Gulf of Maine Mapping Initiative, Priority 1 Area Survey Report

18 November 2005

Under Contract No:
DG133C-03-CQ-0014
CLIN002

Prepared For:
National Oceanic and Atmospheric Administration
National Ocean Service
Silver Spring, MD

Delivered To:
Center for Coastal and Ocean Mapping
Joint Hydrographic Center
University of New Hampshire

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From Science to Solutions™

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Gulf of Maine Mapping Initiative,

Priority 1 Area Survey Report

SAIC Doc 05-TR-017

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Revisions				
Rev	Date	Pages Affected	Approved by	Remarks
0	11/18//2005	All		Original Document

REPORT CERTIFICATION

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Lead Hydrographer

SAIC

____ Date: *11/18/2005*

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ACRONYMS

Acronym	Definition
CTD	**C**onductivity, **T**emperature, **D**epth profiler
DGPS	**D**ifferential **G**lobal **P**ositioning **S**ystem
DPC	**D**ata **P**rocessing **C**enter
DXF	**D**ata e**X**change **F**ormat
GPS	**G**lobal **P**ositioning **S**ystem
GOMMI	**G**ulf **O**f **M**aine **M**apping **I**nitiative
GSF	**G**eneric **S**ensor **F**ormat
IMU	**I**nertial **M**easurement **U**nit
ISO	**I**nternational **O**rganization for **S**tandardization
ISS-2000	**I**ntegrated **S**urvey **S**oftware 2000
ISSC	**I**ntegrated **S**urvey **S**ystem **C**omputer
IRIG-B	**I**nter **R**ange **I**nstrumentation **G**roup **B**
JD	**J**ulian **D**ay
LTO	**L**inear **T**ape-**O**pen
MVE	**M**ulti-**V**iew **E**ditor
MVP	**M**oving **V**essel **P**rofiler
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
PFM	**P**ure **F**ile **M**agic
POS/MV	**P**osition **O**rientation **S**ystem/**M**arine **V**essels
PPS	**P**ulse **P**er **S**econd
SABER	**S**urvey **A**nalysis and area **B**ased **E**dito**R**
SAIC	**S**cience **A**pplications **I**nternational **C**orporation
SAT	**S**ea **A**cceptance **T**ests, or **S**wath **A**lignment **T**ool
SBE	**S**ea**B**ird **E**lectrronics
SVP	**S**ound **V**elocity **P**rofile
TTL	**T**ransistor-**T**ransistor **L**ogic
TVG	**T**ime **V**eriable **G**ain
UTC	**C**oordinated **U**niversal **T**ime
XTF	e**X**tended **T**riton **F**ormat

1. INTRODUCTION

Science Applications International Corporation (SAIC), under contract to the National Oceanic and Atmospheric Administration (NOAA), National Ocean Service conducted a multibeam bathymetric survey within the western Gulf of Maine (Figure 1) in support of the Gulf of Maine Mapping Initiative (GOMMI). SAIC worked closely with the University of New Hampshire, Joint Hydrographic Center during the survey planning and execution phases of the program in order to prioritize survey sub-areas within the overall survey area boundary.

This survey acquired multibeam bathymetry and imagery using a Reson 8101 multibeam echo sounder installed on the survey ship *M/V Atlantic Surveyor*, operated by SAIC. The survey plan was to conduct survey operations within the survey area (shown in black in Figure 1) to the extent possible under the current level of funding. Figure 1 also illustrates the final survey coverage obtained during the 2005 effort.

Survey operations were conducted in two separate time periods, 25 April-30 June and 07-15 September 2005. During the first period, the survey was initiated at the southwestern most corner of the area, off Provincetown, MA and progressed to the north and east. During the second period, survey operations concentrated on the high priority areas of Caches and Fippennies Ledges.

