Joint Canada -U.S. Mapping Cruise

in support of extending territorial claim under the United Nations Convention on the Law of the Sea

Canadian Scotian Shelf

(US boundary to Laurentian Fan)

HDC Project Number 2901486

Final Field Report #2600352

August 15 - September 10, 2012

R/V *Atlantis*

Cruise Number: AT22-01

Hydrographer-in-Charge:

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Under international law, as reflected in the Convention on the Law of the Sea, every coastal State [country] automatically has a continental shelf out to 200 nautical miles (nm) from its coastal baselines, or out to a maritime boundary with another coastal State. However, a coastal State may define a continental shelf beyond 200 nm (called an extended continental shelf), if it meets the criteria outlined in Article 76 of the Convention. The process required the collection and analysis of data that documents the natural prolongation of the continental landmass beyond 200 nm as determined by the formulae and limit lines in Article 76.

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ACRONYMS

BOS	Base of Slope (deemed to be where maximum slope change will be found)
CHS	Canadian Hydrographic Service (within DFO)
CTD	Conductivity, Temperature, Depth (Profile Measurement)
CCOM/JHC	Center for Coastal and Ocean Mapping/Joint Hydrographic Center (U.S.)
JD	Julian Day Number
DFO	Department of Fisheries and Oceans (Canada)
FM	Frequency Modulated
FOS	Foot of Slope (max change in slope)
HDCS	Hydrographic Data Cleaning System (CARIS data format)
HIC	Hydrographer-in-Charge
HWS/PU	Hydrographic WorkStation / ProcessingUnit
MAC	Multibeam Advisory Committee (UNOLS)
NOAA	National Oceanic and Atmospheric Administration (U.S.)
NRCan	National Resources Canada (Federal Department)
OCS	Office of Coast Survey (NOAA- U.S.)
QC	Quality Control
SSSG	Shipboard Scientific Services Group (WHOI)
SSP	Sound Speed Profile
SSS	Surface Sound Speed
SIS	Seafloor Information System (Kongsberg MultiBeam software)
TRU	Transceiver Unit (Kongsberg)
TSG	Thermosalinograph
UDP	User Datagram Protocol
UTC	Coordinated Universal Time (formerly GMT)
UNCLOS	United Nations Convention on the Law of the Sea
UNOLS	University-National Oceanographic Laboratory System (U.S.)
WHOI	Woods Hole Oceanographic Institution
XBT	Expendable Bathy Thermosaliograph

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CHS Project numbers:-

HDC project number for **AT22-01** *"Atlantis"*	2901486 (Scotian Shelf)
RAWDAT	2702351
PRODAT	2702352
PREDAT	2702353
VALSRC	2400302
FLDNOT	2200447
Final Field Report	2600352

Final data submission includes raw data, processed data, metadata and a CUBE surface at 100m resolution. These data were submitted to the UNCLOS project on 5 Dec 2012.

Projection/ Datum : WGS84 UTM Zone 20 and Zero tide applied

BACKGROUND

The purpose of the Canada-U.S. UNCLOS Joint Mapping Cruise was to better define the foot of the slope (FOS) of the Continental Shelf in the North Atlantic Ocean, north of the U.S.-Canada Border. The cruise was conducted aboard WHOI vessel *R/V Atlantis* from August 15 to September 10, 2012; out of Woods Hole, Massachusetts. The onboard science party was comprised of five Canadian hydrographers, two Canadian geologists, and one U.S. hydrographer.
Staffing aside, the joint aspect of the survey involved Canada providing operational funds and USA providing the platform. All data acquired will be shared. The *Atlantis* was available for this project as the upgrade of the manned submersible Alvin (increased depth capability from 4500m to 6500m) had come up against a number of scheduling delays. Therefore, the bad news for the Alvin team and research scientists turned out to be a wonderful opportunity for us Canadians!

This report describes how the cruise was conducted and the data was acquired. It is intended as a cruise report and specifically excludes final data processing, analysis, and results.

Figure 1 ***R/V ATLANTIS*** **alongside at Woods Hole, Mass.**

R/V ATLANTIS SPECIFICATIONS

Built: 1997
Length: 274 feet
Draft: 19 feet (5.8 m)
Displacement: 3,510 LT
Range: 17,280 NM
Laboratories: 3,517 sq. feet
Speeds: 11.0 knots cruising
***Alvin* Conversion:** 1997
Beam: 52.5 feet
Gross Tons: 3,200 T

Complement:
- Crew - 22
- Scientists - 24
- DSOG – 12 (to operate "*Alvin*")
- SSSG Techs – 2

Endurance: 60 days
Fuel Capacity: 267,540 gallons
Propulsion: Diesel-electric, azimuthing stern thrusters
Bow Thruster: Azimuthing jet 1,180 SHP
Ship Service Generators: Three 715 kw 600 VAC
Portable Van Space: At least six 20 ft. vans
Winches:
- Traction - 30,000' .68" EM or 9/16" wire
- Hydro - 33,000' 3-cond. EM or 1/4" wire

Heavy Equipment:
- Cranes - two @ 42,000 lbs. cap.
- HIAB cranes (2)
- Midships hydro boom

Sewage System: Envirovac flushing system
Ownership: Title held by U.S. Navy; operated under charter agreement with Office of Naval Research
Other Features: Dynamic positioning system, ROV and submersible hangars, fully equipped machine shop, two rigid-hull inflatable rescue/work boats

SENSORS & DATA ACQUISITION

Data from a 12 kHz multibeam echosounder, a 3.5 kHz sub-bottom profiler, a magnetometer, and a gravimeter were continuously acquired from August 16, 2012 (JD 229) to September 9, 2012 (JD 253), with intermittent periods of down time for vessel turns, two full depth CTD casts, and equipment maintenance and repair. The following describes these primary sensors and how they were used aboard *Atlantis* during this cruise, including what is known about corrective and ancillary data.

Naviagtion Sensor input

CNav GPS

The ship's CNav GPS antenna is mounted on the port side of the flying bridge and was used as the sole positioning source. All positions were recorded in WGS84. Little additional information was available about the unit, but the output positions appeared to be very consistent and were never a problem.

Figure 2 Looking forward to bridge area from aft deck. CNav antenna (leftmost one on flying bridge)

IXSEA PHINS Integrated Inertial Motion Sensor

Atlantis has two IXSEA PHINS inertial motion sensors, one for the SSSG systems (Science use) and one for vessel navigation and *Alvin* operations. The SSSG PHINS was solely used to correct data acquired during this cruise and is mounted in similar fashion to the ship's PHINS. Position data were provided to PHINS from the CNav, with the offsets to the CNav antenna entered in the PHINS software. Additionally, angular offsets to align the PHINS IMU with the ship's reference frame had been entered in the PHINS software when system was initially calibrated.

An offset and wiring diagram of the PHINS and Kongsberg EM122 integration aboard *Atlantis* is attached to this report.

Figure 3 IXSEA PHINS inertial motion sensors

Seabird CTD

Two deep-ocean CTD casts were conducted with the ship's rosette: one at the beginning of the cruise on August 17, 2012 (JD230) and one at the end of the cruise on September 8, 2010 (JD 252), a t nearly the same location. All of the Seabird oceanographic sensors recorded data during the casts and are available in the final data submission. The primary sensors for conductivity, temperature, and pressure were used for computing the sound speed profiles that was used for comparison with the "SVP Editor" generated SSPs. The salinity profile was also compared to that of the 2009 WOA salinity profile for the CTD location.

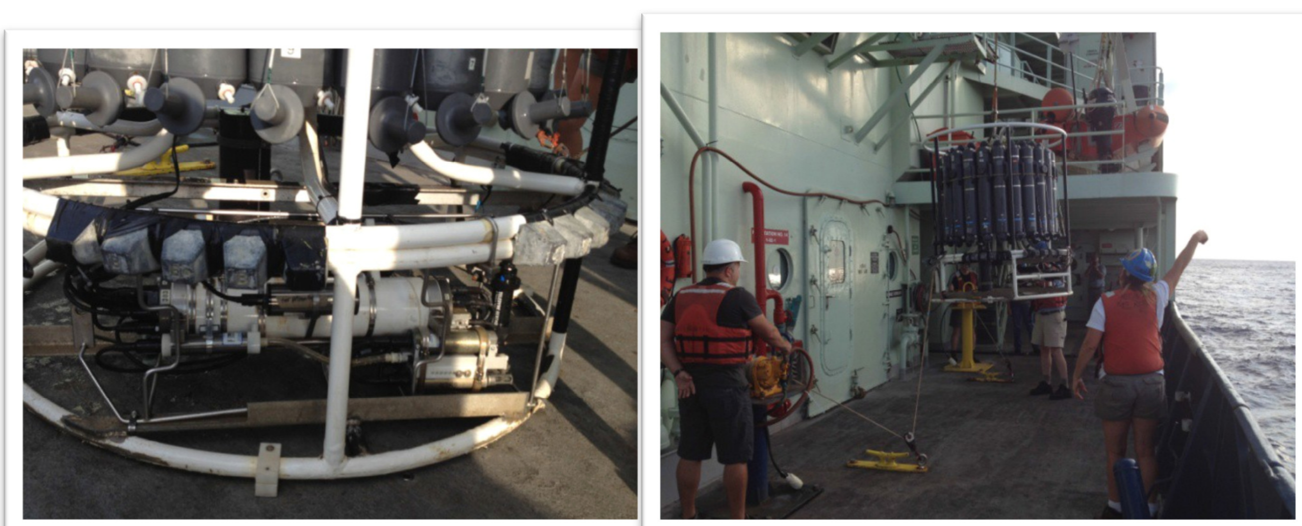


Figure 4 CTD rosette being recovered

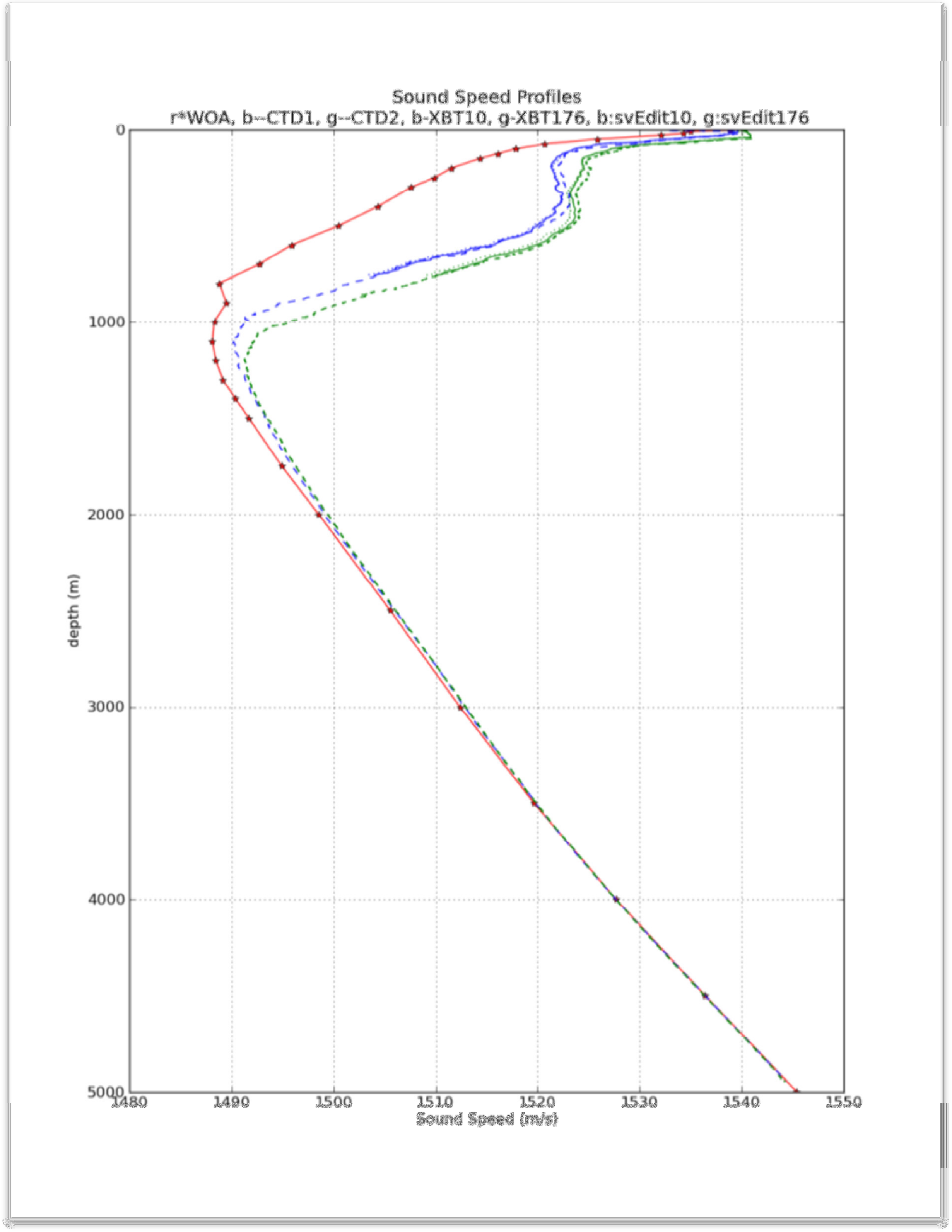


Figure 5 Plot showing the tow full depth CTD casts as well as the "Deep Blue" XBT casts made at the same time. The two casts were made at the start and end of the survey in very close proximity to each other. The red line is generated from the World Ocean Atlas.

EM122 Multibeam Echo Sounder (12 KHz)

Hardware Integration

The Kongsberg EM122 MBES components consist of separate flat transmit and receive arrays mounted in a Mills cross configuration in a gondola extended from the hull and slightly forward of the center of rotation of *Atlantis*. The system was installed aboard the *Atlantis* in 2010 and has not been used as the primary sensor for a Multibeam survey before. That is why Peter Lemmond volunteered to participate on this survey; he was very interested in seeing the system fully utilized as the primary sensor. The author is most grateful for his participation and input while the survey was ongoing. The EM122 has serial number 118 and its capability includes dual swath mode which was utilized throughout AT22-01.

