement of the ship's motion, especially roll, is the limiting factor in realizing the full accuracy potential of these multibeam sounders.

CSS Matthew is a small ship and thus not ideal for gravity measurements in the open ocean since considerable vessel accelerations are produced in even moderate seas (State 3 and 4). The close line spacing on this survey allowed for considerable redundancy so that the disturbed portions of the records could be deleted and still maintain reasonable coverage. Frequent returns to the home port allowed good harbour calibrations. Ship acceleration may not be the only limitation on the quality and accuracy of gravity data. We have noticed correlation between crossover discrepancies on adjacent tracks which may indicate a vertical acceleration due to long period internal waves.

Special attention was paid to the magnetic measurements with the objective of a survey accuracy of 2 to 3 nT, an order of magnitude improvement over the previous practice. This is achievable by carefully monitoring and correcting for temporal changes of the magnetic field (diurnal variation and other disturbances), the position of the towed sensor relative to the fix reference position on the ship, depth of the sensor as a function of the speed, etc. Preliminary data processing has shown that by applying the above corrections, the RMS crossover error can be reduced to a half (from 21 nT to 12 nT).

The application of new technologies is a part of a larger initiative involving the private sector along with government and university labs. The goal of these strategic alliances is to achieve common objectives and develop competitive products that position Canada at the forefront of ocean mapping technology internationally while responding to domestic needs.