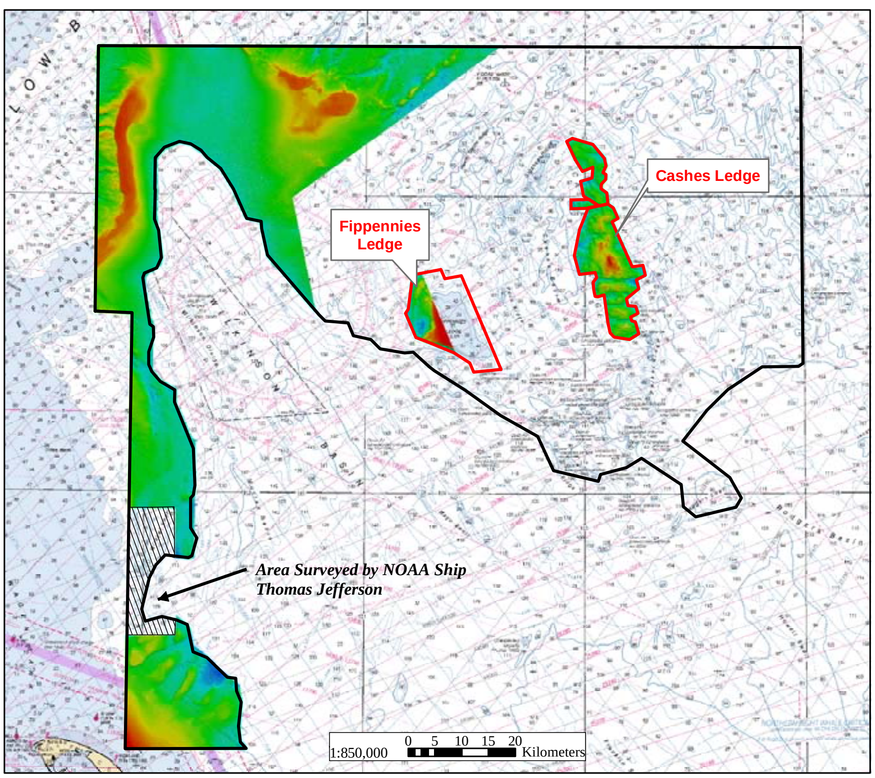

Figure 1. Gulf of Maine Mapping Initiative (GOMMI) Survey Area

Vessel operation, data acquisition, initial data processing, and on board quality assurance were performed by SAIC. All data were shipped to the Data Processing Center in the SAIC Newport, RI office for final data processing. This report documents the field survey and data processing effort.

2. SURVEY PLAN

The survey area bounds shown in Figure 1 were selected based on the range capabilities of the Reson 8101 multibeam, which limited the survey to areas with a maximum depth of 200 meters or less. The southwestern corner of the survey was located approximately 3.5 km northeast of Highland light located on Cape Cod, MA. The survey boundary then extends northward approximately 133 km into Bigelow Bight approximately 51 km east northeast of Portsmouth Harbor and 39 km east of Ogunquit, NH. The area then extends eastward approximately 132 km turning south for 59 km to the 200 meter depth curve. The area continues back to the west, northwest and finally south following the 200 meter depth curve around Wilkinson Basin. A small area in the southwest corner of the survey area over Wildcat Knoll was removed from the proposed survey outlined in Figure 1. The NOAA ship *Thomas Jefferson* was scheduled to conduct survey in this area.

The survey comprised main scheme lines with spacing that varied based on the water depth and anticipated usable swath widths, and irregularly spaced cross lines to provide quality control statistical measures for the bathymetry. The Reson 8101 cutoff angles, range scale and transmit power were varied according to the water depth. Total swath cutoff angles during data acquisition were limited to a maximum of 120 degrees, and in the deeper areas were reduced to a minimum of approximately 80 degrees. Changes in the range and transmit power were minimized while maintaining data quality. The intent was to obtain 100% coverage with multibeam bathymetry and imagery; however, there are some areas where small gaps exist between bathymetry swaths. Vessel speed for the survey was nominally 7 knots. Irregularly spaced cross lines were acquired to provide quality control statistical measures for the bathymetry.

3. OPERATIONS

Survey operations were conducted in 2 phases:

Phase 1: 25 April 2005 to 30 June 2005 (JD 115-181) and
Phase 2: 07 September 2005 to 15 September 2005 (JD 250 to 258)

During Phase 1 of the survey, the priority was to collect data starting at the western side of the survey area and work eastward. Coverage was obtained from the western bounds of the survey area eastward to Three Dory Ridge.

Phase 2 of the survey was focused on discrete high priority areas not covered during Phase 1. The Phase 2 effort was concentrated on Cashes Ledge and Fippennies Ledge as shown in Figure 2.