The draft of the *Atlantis* was deemed to be 5.27 meters for the duration of the survey.

The system's Transceiver Unit (TRU) was installed in the Main Survey Lab on the main deck and a Hydrographic Work Station (HWS) with the Seafloor Information System (SIS) software was located across the companionway in the ship's Computer Lab on port side of the main deck. All watches were carried out in the Computer Lab and the three data processing computers (running CARIS HIPS software) were deployed in the Main Survey Lab (starboard side).

Figure 6 EM122 Transceiver Unit (TRU) in Main Lab area. Note extensive cabling coming through deck from Transducers.

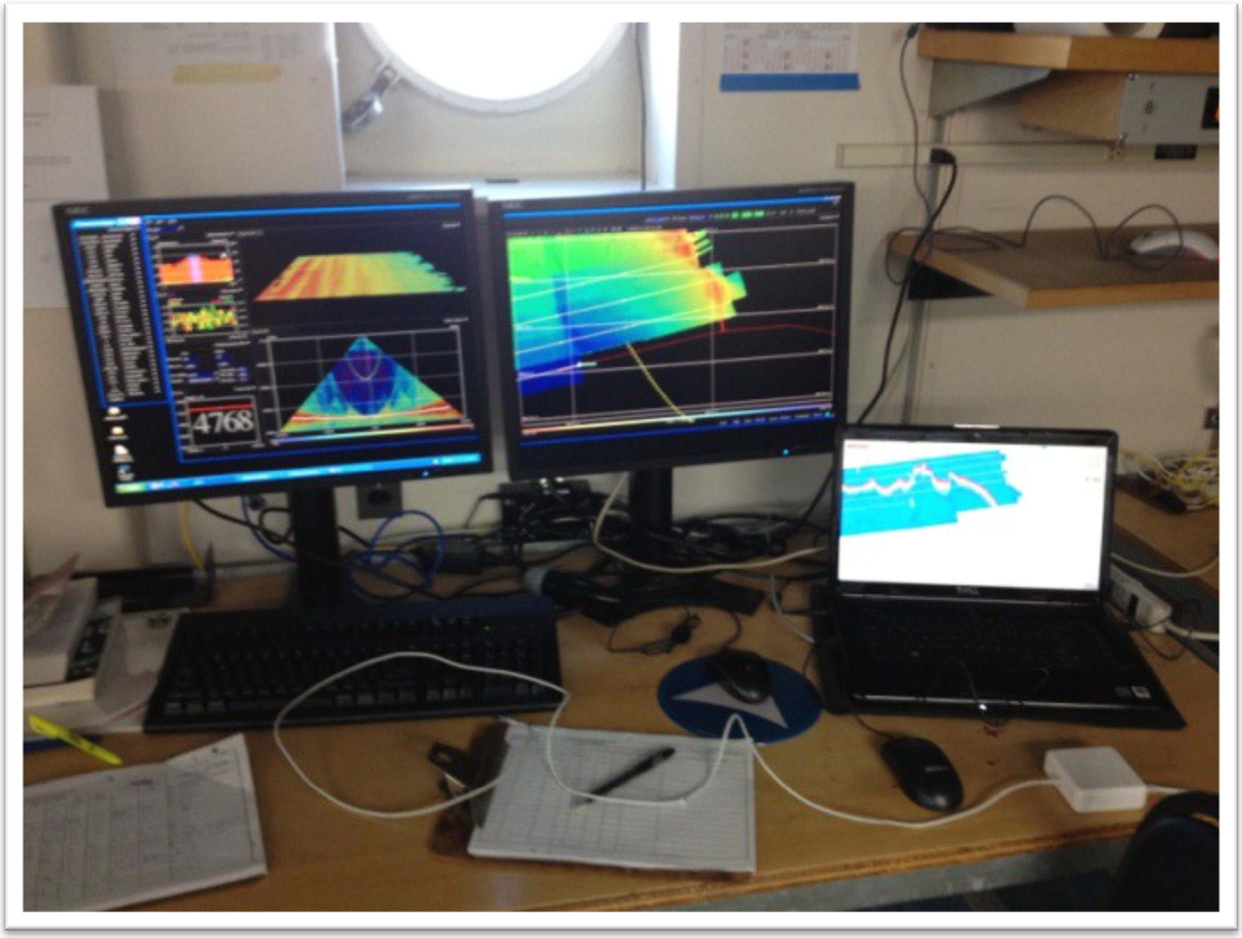


Figure 7 HWS logging station with SIS Displayed. Note laptop with OLEX display on the right.

Vessel heading, heave, pitch, and roll data were provided to the EM122 TRU via a serial connection from a XYSEA PHINS integrated motion sensor located in a store room aft of the laundry room on the #3 deck (below main deck, also referred to as the “tank top”). Vessel position and GPS UTC time were provided to the EM122 TRU via serial connection from a CNav satellite-corrected GPS mounted on the port side of the ship’s flying bridge. Real time surface sound speed data were provided to the EM122 TRU via a serial connection from a Seabird TSG installed near a seawater intake on the starboard side near the bow thruster. Vessel attitude velocities were provided to the EM122 TRU via UDP Ethernet from the PHINS for use in FM mode. Offset and integration diagrams of how these systems were understood to be integrated for the acquisition of these data are included in this report.

SVP Editor and SSP Data

The SVP Editor software (downloaded from the UNOLS MAC website) was installed on the HWS/PU while alongside Woods Hole, MA. During MBES acquisition XBT casts were imported into SVP Editor and recalculated using the 2009 WOA database salinity profiles, appended with the surface sound speed from the TSG and then extended with 2009 WOA database sound speed profiles to 12,000 meters. The profile was then sent to SIS for real-time ray tracing along with associated SVP Editor-created CTD profiles for real-time backscatter corrections. This software (written by Dr. Jonathan Beaudoin of UNH) proved to be invaluable and was a vast improvement over what the ship had been using prior to this survey. Lt Briana Welton’s familiarity with the software made our acceptance and use on the package virtually seamless.

When the software sent an updated SSP to the mutibeam sounder a new survey line was automatically started within SIS. The frequency of casts was a minimum of once every four hours (when each new watch-keeper started their shift) or as often as the watch-keepers deemed one might be required. They were given complete discretion to make a cast whenever there was any concern as to the validity of the SSP being used. There was an ample supply of Sippican “Deep Blue” XBT’s aboard, so no restrictions were made as to their use.

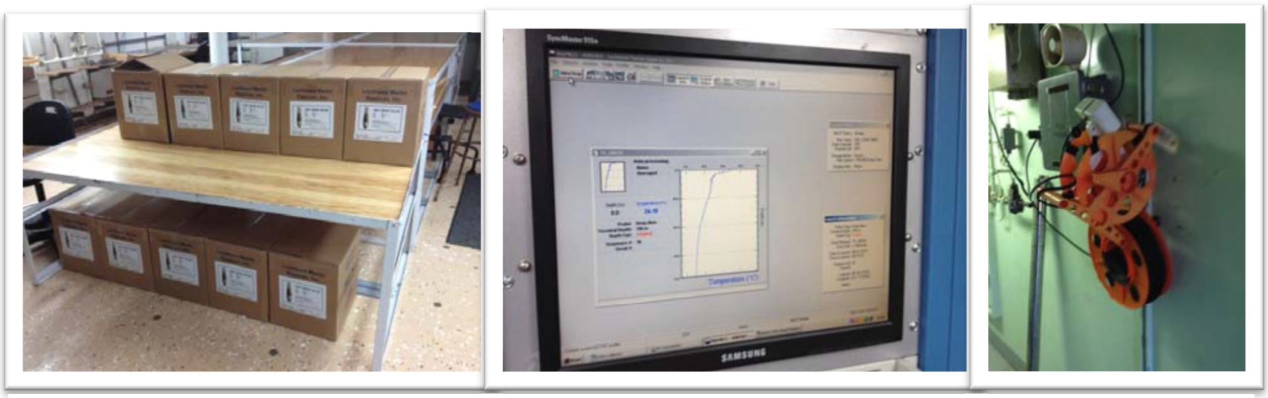


Figure 8 Figure 2 (L to R) Part of the supply of “Deep Blue” XBTs at start of cruise, Screen Grab of a cast to 760 meters and the portable XBT launching system stored in the ROV bay.

Knudsen Sub-bottom Profiler (3.5 kHz)

The Knudsen sub-bottom profiler consists of a multi-frequency single beam transducer mounted in the ship’s sonar pod and is controlled by a topside processing unit. Position data from the CNav were integrated with Sounder Suite EchoControl Version 1.73, which was also used for real time monitoring and logging of .**keb**, .**kea**, and high and low frequency .**sgy** raw data files. The profiler was operated with the HF channel off, LF channel on, a fixed gain of 255, TVG on, processing gain one, TX Blank of 10 m, sensitivity off, a power setting of 4, and a pulse length of 24 ms. The phase range and max limits were adjusted as necessary according to seafloor depth. New files were manually started approximately every two hours. The time source for the data files was the computer time which was set to sync daily with the ship’s time server. However, computer clock drift of 4-5 seconds over a 24-hour period was noted early in the cruise, so the computer time was manually synced approximately every two hours by the data acquisition watch.

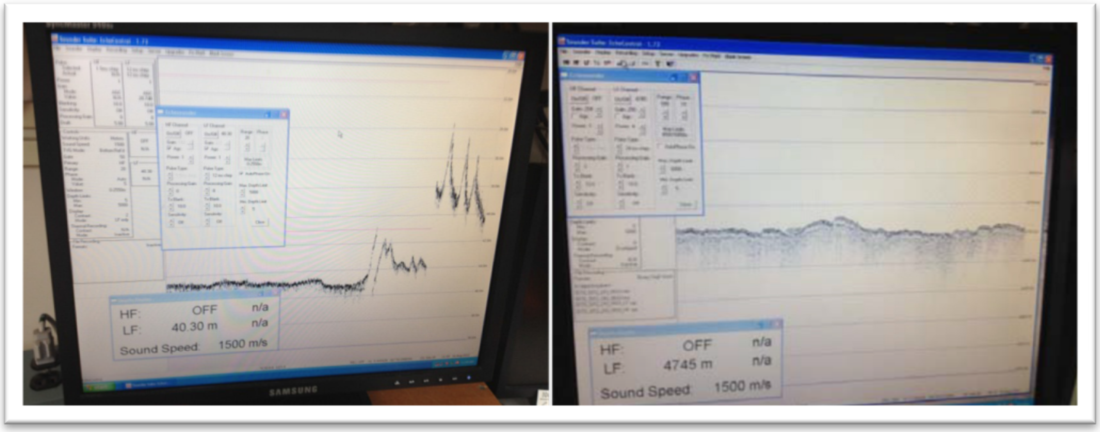


Figure 9 Two sample screen grabs from 3.5KHz sub-bottom sounder

Lockheed Martin Sippican XBT System

Twenty dozen (244) 760-meter Sippican “Deep Blue” XBT probes were acquired by the CHS for this cruise. XBT casts were conducted at least every four hours or more frequently when the SSS deviated from the previous SSP by more than 3 m/s.

On August 17 (JD230), a single 2000-meter-deep XBT cast (probe provided by SSGS staff) was conducted as well as a 760 meter Deep Blue” cast. These were deployed just after the full depth CTD cast (to 4959 meters). The four hours to complete the CTD cast was allocated so that we would have as complete a set of data as possible for comparison purposes. It was also important to confirm that the new XBT processing software (from UNH) was providing suitable SSPs. The comparison of the acquired casts and the one generated for MB use by the “new to us software” was entirely satisfactory, and a great relief to the HIC.

The raw Sippican **.rdf** files were processed in Sippican’s WinMK21 software into **.edf** files for import into “SVP Editor” for further manipulation. A total of 181 XBT casts were conducted during the cruise.

Seaspy Magnetometer

The Seaspy magnetometer was brought aboard *Atlantis* especially for this cruise, and was deployed after the first full depth CTD cast on August 17, 2012 (JD 230). The "mag" was deployed while the ship was doing approximately 1.5 knots and we immediately carried out a series of figure "8" turns with 45degrees/minute wheel to calibrate the system on crossover. System was operating properly and the results of calibration were satisfactory. The tow body is neutrally buoyant and was towed astern of the ship with 340 meters of cable deployed for the majority of the cruise. The data were monitored and recorded using Sealink software version 8.00022 and logged in the form of **.xyz** and **.mag** files that were manually incremented at the start of each Julian Day. Position and time were provided by the CNav.