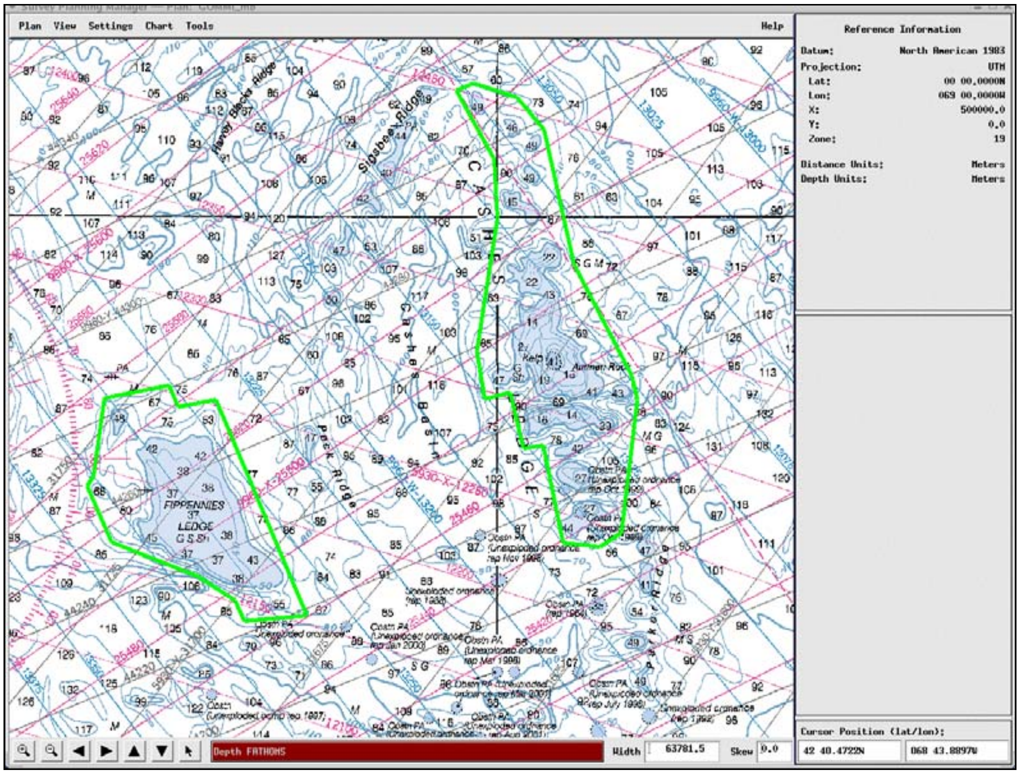

Figure 2. Phase 2 Survey Effort Over Cashes Ledge and Fippennies Ledge

3.1 The Survey Vessel

The *M/V Atlantic Surveyor* (Figure 3) was used as the data collection platform. The vessel is equipped with an autopilot, echo sounder, Differential Global Positioning System (DGPS), radars, and two 40 KW diesel generators. Accommodations for twelve surveyors are available within three cabins. Table 1 displays the vessel characteristics for the *M/V Atlantic Surveyor*.

Figure 3. *M/V Atlantic Surveyor.*

Table 1. Survey Vessel Characteristics, *M/V Atlantic Surveyor*

Vessel Name	LOA	Beam	Draft	Max Speed	Gross Tonnage	Power (Hp)	Registration Number
M/V Atlantic Surveyor	110'	26'	9'	14 knots	Displacement 68 net tons Deck load 65 long tons	900	D582365

Three 20-foot ISO containers and a generator were secured on the aft deck of the *M/V Atlantic Surveyor*. One ISO van was used as the real-time, survey data collection office and the data processing office. The other ISO van was used for post processing back-up, and communication (telephone and email). The third ISO container was used for spares storage, maintenance and repairs. The generator provided dedicated power to the survey containers and associated survey equipment (Figure 4).

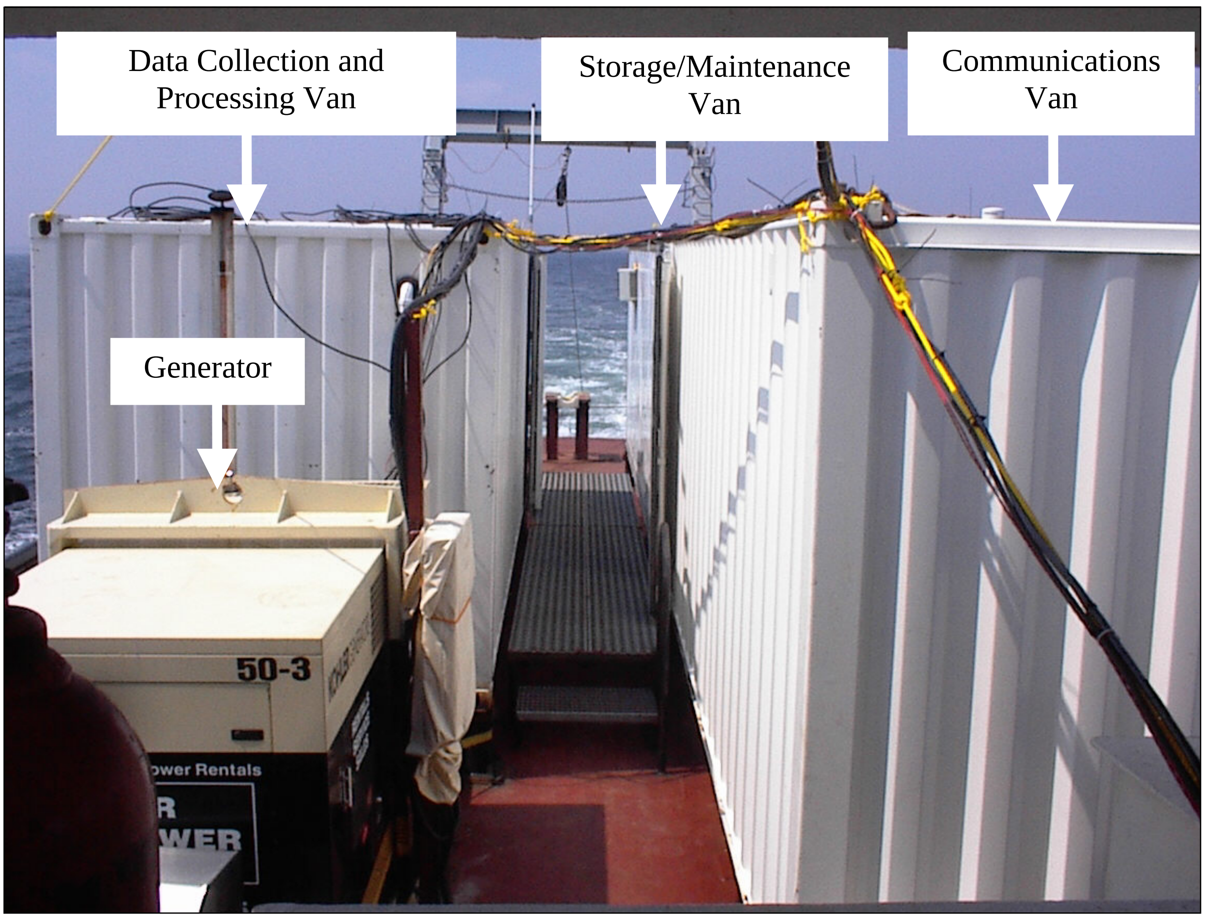

Figure 4. The *M/V Atlantic Surveyor's* Aft Deck

The Position Orientation System/Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) was mounted below the main deck of the vessel, 0.40 meters port of centerline and 0.34 meters forward and above the RESON 8101 transducer. The multibeam sounder transducer was mounted on the hull 0.52 meters port of the keel. A Brook Ocean Technologies Moving Vessel Profiler 30 (MVP-30) was mounted to the starboard stern quarter.

3.1.1 Acquisition Systems and Operations

The real time bathymetry/imagery acquisition system used for the Gulf of Maine Mapping Initiative Priority 1 Area Survey is detailed in Table 2.

Table 2. *M/V Atlantic Surveyor* Acquisition System

	Manufacturer / Model Number	Subsystem
Multibeam Sonar	RESON SeaBat 8101	Transducer 8101 Processor
Vessel Attitude System	TSS POS/MV Inertial Navigation System	
Positioning System	TSS POS/MV	
	Trimble 7400 GPS Receiver	
	Trimble Probeacon Differential Beacon Receiver	
	Leica MX41R Differential Beacon Receiver	
Sound Velocity System	Brooke Ocean Technology Ltd., Moving Vessel Profiler-30	Applied Microsystems Ltd. Smart SV and Pressure Sensor
	Sea-Bird Electronics, Inc. CTD Profiler	

Data acquisition was carried out using the SAIC Integrated Survey System **(**ISS-2000). Real-time navigation, data time tagging and data logging were controlled by the ISS-2000 on a Windows 2000 computer. Survey planning, data processing and analysis were performed on LINUX machines using SAIC's SABER software.

Navigation was recorded from both the POS/MV system and the Trimble 7400. Data from the POS/MV was used as the primary navigation and was merged with the multibeam data. Vessel positioning confidence checks were done by comparing data recorded from the POS/MV to data recorded from the Trimble DGPS.

Confidence checks of the multibeam echo sounder were made using lead line comparisons during port calls (approximately every 1-2 weeks). The lead line results are presented in Appendix A.

3.1.2 Vessel Configuration Parameters

During SAIC's preparation for the 2005 survey season, the acquisition system configuration aboard the *M/V Atlantic Surveyor* was measured in reference to the IMU and converted to be relative to the Reson 8101 transducer, as tabulated in Table 3 and depicted graphically in Figure 5.

Table 3. *M/V Atlantic Surveyor* Antenna and Transducer Locations Relative to the POS/MV IMU Vessel Reference Point (measurements are in meters)

Sensor	Offset in ISS-2000		Offset in POS/MV	
Multibeam Reson 8101 Transducer Hull Mount			X	-0.34
			Y	-0.12
			Z	+1.64
Reference to Heave (POS/MV IMU)			X	0.00
			Y	0.00
			Z	0.00
POS/MV GPS Master Antenna			X	+4.36
			Y	-0.61
			Z	-6.24
Trimble GPS Antenna	X	+4.70		
	Y	+0.51		
	Z	-7.88		

The SAIC Integrated Survey System (ISS-2000) utilizes a coordinate system where “z” is considered to be positive down, “x” is considered to be positive forward, and “y” is considered to be positive athwart ships to starboard. All sensors connected to ISS-2000 have their coordinate system corrected to match the one used by ISS-2000.