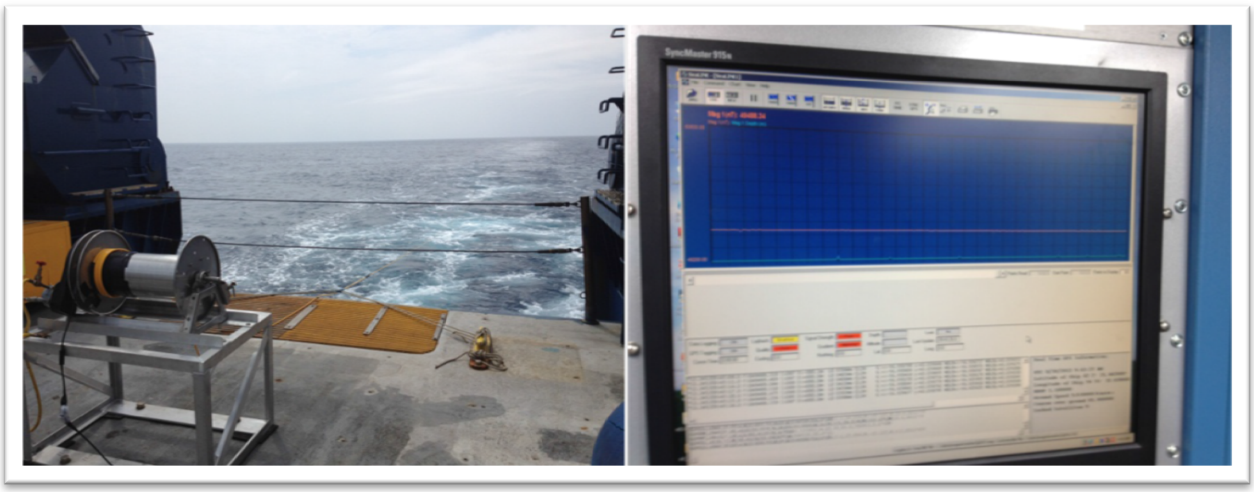


Figure 10 Magnetometer steamed from stern and Display/Logging screen

Occasional sync errors were noted with a restart of the logging software required to reinitialize the software. This resulted in several interruptions to data logging. The tow fish was recovered at 23:30 on September 5, 2012 (JD 249) due to data becoming erratic. It was not redeployed as the cable had been damaged due to a very significant amount of twisting. A slip-ring where the cable attaches to the fish would significantly decrease the chance of this happening again. Although the WHOI scientists & technicians consulted prior to the cruise had indicated that twisting of the magnetometer cable was not a problem they had encountered before, this problem was entirely consistent with Dr. Calvin Campbell's extensive experience with deploying this make & model of sensor. See Appendix A for specific photos of damage.

Gravimeter

The WHOI/UNOLS PG #1 Gravimeter was taken off WHOI *R/V Knorr* and installed in the Computer Room of *Atlantis* for this cruise. Little is known about the system, but raw data from the system was logged in the form of **.GEF** and **.SDE** files, which automatically incremented hourly. Position and time were provided by the CNav. Three red/green indicator lights were checked by the data acquisition watch every half hour during the cruise. The SSSG Techs also performed additional checks daily. The system appeared to work flawlessly with the red lights (indicators of a problem), not once being evident. See Appendix B for logged data format.

Figure 11 Gravimeter installed in Main Computer Lab (aft and close to amidships)

Ancillary Ship Data

Ancillary ship data from the numerous oceanographic and meteorological sensors aboard *Atlantis* were recorded as part of the ship's standard observation program and so were also copied and archived with the primary raw data files described above. These data sets are also archived with the final data submission to the UNCLOS program, was well as being archived by WHOI technicians at the Wood Hole Institute.

This data (and the associated MetaData) logged during AT22-01 cruise, is listed below, it is extensive and will not be fully described in this report.

- ADCP,
- Atmospheric Data; including air temp, barometric pressure (from three different sensors)
- Lat & Long (decimal degrees),
- Nadir depth from EM122,
- Nadir depth from 3.5KHz sounder,
- NEMA GRRMC data from raw to processed from shipboard distribution,
- Humidity & Relative Humidity
- Shortwave Radiation
- True Wind speed and direction
- Relative wind speed and direction
- Ships Heading & speed
- Rain Accumulation
- Rain Intensity
- Sea Surface Temperature
- Sea Surface Fluorometer

Figure 12 Navigation Displays at Watchkeeping Station

Transit from Barbados to Woods Hole.

It was a very tight timeframe once it was confirmed that the *R/V Atlantis* was available for this project. The duration we required was tenuous at first but by July,14th, the 27 days of survey time was confirmed, As well, Eric Benway (Marine Operations Coordinator at WHOI) offered us the opportunity for a few staff to join the ship in Barbardos and transit with her to Woods Hole. This generous opportunity was gratefully accepted as it gave me on opportunity to familiarize myself with the vessel and her systems on the nine day transit. G
However, getting DFO senior management approval to travel to Barbados proved to be quite a challenge, but by the evening of July 26th Ottawa approval was given and tickets were booked the next day. Heather Joyce and I depart for Barbados via Toronto at 06:00 on Saturday July 28th. We join the Atlantis at noon on Monday July 30th and she departs early PM the next day after ship familiarization briefing, fire & boat drill and full ship search for stowaways (none found).

The transit north was uneventful with fine weather and seas. Two men from SAIC were aboard to service a DART II bouy (part of the NOAA early Tsunami warning system), that had failed a few weeks before. The ship spent the day of August 5th onsite (in 5250 meters of water) replacing the mooring and confirming it was operational again. The EM122 had to be turned off (from pinging) during this time in order to not interfere with communications with the DART mooring.
During this transit north, I was able to learn a lot about the ship and her systems as well as to plan cabin assignments and work areas. This time aboard prior to the start of the survey allowed us to maximize the efficiency of the UNCLOS survey. I am very grateful that this opportunity was made available to CHS. Also, during this timeframe I was able to install on OLEX laptop system that proved to be very useful during the survey for planning and data evaluation purposes. This was achieved by simply inserting a small 100MHz Hub between the SIS computer and the EM122 transceiver. A CAT 5 cable was then run to the laptop and the EM122 set to output a telegram from the transceiver to the IP number of the Olex PC. Bottom hardness as well as bathymetry was captured.

Calibration check of installed Multibeam system

While I had been assured that the EM122 multibeam system had been properly calibrated when it was installed, I could not be shown any documentation to that effect. Also, the system had not yet been used to carry out a systematic hydrographic survey. Therefore, it was deemed prudent to carry out whatever checks were possible within the limited timeframe that was available. The fair weather for the transit north and the lack of significant problems associated with the DART II bouy repair allowed me almost a day for running calibration lines prior to initial arrival at Woods Hole.

On Monday August 6th I was able to run a pair of lines to calibrate for roll in 4500 meters of water, as well as one line overlapping beam-tips only. These lines were ftp'd back to BIO for Chris LeBlanc to convert (to make sure that was not a problem) and to analyze for any roll error. It was while running these lines that some of the challenges of a deep water survey became very apparent. An immediate course change of a mere six degrees left holes in the swath on the outside edge ! (65/65 degrees and 10 knots speed). Therefore course changes while running a survey lines will have to be kept to roughly half that amount. Also, the transit time between overlapping lines is between one and one and a half hours, so long lines will have to be planned to maximize vessel efficiency. As well, the ping rate was slightly better than twice per minute compared to the 5 to 10 Hz we were used to!!

On Wednesday August 8th I was able to have the ship for twelve hours, to run a number of north-south Pitch/Time lines up & down the edge of the shelf break (1650 to 800 meters depths). Also had time to run a pair if reciprocal lines east-west midway up the N-S lines. Although of interest these last two lines did not prove to be useful, but was all that could be fitted in with the time left.

Results of Calibration check

The pitch/time lines did not yield any discernible errors. Nor were we able to "see" any gyro error. The roll check however did give us a very small error that we compensated for in the Vessel Configuration File in the HIPS processing system.

This -0.015 correction would have been entered in the SIS parameters if I were aboard a CHS vessel, but I did not want to affect any changes to a system that was not ours, so this was deemed to be the best way to handle such a small error. Overall, the *Atlantis* multibeam system was very well calibrated, quite impressive given that they did not have extensive expertise in hydrographic surveys. See below for visual of results.

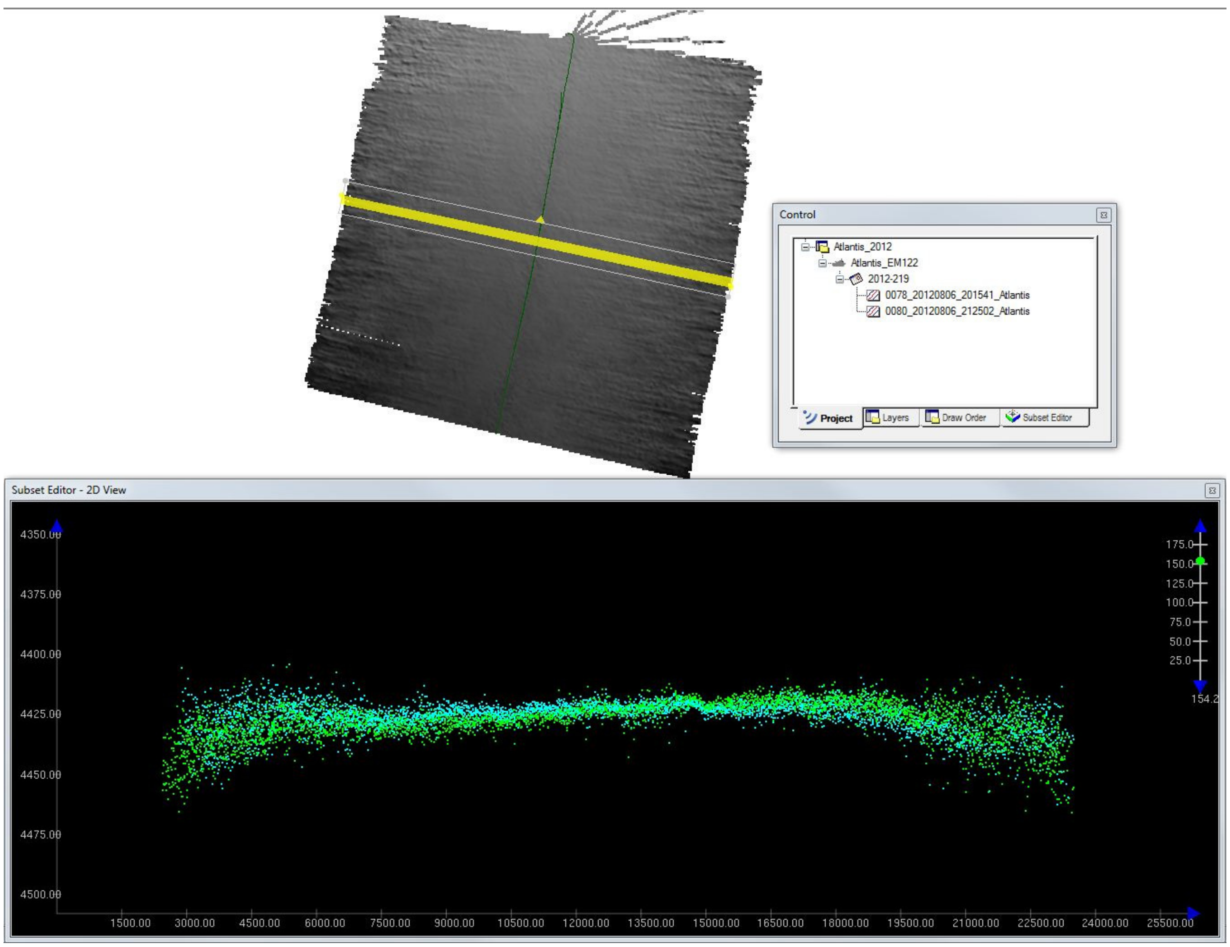


Figure 13 Grey scale plan view of surface created from 2 Roll lines run by RV Atlantis on Aug. 6, 2012. Also shown is a cross-section of Roll Lines with no correction.

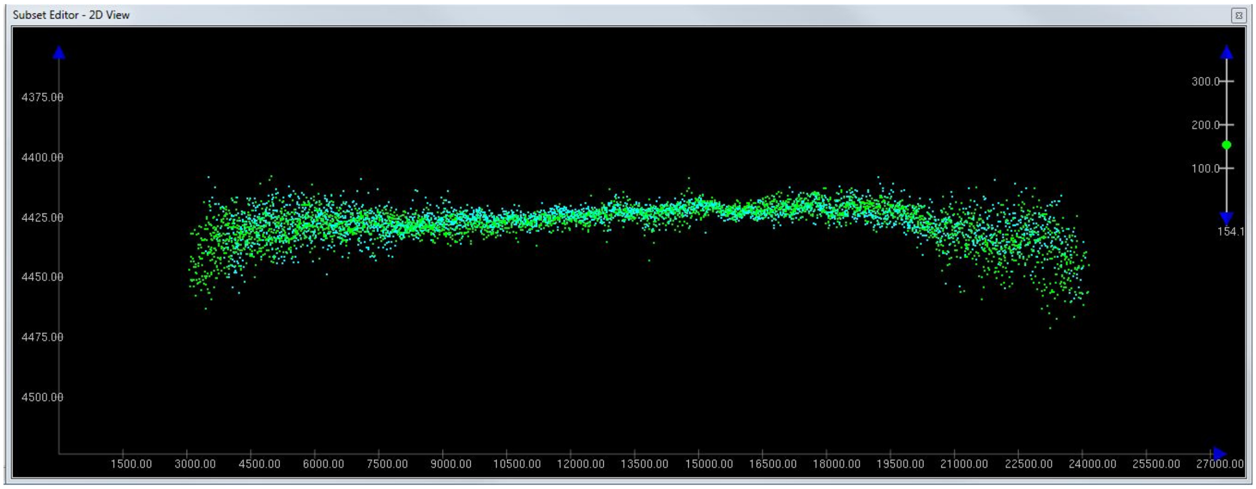


Figure 14 Cross-section of Roll Lines after -0.015 degree correction.