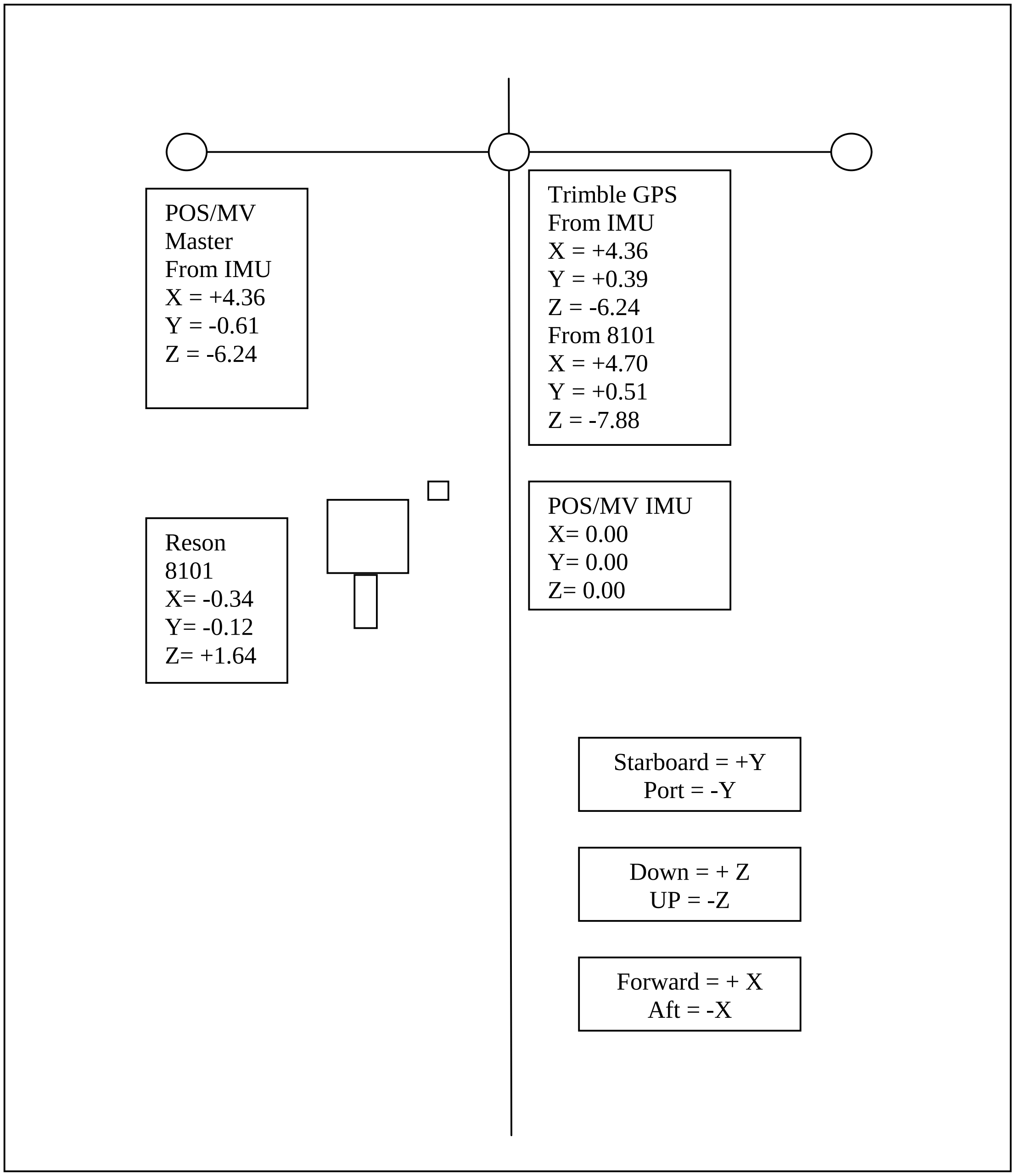

Figure 5. Configuration of the *M/V Atlantic Surveyor* during Survey Operations (measurements in meters)

3.1.3 Static and Dynamic Draft Measurements

3.1.3.1 Static Draft

Figure 6 shows the static draft calculations for the *M/V Atlantic Surveyor*. Depth of the transducer below the deck (3.30 meters) was determined from measurements made while the boat was hauled in May 2004. The distance below the boat deck to the water surface was then measured and subtracted from the transducer depth to determine the draft of the transducer's acoustic center. Draft measurements were taken on each side of the vessel at each port call, both after arrival and before departure, in order to prorate the daily draft for fuel and water consumption. The static draft value was recorded in the real-time Navigation Logs (Appendix B) as well as the Static Draft Log (Appendix C). If the static draft value changed from the previously noted value, the new value was entered into the ISS-2000 system.

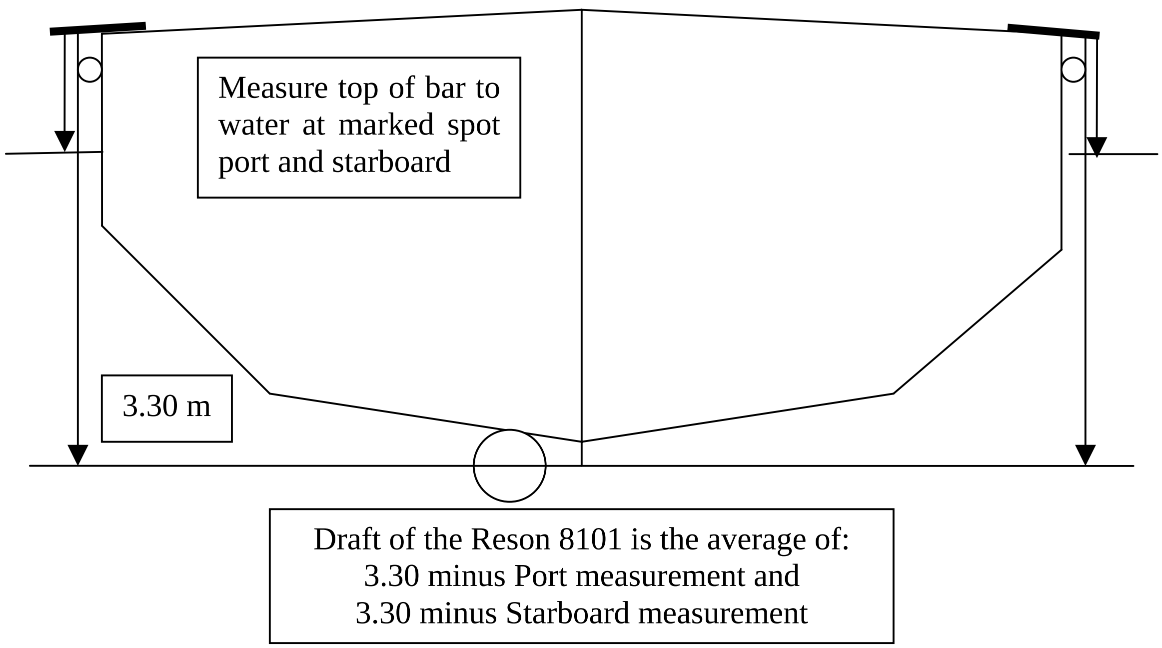

Figure 6. *M/V Atlantic Surveyor* Draft Determination

3.1.3.2 Settlement and Squat

Settlement and squat correctors were determined during the initial Sea Acceptance Test for the *M/V Atlantic Surveyor* in June 2004. The correctors were determined by establishing a multibeam soundings reference by bringing the *M/V Atlantic Surveyor* to "all stop" and drifting with the wind and current. The vessel drifted nearly dead astern making it possible to record a normal swath of soundings (asmba04162.d01). A survey line was created that crossed the reference swath at a selected spot and run twice at each of the shaft rpm settings. A Pure File Magic (PFM) grid was made from these files. In the Multi View Editor (MVE), an area of the PFM near nadir was selected for display. The reference file and the two files for the desired shaft rpm were displayed and depth differences and offsets were measured in several places. Correctors resulting from the average of these measurements are shown in Table 4. This procedure is valid because the IMU and the multibeam transducer are mounted almost directly in line vertically.

Table 4. *M/V Atlantic Surveyor* Settlement and Squat Determination

Shaft RPM	Depth Corrector	Depth	Approximate Speed, Knots	Multibeam Files	
0	0.00	22.04	0	asmba04162.d01	
140	0.00	22.04	4	asmba04162.d02	asmba04162.d03
180	-0.01	22.05	5	asmba04162.d04	asmba04162.d05
220	0.00	22.04	6	asmba04162.d06	asmba04162.d07
255	0.00	22.03	7	asmba04162.d08	asmba04162.d09
300	0.04	22.00	8	asmba04162.d10	asmba04162.d11
340	0.10	21.93	9	asmba04162.d12	asmba04162.d13
390	0.13	21.91	10	asmba04162.d14	asmba04162.d15

3.1.4 Multibeam Bias Calibration Results (Patch Test)

SAIC conducted a "System Acceptance Test" 11 April 2005 (JD 101) prior to the commencement of the survey season and a confirmation patch test again on 07 September 2005 (JD 250). A timing test and transducer alignments were determined during the System Acceptance Test in April 2005 and transducer alignments were verified during the patch test in September 2005.

3.1.4.1 Timing Test

A ping timing test was completed on 08 April 2005 (JD 098) to verify that no timing errors exist within the survey system. The fundamental measurement tool is the event marking capability of the Symmetricom BC635PCI IRIG-B card. An event is characterized by a positive-going TTL pulse occurring on the event line of the IRIG-B connector on the back of the Integrated Survey System Computer (ISSC). The pulses of interest are the transmit trigger of the RESON 81-P and the 1PPS timing pulses from the POS/MV. This test demonstrated that all Generic Sensor Format (GSF) ping times matched the corresponding IRIG-B event times to within 2.5 milliseconds or less (Figure 7).