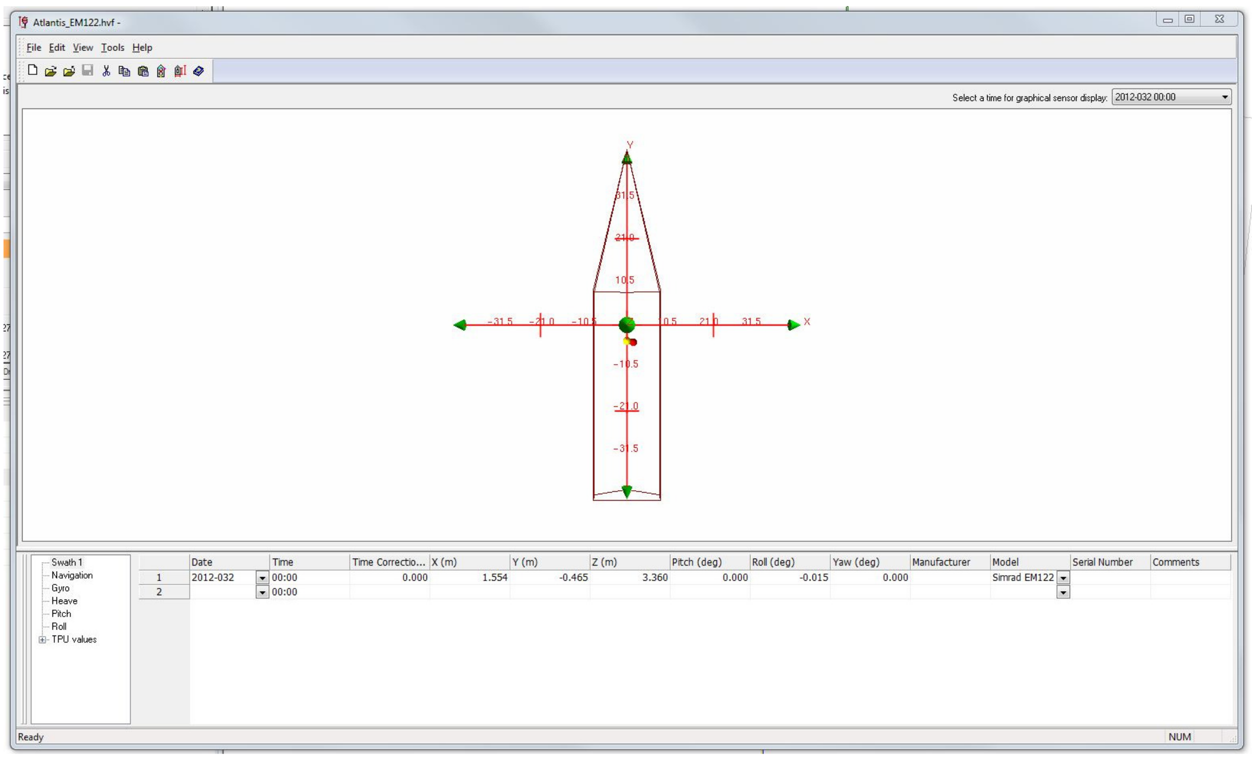


Figure 15 HIPS Vessel File for RV Atlantis showing implementation of -0.015 degree roll correction.

Pre-Survey time aboard Atlantis

By 10:00 on Thursday August 9th the Atlantis was alongside at Woods Hole and he ship had cleared customs. Steve Forbes arrives near suppertime and we have an initial meeting prior to

Friday's meeting aboard Atlantis.
At 10:00 on Friday Steve and I meet with Captain A D Colburn, Eric Benway (Marine Operations Coordinator), David Fisichella (Head of SSSGs) and the *Atlantis* assigned SSSGs Peter Lemmond and Allison Heater. This meeting went well and was basically a review of all of our expectations. Nothing new was put on the table.
The CHS survey teams arrive this afternoon and Heather Joyce departs. Fort the rest of the day they settle into their cabins and have a quick tour of the ship. The GSC personnel arrive on Sunday August 12th and Lt Briana Welton arrives on Monday 13th August. Familiarization of the ship and setting up the processing PCs keeps us all very busy during this period.

On the early evening of Saturday August 11th an e-mail was received from Albert Suchy (Director of Ship Operations at WHOI). In this communication he explained that the "couplings between the propulsion motors and the propulsion Z-drives that drive the propellers" had substantial wear and for the sake of prudence they wished to replace them before we sailed for the survey area. This would likely delay our departure, but they were quite prepared to extent our survey by whatever time our sailing was delayed. In my opinion, this was a very reasonable proposal.
As it turns out, they engineering staff carried out an amazing repair (especially true once I realized the extent of the work required). In my over three decades of hydrographic surveying I do not recall such a repair being done in such a timely manner. Instead of a Tuesday AM departure we were away with the tide on Wednesday August 15th at 14:35. During this time we were also provided numerous updates via e-mail explaining the progress being made.
I am indeed very grateful and impressed by the outstanding professionalism exhibited by WHOI to ensure our survey objectives were met. Bravo Zulu to you all.

If this situation had happened aboard the Matthew at BIO, in my experience with Canadian Coast Guard engineering, there would not have been enough expertise and staff available to carry out such a repair on short notice. Therefore, they would have asked for three quotes from industry and those would not likely even have been received let alone evaluated and awarded in the timeframe that had us departing from the wharf at Woods Hole. As well, the resulting lost CHS shiptime would NOT have been compensated in any way. It is heartening to see that this is not the case elsewhere.

SOUNDING WATCHES

The science party consisted of the following personnel:

Michael Lamplugh, HIC - DFO / CHS
Christopher LeBlanc – Data Processor - DFO CHS
Kiran Persaud – DFO / CHS
Michael White - DFO / CHS
Lynn Collier – DFO / CHS
Calvin Campbell –PhD GSC / NRCan
Christiane Theriault – GSC / NRC
Briana Welton, LT / NOAA - OCS, CCOM/JHC

Figure 16 The Survey Team: (L to R) Lynn Collier, Briana Welton, Calvin Campbell, Kiran Persaud, Mike White, Christiane Theriault, Chris LeBlanc & Michael Lamplugh

Two-person twenty-four hour data acquisition watches were kept using the following schedule:

0000-0400	**0400-0800**	**0800-1200**	**1200-1600**	**1600-2000**	**2000-2400**
Christiane Theriault	Briana Welton	Briana Welton	Calvin Campbell	Calvin Campbell	Christiane Theriault
Kiran Persaud	Kiran Persaud	Michael White	Michael White	Lynn Collier	Lynn Collier

Christopher LeBlanc was the dedicated data processor and kept everyone immediately informed if there were any problems evident in the data such as in the coverage, refraction or general data quality. He was also in-charge of tasking all CHS staff during the four hours of data processing that was carried out each day. He brought with us three powerful Windows7 laptops with CARIS HIPS/SIPS 7.1.2 installed. These systems each had dual monitors and were interconnected on our own internal (1 Gigabyte) network complete with back-storage drives. This enabled CHS staff to do their off-watch processing almost any time it was convenient for them to do so.

GSC staff worked on data that was specific to their expertise such as the sub-bottom (3.5KHz), gravity and magnetic data on computers they brought with them. Lt. Brianna Welton kept busy with her UNH coursework, SVP data analysis and her trip report during her non-watch-keeping hours.

Figure 17 Chris at his workstation and the two secondary HIPS processing stations Note dual screen capability.

On a daily (actually, line by line basis) the latitude and longitude of waypoints on each line was calculated, vetted with the Captain and delivered to the officer-on-watch by the HIC. The lines were designed to give minimum overlap with the adjacent line and thus yield maximum coverage (with no gaps) to make the survey as efficient as possible. Each line was planned immediately prior to its commencement so that the coverage and data quality of the current line was known and included in the planning process. There were also extensive daily consultations made with geologist Calvin Campbell to ensure all aspects of the survey acquisition including sub-bottom results were fully explored. The waypoints were included in a daily operational plan posted for staff and provided to the bridge. Since the average depths in the survey area were in the 4,000 to 5,000 meter range we had an effective swath width of approximately 20 km. This huge swath width created its own special line-running/planning challenges. All end of line turn speeds were kept to no more than 45 degrees/minute (to ensure bottom tracking was maintained) and online course alterations were restricted to no more than 3 degrees. If this was exceeded there were gaps created in the coverage at the “outside” of the turn radius.

Data logging was turned off during each 45 degree/minute major course alterations (EOL and starting transit to SOL etc.). However, once the desired course between lines was achieved data logging commenced. My philosophy was to acquire data at every opportunity.

Vessel survey speed was generally 10 to 11 kts during calm sea states. During higher sea states when the EM122 MBES lost bottom tracking, the ship would slow to 8 to 9 kts and at the worst case to 2 - 3 knots (ie. for half of JD248).

Raw data files were logged to the local hard drives of the computers running the respective acquisition software, and automatically transferred to *Atlantis's* central data storage drives (DataOnNetwork) with read-only permissions and network accessibility. In addition to SIS, MBES coverage was monitored with the CHS supplied OLEX software running a laptop with an Ethernet connection to the Kongsberg network. All other data displays were monitored in their native software displays by the data acquisition watches, and associated paper logs entries were made at regular intervals. Paper logs for each major piece of equipment were filed in binders and retained for submission to the Hydrographic Data Center at BIO.

Atlantis's SSSG Techs also performed daily maintenance and health checks on all major sensors used for this cruise.

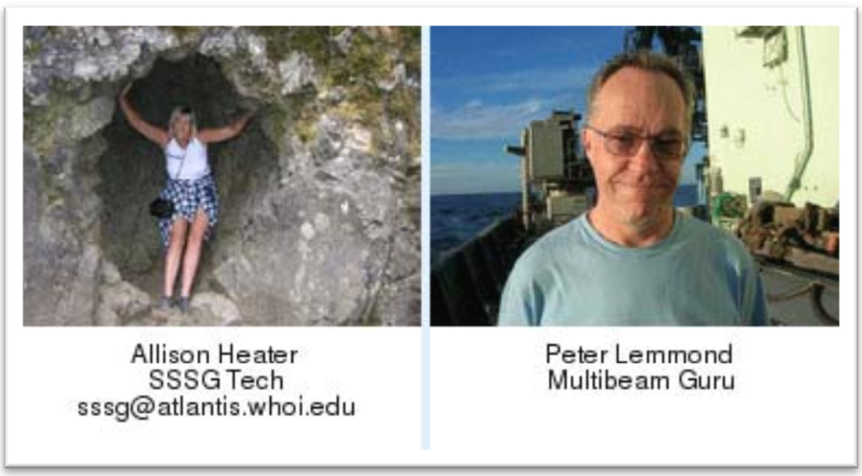


Figure 18 Allison Heater and Peter Lemmond. The two technicians from the SSSG (Scientific Ship Support Group) that kept all systems operational for the duration of the survey.

SURVEY METHODOLOGY

Initial Tasking

At the Bedford Institute of Oceanography in Dartmouth there were a number of meetings to plan the priorities of the desired areas for UNCLOS mapping aboard the *R/V Atlantis*. With the uncertainty of the true location of the Bottom of Slope (BOS), the sub-bottom composition, to say nothing of weather (hurricane season) and Gulf Stream challenges, there were many "best guesses" prior to actually getting "on-site". Below is the final diagram provided prior to the ships departure from Woods Hole, with polygons indicating each area's priority.

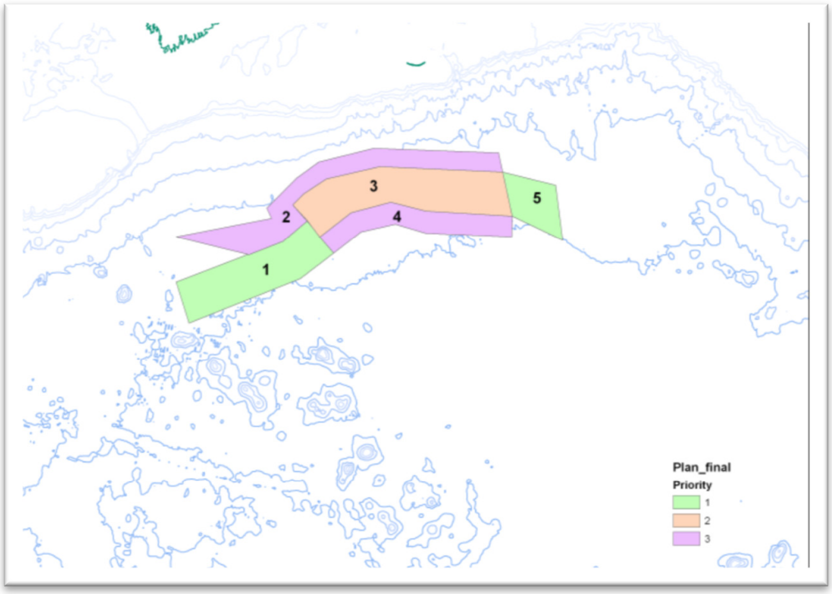


Figure 19 Initial Scotian Shelf Priority Areas.

Modified tasking(on-site)

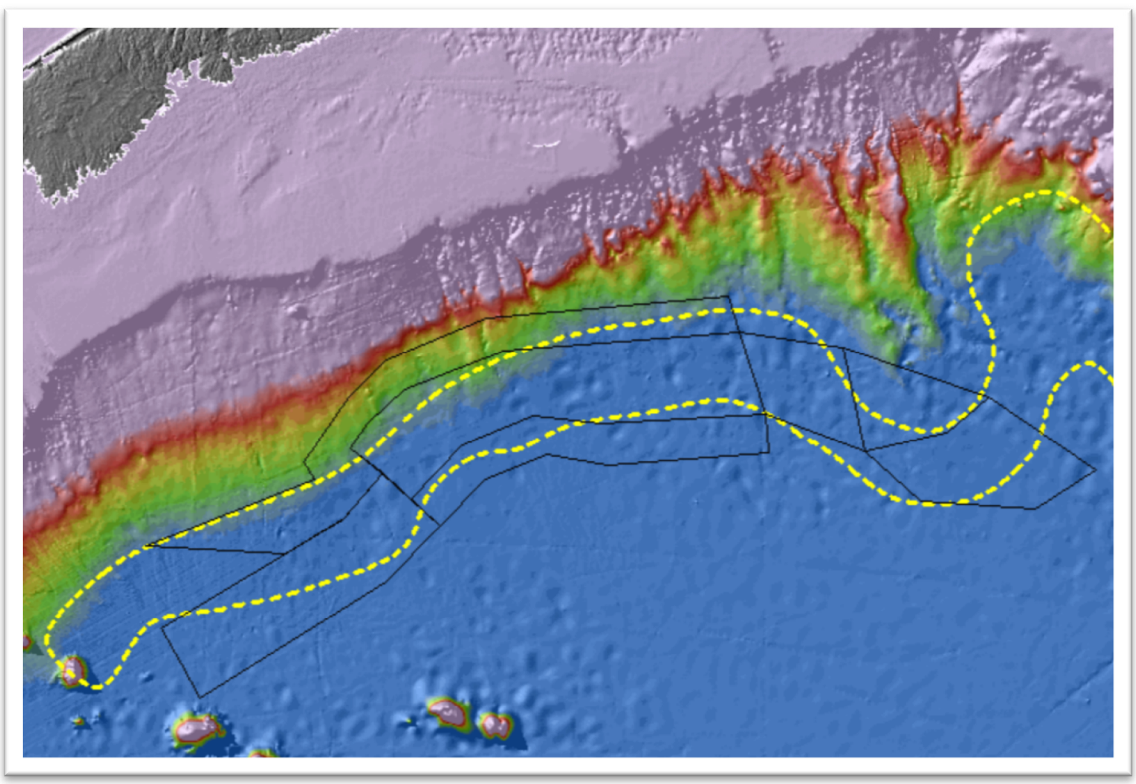


Figure 20 2012 Modified UNCLOS work area on Scotian Shelf. Note: yellow pecked line is the BOS Zone

Once the *Atlantis* had departed for the work area, I discovered through discussions with Dr. Calvin Campbell, that he and Dr. Dave Mosher (GSC-Atlantic) had developed a "best guess" Base of Slope Zone (BOS) for the east coast of Canada. This BOS ran from the US/Canada border to northern Labrador. I asked him for a copy of this polygon, and it quickly became invaluable as an overlay for designing the survey line layout. In order to get maximum sounding hours each day I strove to minimize major course alterations. Therefore, I worked to cover the BOS zone with the minimum number of lines, regardless of the given area's priority from the initial tasking. This approach was vetted via e-mail with Steve Forbes.

Once the survey got underway and the challenges of line-running with the EM122 (this was the first time the author had run a systematic survey with this multibeam sensor) became quickly apparent. Making course alterations of more than three to five degrees at one time would likely leave a "hole" in the outer-beam coverage. Major course alterations were kept to no more than 45 degrees per minute in order to maintain bottom tracking. Although these course alterations were not logged; data logging was maintained continuously at all other times. I had initially anticipated asking the bridge to maintain an offset distance from a baseline in conjunction with observing the swath coverage (as per my usual survey methodology in shallower waters up on the continental shelf), however the ships autopilot would not easily accommodate such a process and the EM122 ping rate was so low that this was soon deemed impractical.

The best solution became to provide as long a line as was reasonable with specific waypoints. The procedure was then to alter course quickly and settle on a new course between lines, and then do the same when we arrived at the next (near parallel) line to the last. ALL lines were specified by waypoints (even between lines) and provided to the bridge. Roughly 1-2 hours was required to end one line and initiate the next line, depending on the water depth and thus the swath width. Line spacing varied from 9 to 18 km.
This approach, in conjunction with closely monitoring the "Slope Processes" as seen in the 3.5KHz sub-bottom data, allowed us to survey the entire area with only 35 lines. That included the short lines transited between the main coverage lines. By minimizing the amount of time spent on turns and transiting to the next adjacent line, the survey time was used as efficiently as possible.

Operation

Bathymetry, backscatter, and water column data from the Kongsberg EM122 MBES were monitored in real time and logged to **.all** and .**wcd** using SIS version 3.83 build 89 (March 25, 2011). New data files were set to automatically increment every two hours, but were manually incremented during turns and major course changes. The EM122 MBES was primarily operated in equidistant, high density mode with FM enabled, with pitch, roll stabilization; with a 65-degree swath angle on both port and starboard for 432 beams per swath and 864 beams per ping (dual swath mode enabled). The heading stabilization option was not deemed to be an advantage so was not enabled. The swath angle was occasionally increased to gain additional seafloor coverage when necessary (to ensure no gaps between adjacent lines), this was only done when the ship was having trouble staying on desired track or the depths were less than anticipated.
For lines 2126 to 2132 (SIS line numbers on August 24th –JD237) the EM122 MBES was operated with FM disabled in an attempt to minimize along track high frequency wobbles in the outer sector beams. The FM option was re-enabled after it was deemed that the changes made no difference in

data quality. During periods of increased sea states additional real-time parameter filters were employed. Screen grabs of SIS software settings as well as the PU Settings file were obtained from SIS and are retained with the raw data.

Chronology

JD 228 15 August Wednesday	*Atlantis* engineers turned props alongside in a successful test of recent repairs. Ship familiarization for hydrographic staff in the morning. 14:30 Ship departs WHOI for work area. Survey watches promulgated to staff. Steam south to join shipping lanes then NE to start of survey.
JD 229 16 August Thursday	Favourable weather. Transit to start of survey. Full fire and boat drill in AM. Computers set-up, network connections to printers tested. 16:00 Survey shifts started Start of requested "tie-line" down slope at 18:00 (22:00 UTC). Multi-beam, gravity & sub-bottom being logged.
JD 230 17 August Friday	09:00 training for all in XBT casts and entering new cast into SIS. Using new software from UNH developed by Jonathan Beaudoin for UNOLS –works very well. 13:15 end of "tie-line" 13:44 CTD in the water and data collected to 4959 meters (@depth 15:35) 17:15 CTD back on deck. Deep and shallow XBT deployed (1830m & 760m) 18:00 magnetometer deployed and figure "8" course run to gather data for magnetometer calibration. 19:32 start first survey line in work area (23:32 UTC). MultiBeam, sub-bottom, gravity & magnetics all being collected. Seas calm so tried 11 knots survey speed, but data a bit noisy, reduced speed to 10.3 knots
JD 231 18 August Saturday	12:30 magnetic data had been a bit noisy, but now it has failed. Sensor (with 300 meters cable) recovered. Continue surveying and logging other three sensors. 19:15 EOL –this was 380 kms long. 20:40 SOL to the SW
JD 232 19 August Sunday	00:15 SIS crashes. Cause is not clear but sluggish performance by video card when display switched to "night mode" suspected of being a contributing factor. Ship had to go back approx. one mile to pick up line. 10:13 Magnetometer redeployed and logging data. EOL 17:17 & SOL 18:25 to NE
JD 233 20 August Monday	EOL 17:00 & SOL 19:00 to SW Weather conditions still very good, water temp is 24.7C
JD 234 21 August Tuesday	Today had the most swell encountered this trip 2-3 meters. (Remnants from "Gordon"). Had to reduce survey speed by 0.5 knots on SW leg to avoid data loss due to aeration. EOL 17:00 & SOL 17:59 to NE

JD 235 22 August Wednesday	Calm seas today & gentle swell. Survey speed still at 10.3 knots 16:26 End of Line reached and turn to north initiated 17:16 Turn completed and ship online to SW
JD 236 23 August Thursday	Slight swell today, but still minimal ship movement. EOL 12:20 SOL 13:10 to NE; this is the last line in this western section
JD 237 24 August Friday	06:50 EOL 08:13 SOL to the east @ 10.3 Knots -now starting next survey "block" For this first line we disabled "FM" capability (used in the Deep mode). This was to evaluate how improved the sounding data will be; as the outer beam "wobble" has been attributed to the use of FM mode. Reduced swath width possible (10-15%). Weather & sea state still very good
JD 238 25 August Saturday	03:28 EOL 04:12 SOL All four sensors continue to work well EOL 23:25
JD 239 26 August Sunday	SOL 00:53 EOL 23:00 SOL 23:59 All logged data times are UTC
JD 240 27 August Monday	EOL 20:54 Re-booted SIS, PU & Pre-Amp due to timing error, while transiting to next line. All systems subsequently Okay SOL 21:44
JD 241 28 August Tuesday	EOL 18:19 SOL 19:11 Wind comes up and a swell builds by early evening 19:50 Captain has a forward tank ballasted (80 tons), this helps keep the bow down and helps prevent aeration from impacting sounding
JD 242 29 August Wednesday	Overnight some swell developed from the NW, a bit of pitching before turning. Some data dropouts before speed reduced. Fwd ballast an asset. 13:00 Meet with SSSG & Captain about survey progress. All good. EOL 16:33 SOL 17:30 sea-state is building
JD 243 30 August Thursday	SOL 10:00 continue survey line into the most easterly block EOL 23:25 @ start of next line we will reduce speed by one knot as the wind/swell now on the bow.
JD 244 31 August Friday	00:19 SOL line to the west Pitching is an issue to maintain data quality. After discussions with the Captain he was able to ballast all forward tanks (as well as some aft ones to maintain ship's trim). This kept the bow down in the water and noticeably improved the data quality while pitching. 20:18 EOL & 23:15 SOL to the East
JD 245 1 Sept	07:22 EOL & 08:49 SOL line to W –into wind/swell. Reduced speed required to acquire usable data. With 25-30 knot winds and related seastate only 425

Saturday	RPMs possible (~ 6 knots). Early evening wind shifted N and we increased speed
JD 246 2 Sept Sunday	01:51 EOL & 02:45 SOL to east and back to 10.3 Knots 13:35 EOL & 15: 23 SOL back to SW @ 10.3 knots –rolling but good data.
JD 247 3 Sept Monday	02:33 EOL & 03:51 SOL to the NE AM Wind 30 knots N-NE with significant seas, starting at sunrise. We are heading into it and down to 425 RPM as of 09:15. 2-3 knots over ground and data quality poor but usable. T-storms & heavy rain. PM wind now over 40 knots and seas increased. Beams into 55 deg intermittent returns however. The rest of the day is spent essentially "hove-to", but we were able to acquire a sparse dataset that should be usable.
JD 248 4 Sept Tuesday	From midnight to 04:00 wind increased to 50 knots plus and backed to north. 16:15 A/C to 330 to head into wind/seas. Stayed a consistant northerly 40 knots or so until mid-PM 06:30 A/C to NW to position us better for tie-line with conditions improve (400 RPM ~ 5knots) 19:45 A/C 235 deg to get to tie line up Laurentian Fan (seas on stern not beam) Winds now just under 30 knots; still from 330 deg 20:50 SOL "tie line". Seas still as issue, but not as much yesterday.
JD 249 5 Sept Wednesday	10:00 SOL line to west that picks up 4 "tie-lines" 18:23 SOL line up east side of The Gully downslope of MPA 23:16 EOL and start to recover magnetometer (left on deck for rest of trip)
JD 250 6 Sept Thursday	00:17 SOL line down west side of "The Gully" down slope of the MPA 13:35 EOL checkline to south 14:40 SOL running west; weather conditions deteriorating. Wind up to 25knots SE and seas building; have to reduce speed to continue sounding.
JD 251 7 Sept Friday	10:42 EOL & 10:42 SOL line to the east 15:25 EOL & 16:20 SOL line to west 20:10 EOL & 21:46 SOL line to east The short lines here are to cover a spur with "slope processes" that extends much more seaward than initially expected.
JD 252 8 Sept Saturday	03:18 EOL & 04:19 SOL line to west 11:03 EOL & 12:09 SOL to the SW This line is the last line (#35) in our survey area. EOL 20:45 (Line overlaps the start of first line on 17 August in survey area.) 21:08 start CTD cast to 4959 meters 22:53 CTD at bottom; cast starts back up
JD 253 9 Sept Sunday	00:35 Finish CTD cast, secure gear 00:52 SOL final tie-line upslope Transiting to WHOI after completing upslope sounding line at 12:34 14:30 Increased speed to 13.5 knots to get ahead of weather front. Data OK 20:25 EOL @ top shelf break. Discontinue EM122 and 3.5 KHz sub-bottom collection.

	Data back-ups started & last processing steps initiated. Start to secure CHS equipment for transit.
JD 254 10 Sept Monday	09:00 Arrive off Woods Hole and wait for slack water to enter harbor. PM alongside wharf at WHOI. Staff packing up and preparing for travel to Halifax. Data back-ups being done.
JD 255 11 Sept Tuesday	AM packing up gear and making final data back-ups & checking them. PM Calvin & Mike meet with Steve Forbes, Captain Colburn and staff from WHOI for a post cruise meeting. All staff travel to Boston & stay the night
JD 256 12 Sept Wednesday	08:00 All staff fly back to Halifax from Boston

Data Quality

The internal evaluation that was constant and ongoing during the survey operations gave us all a very good feeling of confidence in the sounding data being acquired. Even the outer-beam instability (see “wobble” below) was well within the survey tolerance of 3% of depth and this was our largest error. Occasionally, there was a slight amount of refraction visible in the data, but by using the refraction tool within HIPS/SIPS and by excluding data from the outer beams (where feasible), the effect of these errors were statistically minimal.

Once back in the office Chris LeBlanc provided a number of ASCII files to Steve Grant in the BIO UNCLOS office. He then independently compared the data from the three main checklines to the surface generated without the checklines included. His resulting graphic of the results is included as Appendix C to this report. He even made a specific visit to our work area to complement us on the excellent internal data consistency.

Problems

A 30-50 meter vertical along-track “wobble” artifact is apparent at the very outer beam tips in all of the raw and processed data (see comment above re: disabling FM option). Although this “wobble” was very annoying to view and was a slight challenge for data processing, it must be tempered by the reality that this represented only a 1% error at most, so well within required survey specifications. The source of this error was never discovered.

Across track vertical jumps associated with new SSP input into SIS (and thus the start of a new logged file) are also occasionally apparent in the final bathymetric surface, but overall there was very little issue with sound velocity problems despite the proximity of the survey area to the Gulf Stream and the well-known eddies that it occasionally spawns. A known file logging issue in which the navigation datagram for a few initial pings of the new datagram file are recorded in the previous logged file was discovered early in the cruise. CARIS HIPS has a processing option to address this issue (the swaths are correctly positioned upon conversion into HDCS format by using the last position datagram of the previous file). It turns out that Kongsberg also has a utility to “fix” files affected by this logging issue by appending the files together, but that approach would have led to very large file sizes so was not used for this dataset.