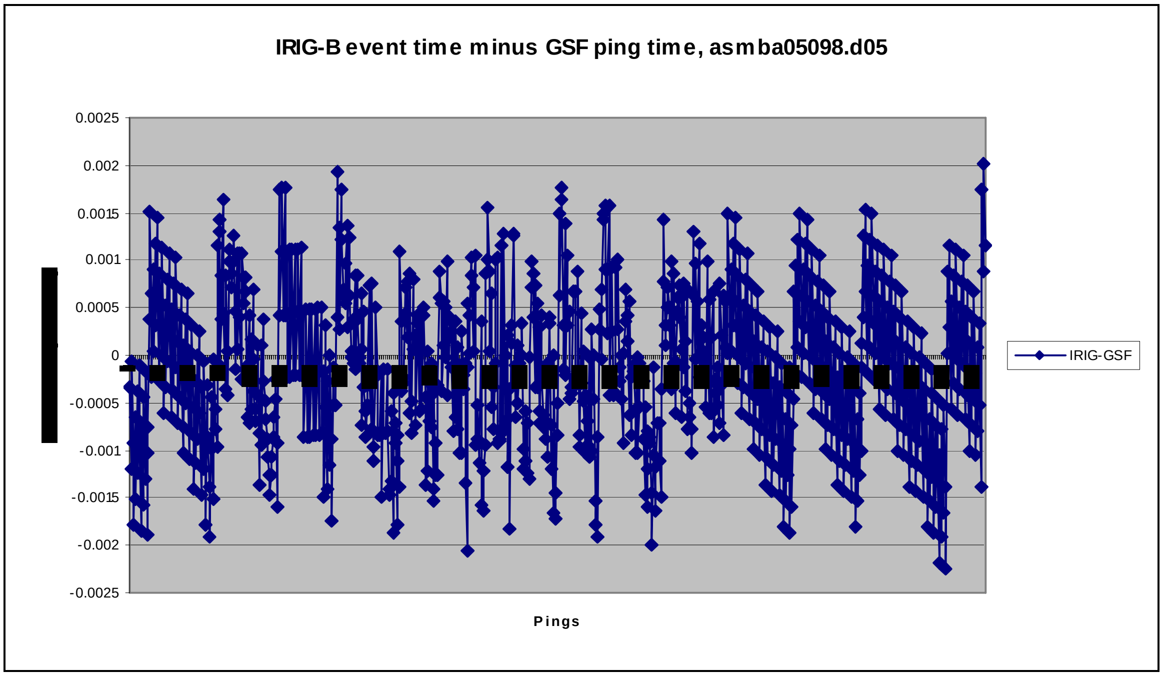

Figure 7. Timing Test Results (08 April 2005)

3.1.4.2 Alignment Results

Roll, pitch, and yaw biases were determined on 11 April 2005 (JD101) over a charted 47 foot wreck in the fish haven approximately 6 kilometers southeast of Manasquan Inlet, NJ (40° 03' 23.55"N, 073° 59' 33.25"W). The pitch, roll and gyro biases were determined and confirmed.

Table 5. Multibeam Files Used for Alignment Bias Calculation in April 2005

Component	Multibeam files (pairs)		Result
Pitch	asmba05101.d02	asmba05101.d03	+2.2°
Roll	asmba05101.d04	asmba05101.d05	+0.59°
Gyro	asmba05101.d06	asmba05101.d08	+2.1°

3.1.4.3 Roll Alignment

Two sets of lines were collected for roll bias calculation. For each set, lines were run along the same survey transect, on reciprocal headings in order that separate roll comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Once a roll bias was determined, the value was entered into the system, and an additional set of lines were run to verify the results. Figure 8 shows images of the SAT tool depicting data collected with the +0.59° roll bias entered in the ISS-2000 system, therefore the indicated additional bias is zero, thus confirming the entered bias.