Results

"ATLANTIS" DATA STEWARDSHIP

Raw data files were copied daily to external hard drives from *Atlantis's* central data storage repository for onboard processing and/or QC. The MBES data were processed onboard by Chris LeBlanc using CARIS HIPS/SIPS, while Sub-Bottom Profiler, Magnetometer, and Gravimeter data were processed and/or checked by Calvin Campbell. Briana Welton also converted EM122 MBES data to CARIS HDCS and into a Fledermaus FMGT project to make daily bathymetric grids and backscatter mosaics for data familiarization purposes.

A copy of all raw data files were brought back to CHS-Atlantic and CCOM for archival as per each office's conventions and with access restricted to the public due to the nature of the project.

CHS Project numbers :

HDC project number for AT22-01 "Atlantis" (Scotian Shelf)	2901486
RAWDAT	2702351
PRODAT	2702352
PREDAT	2702353
VALSRC	2400302
FLDNOT	2200447
Final Field Report	2600352

Final data submission includes raw data, processed data, metadata and a CUBE surface at 100m resolution.
These data were submitted to the UNCLOS project team at BIO on 5 Dec 2012.

Numerical Summary of core data acquired during AT22-01:

EM 122 Multibeam sounded	9975 linear kms
Full depth CTD casts	2
XBT Casts	162
Gravity & Sub-Bottom acquired	8785 linear kms
Magnetometer data acquired	7247 linear kms

FINAL THOUGHTS

Calvin Campbell spent some time during week three that proved to be very valuable, he dug into the data holdings he brought with him. He was able to locate some MB data (supplied from private industry to GSC-A) that had not been included in the combined "existing" dataset we were provided with from the UNCLOS office. This proved to be a tremendous asset in the last week's work plan. I had initially planned to spend two days running four tie lines up the slope (west of the Laurentian Fan) to join our new data with the existing data upslope. In the end we were able to achieve seven tie-lines in 18 hours with using this new dataset. This allowed us to have enough time to still complete all the work we wanted to do even though the weather conditions were necessitating us slowing down. With these seven new lines we now had 15 tie-lines up the slope to existing MB datasets, included one up to the MPA "The Gully". This greatly mitigated the time already lost due to weather. It was also interesting to note that canyon that starts at "The Gully" runs completely through our survey area for a total distance of about 330 kilometers. I have no idea what that might mean from a geological perspective but is was very interested to "track" during the course of the survey.

Near the end of the survey we started to look into the FOS (Foot of Slope) points that had been initially selected in this area, based on SB (single beam) profiles. Singlebeam profiles being the best data available at the time, UNCLOS staff had little choice but to use them. On close examination of the Single Beam profiles draped over our MB (multibeam) coverage I reached a surprising realization. Calvin did an inventory for me and just over half of the FOS points were picked due to the profile cutting across a channel at oblique angles. This includes three of four "critical points". (See Figure below)
With the dataset we have acquired during this cruise for Canada's UNCLOS submission, there are now a much greater number of slope profile choices available in order to maximize Canada's claim on the Scotian Shelf. It appears that all of the new FOS points will be to seaward of the existing picks, some significantly.

Although it is not possible to really complete 110% of a job, I do believe we have essentially achieved the equivalent. All of our initial objectives have been met. We have solid evidence to support the validity of each and every FOS point that had been selected prior to this expedition. However, in our opinion we can now move almost all of those points seaward, in some cases a significant amount –possibly over 100 km in one instance.

It has been noticed that the depths and contours of chart 4001 are not correct in the area of this survey. In fact, the 4000m contour that I think must represent the Laurentian Fan is charted approximately 20 Nautical Miles too far east.

My sincere thanks are extended to Captain A D Colburn and his crew for the professionalism, enthusiasm and friendship offered to myself and the survey team. Without this essential component, we would not have had such a successful mission. Also, the support from the management team at Woods Hole was greatly appreciated.

Finally, on a personal note I would like to thank Steve Forbes for his belief that I was "the man for the job" and for supporting whatever requests I believed were essential to ensure success. My survey team was second to none and lived up to my expectations. Thank you all.
This is my last Hydrographic Survey before I retire in Jan 2013 (after 36 years with CHS). It was a privilege to have had such a wonderful experience to finish my career.

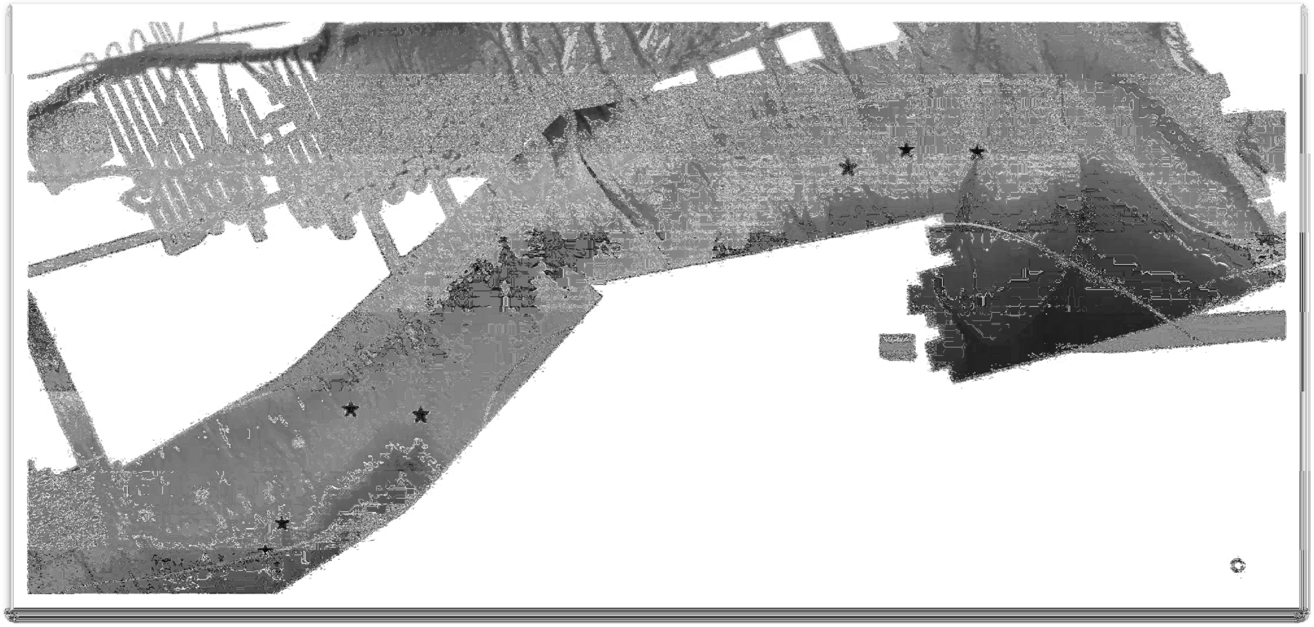


Figure 21 Example of false FOS (Foot of Slope) points picked along single beam profiles. The "stars" are all points that were selected when the profile crossed a canyon channel (ie. maximum change in slope). By "false" we mean that a much more seaward FOS can be selected by having the profile run down the "spur" or high-ground between the channels.

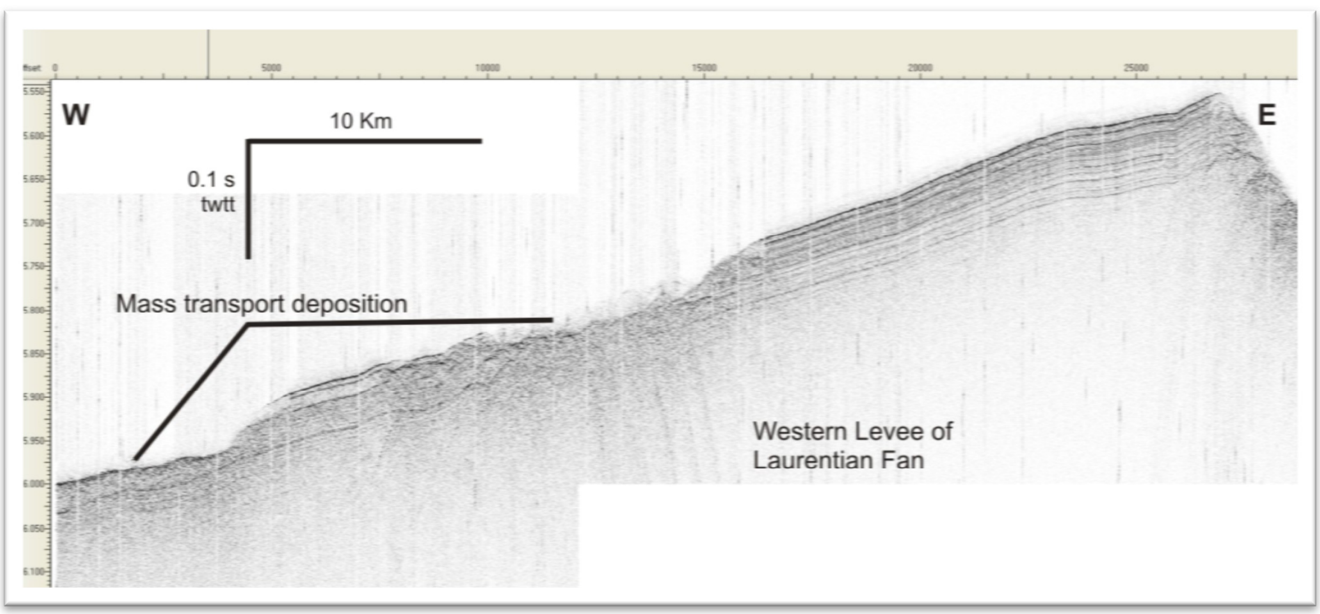


Figure 22 Example of processed 3.5KHz sub-bottom data that clearly shows the difference between seafloor that has not been disturbed and areas where there has been significant change (slides). The data from this sensor proved to be just as valuable to the author as the Multibeam data when determining where to run the next survey line. For example, if "mass transport" was discovered, then we must still be in an area subject to "slope processes", therefore another pass to seaward was warranted.

AREA COVERED

The cruise logged 5386 nautical miles (9,975 kilometers) of EM122 data, covering an area of 139,350 km^2 (or 53,803 $mile^2$) bounded by positions 43.82N, 053.40W and 38.58N, 067.59W.

The following positions (Lat, Long decimal degrees) are the ones used to describe the limit of the project within HDC project number 2901486:-

39.0626874, -64.0209992
40.1795321, -61.8204853
40.6275961, -61.1700432
40.7987707, -59.8943867
41.4325727, -60.1016454
41.6192738, -58.3393927
40.8721371, -58.0264061
41.5363394, -53.8062558
41.7959363, -53.8307207
42.2544908, -55.2939193
42.2644774, -55.8532847
43.1352294, -56.2576518
42.9808659, -58.0125106
43.4079693, -58.4219069
43.6364307, -58.5138081
43.7942473, -58.8397332
43.7428036, -58.8797847
43.5333553, -58.7577692
43.3466692, -58.7164540
42.7883417, -58.3063363
42.4716374, -60.7152383
41.0521625, -62.8188365
40.4915943, -64.0683360
42.4431014, -65.3867980
40.1470906, -64.1146535
39.9505380, -64.5241383
39.8717137, -64.4794541
39.8306644, -64.5815621
40.3862472, -67.5704018
39.6072089, -64.4652531

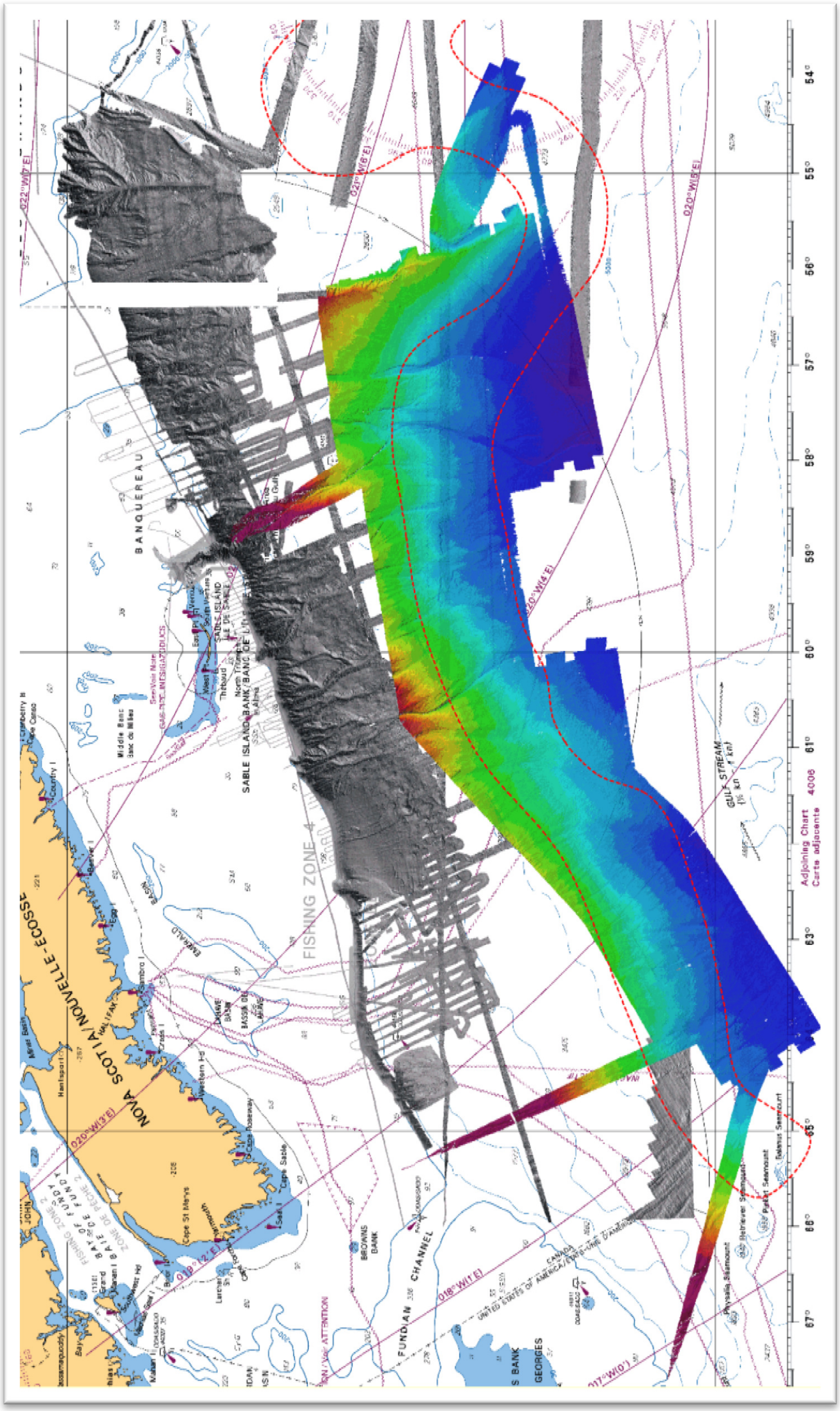


Figure 23 Full *Atlantis* Survey coverage (colour) with pre-existing coverage in B&W

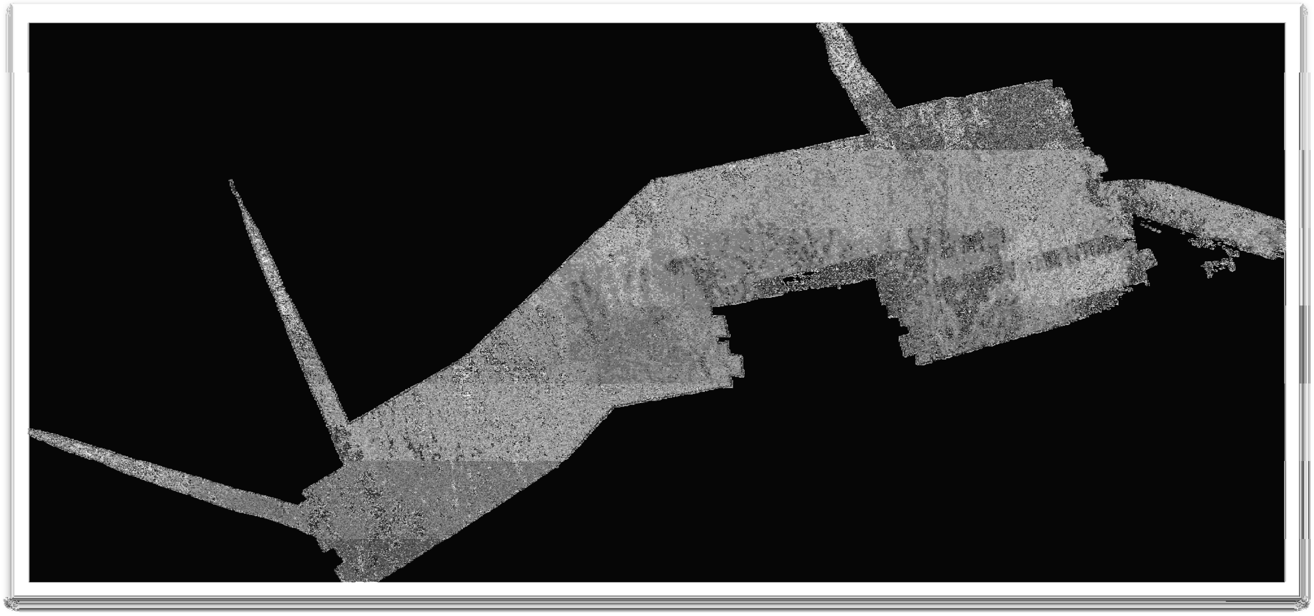


Figure 24 Course Backscatter image of completed survey area generated by Lt Briana Welton using "Fledermaus"

Appendix A

Figure 25 Close-up of magnetometer cable tangle. Cable likely too damaged to repair near fish.

Figure 26 Magnetometer being recovered due to clearly erroneous data being acquired. Slip-ring near fish would be a possible option to mitigate this problem in the future.

Appendix B

GRAVIMETER Data Format (provided by James Kinsey;jkinsey@whoi.edu)

Write the Raw Gravity String (RGS) and send to the logging thread.

The Raw Gravity String (RGS) is created at the native rate of the gravimeter (e.g., for a BGM3, it is created once a second) and uses the MOST RECENT navigation, depth, and heading data. The gravity logging program (gravlog) does not attempt to resolve the asynchronous data streams.
Consequently, the navigation and depth data will be older than the gravity measurements. The nav data uses GPS and should be less than a second old; depending on the site depth, the depth data maybe a few seconds old. The timestamps of the nav and depth data are included in the RGS, enabling the user to resolve the age of the measurement.

For both the nav and depth measurements, ONLY THE BEST AVAILABLE MEASUREMENT IS LOGGED IN THE RGS. On any given vessel, multiple sensors may be obtaining nav and depth data, and gravlog decides which sensor to use based on a prioritization table, the staleness of the measurement, and other metrics. It is not uncommon for the source of the measurement to change during a cruise.
GravLog automatically switches to the best available sensor and uses that "best measurement" in the RGS. For both depth and nav, a source field is included that indicates the source of the obtained easurement.

The data format for the RGS is:

```
  RGS YYYY/MM/DD hh:mm:ss.sss raw_gravity gravity_unixtime counts scale_factor
bias gravimeter_model gravimeter_serial_number  \\
  NAV: latitude longitude number_of_satelites GPS_unixtime GPS_source DEPTH:
depth depth_unixtime depth_source HDG: heading heading_unixtime\\ dnv_status
maggie_data_string
```

Where:

raw_gravity --- the UNFILTERED measured gravity in *MGALS*
counts --- the counts measured by the gravimeter (e.g., for a BGM3, the value transmitted from the data buffer)
gravity_unixtime --- time the gravity measurement was obtained in seconds since Jan 1 1970
scale_factor --- the scale factor for the gravimeter obtained during factory calibration
bias--- the bias obtained during the last ship to pier tie in mGal
gravimeter_model --- gravimeter model used to obtain the gravity measurement
gravimeter_serial_number --- serial number of the gravimeter used to obtain the gravity measurement
latitude --- MOST RECENT vessel latitude as reported by the best available navigation sensor in decimal degrees (+=north;-=south)
longitude --- MOST RECENT vessel longitude as reported by the best available navigation sensor in decimal degrees (+=east;-=west)
number_of_satelites --- number of satelites used to obtain the logged navigation position (-1 indicates GPS *WAS NOT* used)
GPS_unixtime --- time the lat/lon was obtained in seconds since Jan 1 1970
GPS_source --- source of the GPS measurement

```
     depth --- MOST RECENT water depth as reported by the best available sensor
in meters
     depth_unixtime --- time the logged depth was obtained in seconds since Jan
1 1970
     depth_source --- source of the depth measurement
     gyro heading --- most recent heading reported by the vehicle gyro in
degrees
     gyro_unixtime --- unix timestamp of the most recent heading reported by
the vehicle gyro
     dnv_status --- On a BGM3 system, the status of the DNV indicator.  There
are 4 possible values:

SENSOR_DNV_ERROR          --- Error reported by the SENSOR ELECTRONICS
CPS_DNV_ERROR             --- Error reported by the CPS
SENSOR_AND_CPS_DNV_ERROR --- Errors reported by BOTH the SENSOR ELECTRONICS and
CPS
NO_DNV_ERROR              --- No errors reported; system is running fine
     maggie_data_string  --- The most recent magnometer data string rx'd by
gravlog (typically grossly undersampled!!! Use at your own risk.)



  Modification History

  2010-04-17 JCK - created and written
  2010-05-18 JCK - added maggie data string
```

Appendix C

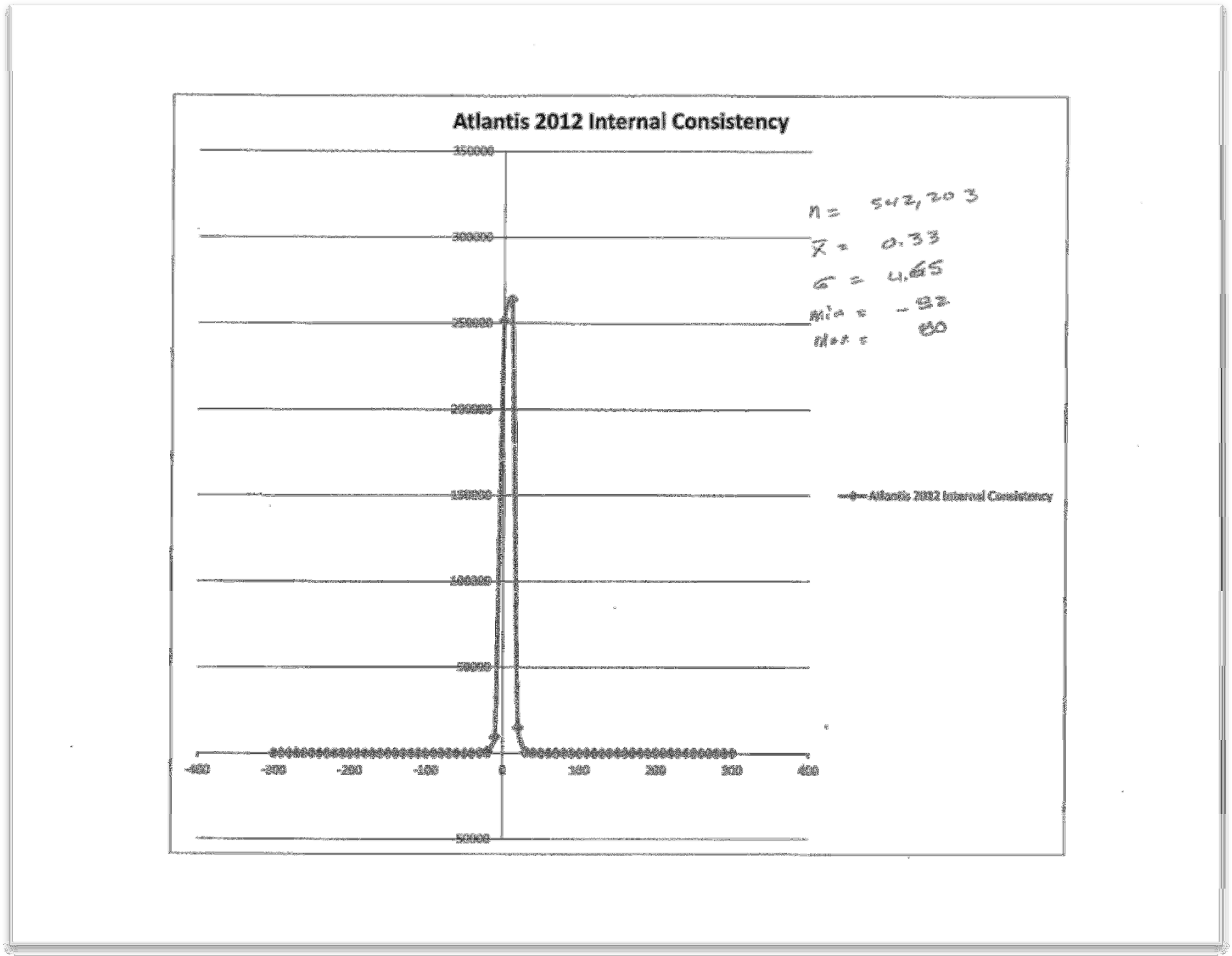
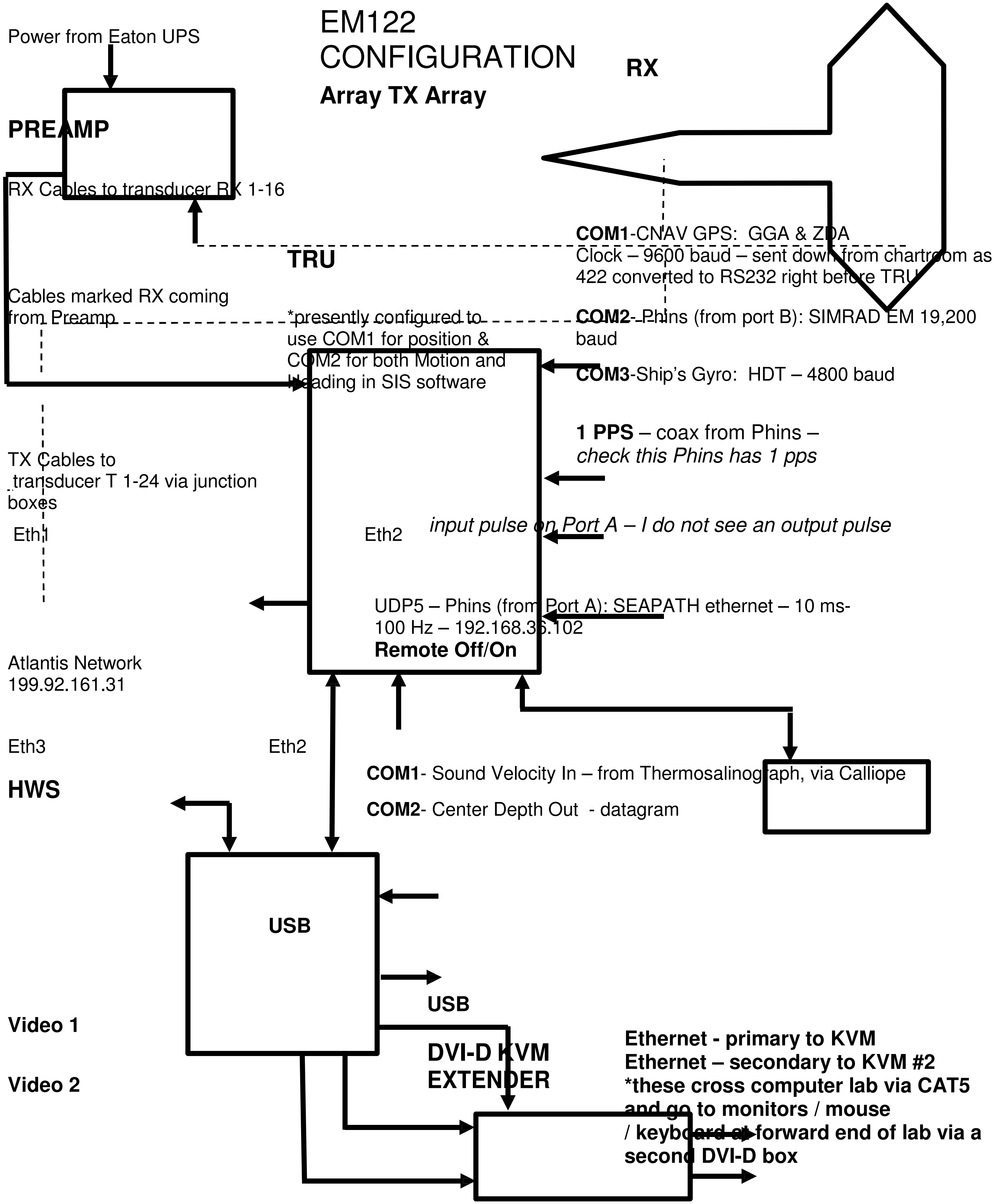


Figure 27 Initial version of Steve Grant's comparison of the "Atlantis" checklines to survey surface.

Appendix D

The Following three diagrams describe the EM122 system as installed on the *R/V Atlantis* and the physical relationship to its input sensors.

Many thanks to Lt Brianna Welton for compiling these diagrams.


EM122
CONFIGURATION
Array TX Array
RX
Power from Eaton UPS
PREAMP
RX Cables to transducer RX 1-16
TRU
Cables marked RX coming from Preamp
*presently configured to use COM1 for position & COM2 for both Motion and heading in SIS software
COM1-CNAV GPS: GGA & ZDA Clock – 9600 baud – sent down from chartroom as 422 converted to RS232 right before TRU
COM2- Phins (from port B): SIMRAD EM 19,200 baud
COM3-Ship's Gyro: HDT – 4800 baud
1 PPS – coax from Phins – check this Phins has 1 pps
TX Cables to transducer T 1-24 via junction boxes
Eth1
Eth2
input pulse on Port A – I do not see an output pulse
UDP5 – Phins (from Port A): SEAPATH ethernet – 10 ms- 100 Hz – 192.168.36.102
Remote Off/On
Atlantis Network 199.92.161.31
Eth3
Eth2
HWS
COM1- Sound Velocity In – from Thermosalinograph, via Calliope
COM2- Center Depth Out - datagram
USB
USB
Video 1
Video 2
DVI-D KVM EXTENDER
Ethernet - primary to KVM
Ethernet – secondary to KVM #2
*these cross computer lab via CAT5 and go to monitors / mouse / keyboard at forward end of lab via a second DVI-D box

NOT TOSCALE

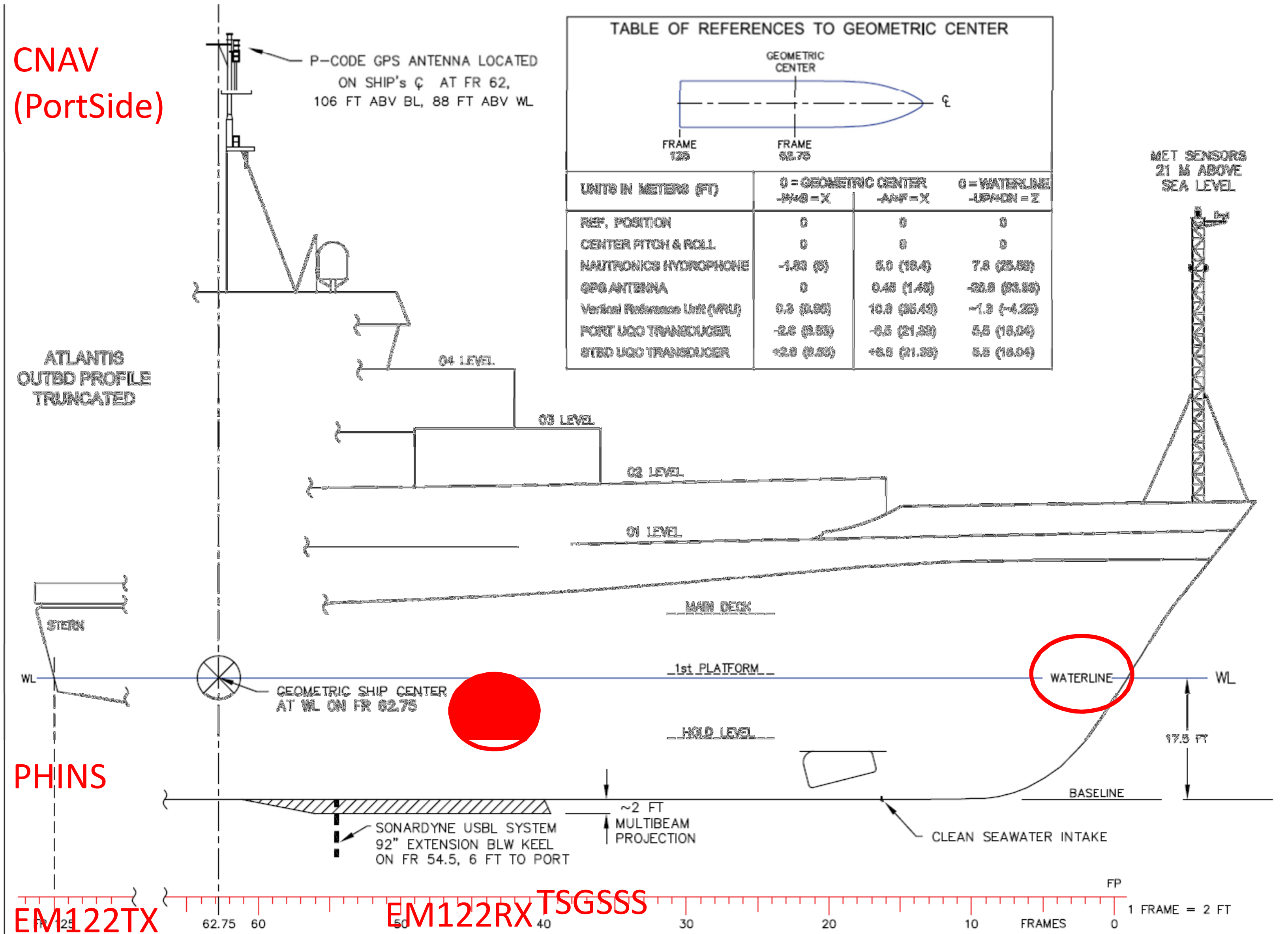


TABLE OF REFERENCES TO GEOMETRIC CENTER

UNITS IN METERS (FT)	0 = GEOMETRIC CENTER -P/+S = X	-A/+F = X	0 = WATERLINE -UP/+DN = Z
REF. POSITION	0	0	0
CENTER PITCH & ROLL	0	0	0
NAUTRONICS HYDROPHONE	-1.83 (6)	5.0 (16.4)	7.8 (25.59)
GPS ANTENNA	0	0.45 (1.48)	-26.8 (88.88)
Vertical Reference Unit (VRU)	0.3 (0.98)	10.8 (35.43)	-1.3 (-4.26)
PORT UQC TRANSDUCER	-2.9 (9.53)	-6.5 (21.33)	5.5 (18.04)
STBD UQC TRANSDUCER	+2.9 (9.53)	+6.5 (21.33)	5.5 (18.04)

SENSORS REFERENCED TO GEOMETRIC CENTER

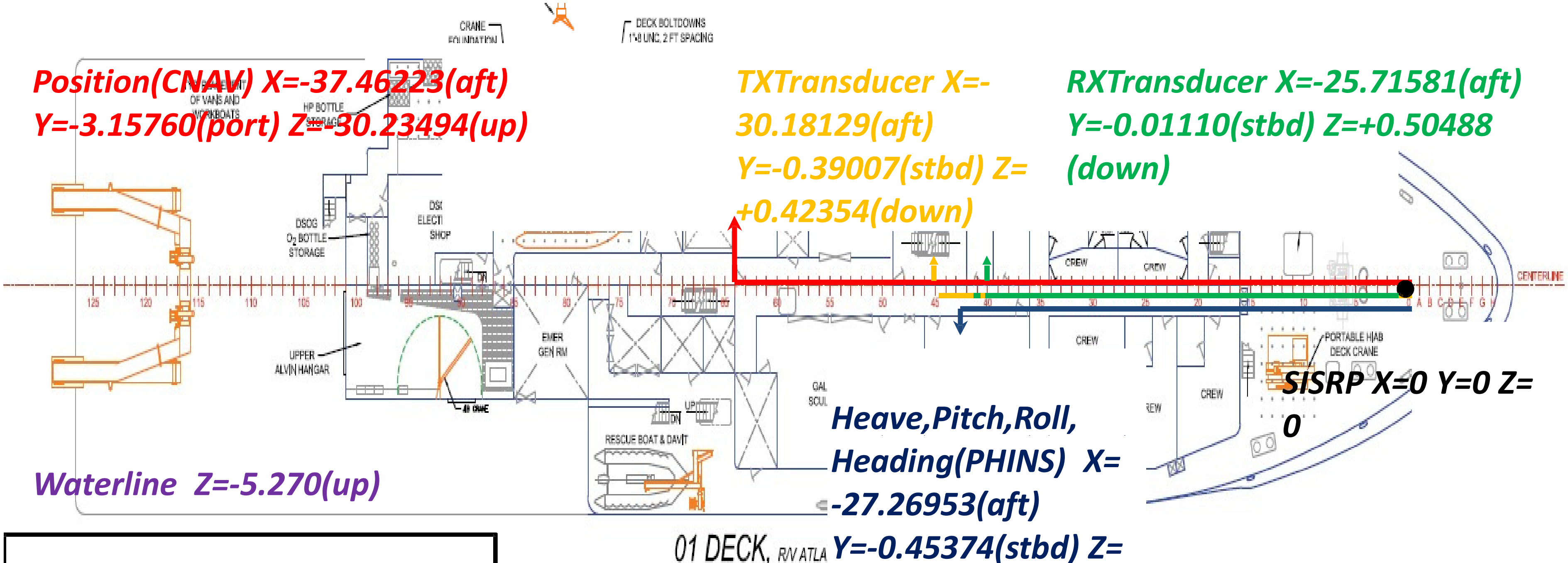
R/V ATLANTIS

Woods Hole Oceanographic Institution
Betsey Doherty 02/22/2012
SENSORS REF TO GEO CENTER SAT0101

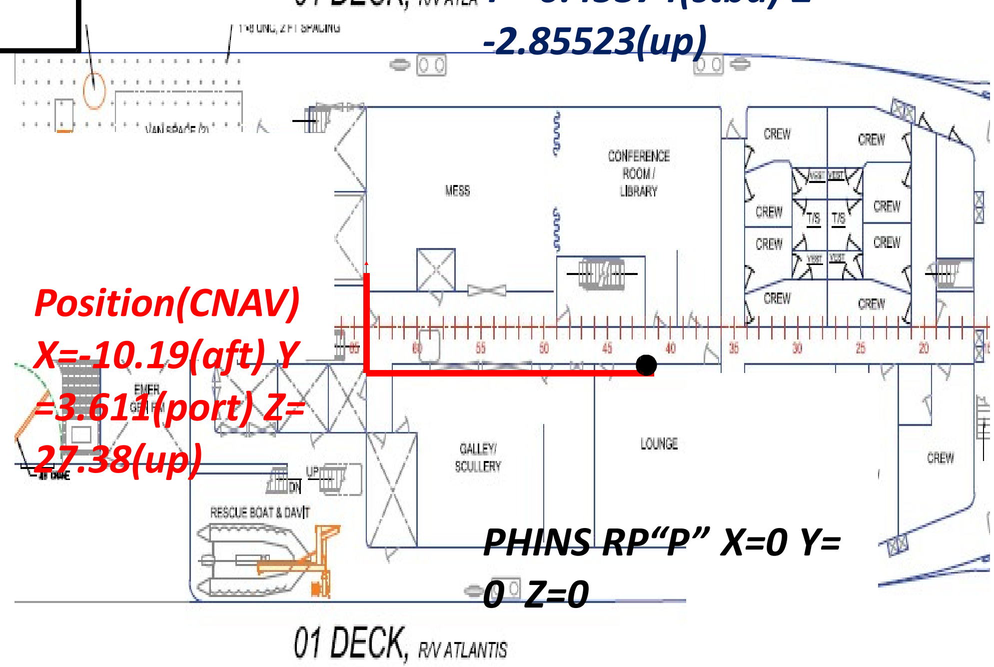
EM122SIS
RefPt
FrameZero

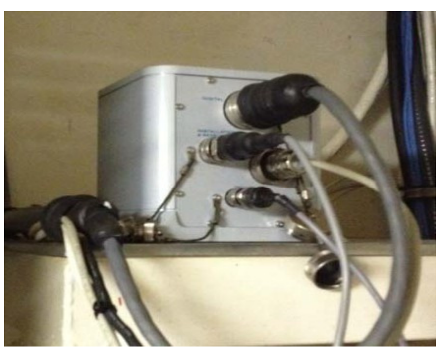
OffsetsEnteredinSIS:

NOTTOSCALE



OffsetsEnteredinPHINS:





PHINSAngular Offsets
Roll:-0.412 (port up) **Pitch:-0.142** (bowdown)
Heading:0

Reversed180 deg duetoIMU mounting