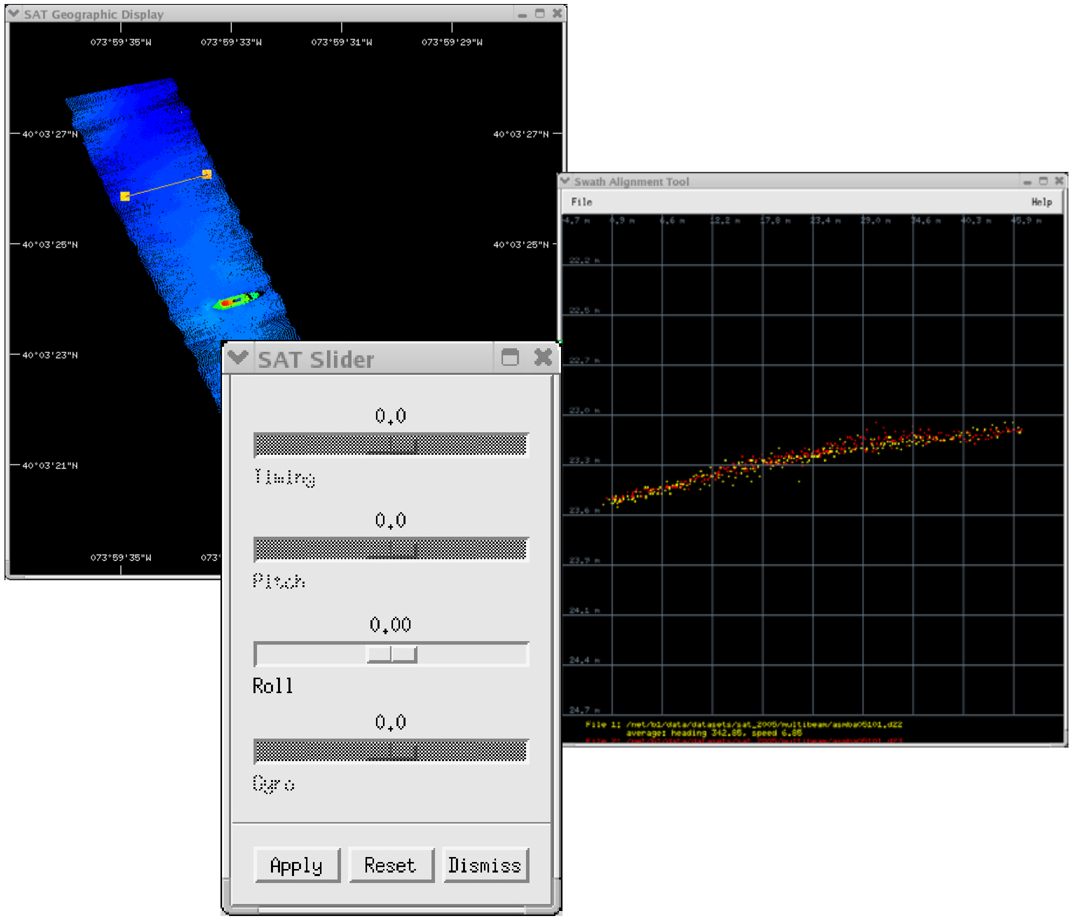

Figure 8. Swath Alignment Tool: Roll Bias = +0.59°

3.1.4.4 Pitch Alignment

Two sets of lines were collected for pitch bias calculation. For each set of measurements, lines were run along the same survey transect, on reciprocal headings in order that separate pitch comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Once a pitch bias was determined, the value was entered into the system, and an additional set of lines were run to verify the results. Figure 9 shows images of the SAT tool depicting data collected with the +2.2° pitch bias entered in the ISS-2000 system, therefore the indicated additional bias is zero thus confirming the entered bias.

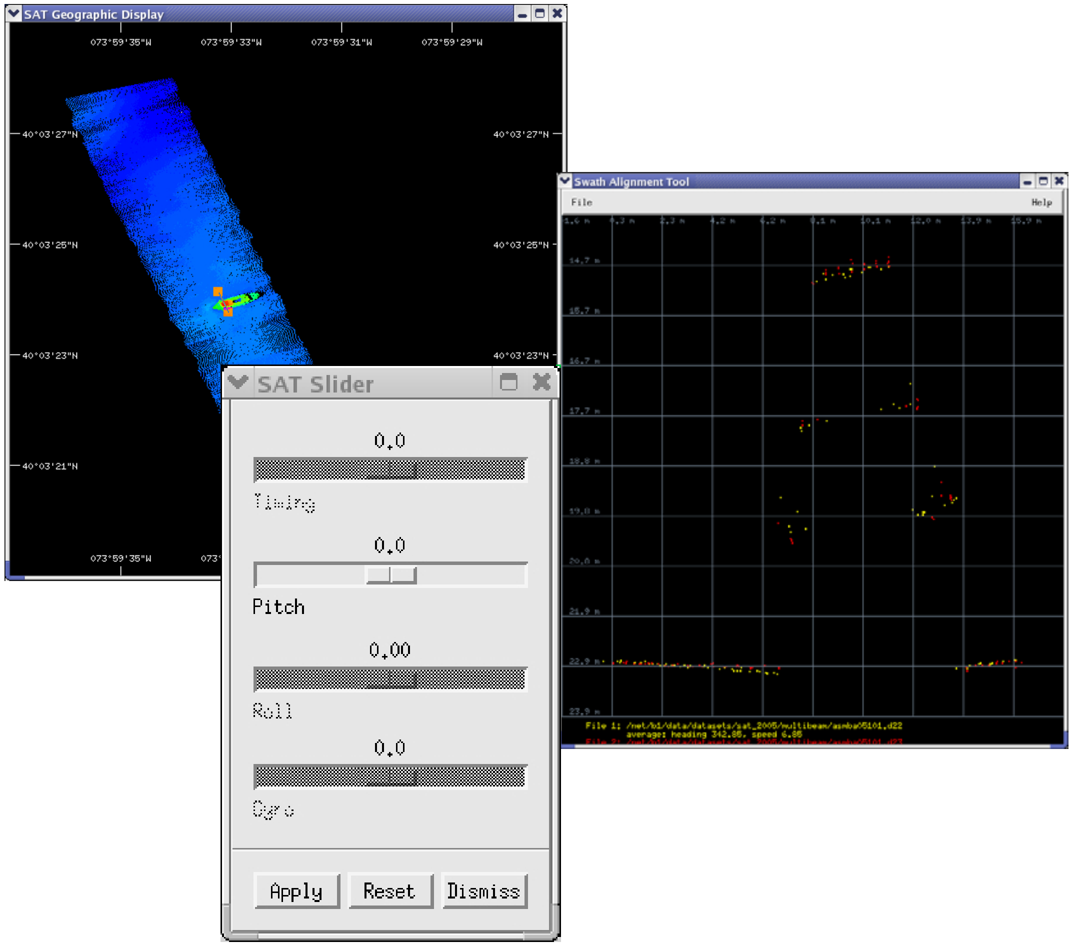

Figure 9. Swath Alignment Tool: Pitch Bias = +2.2°

3.1.4.5 Gyro Alignment

Two sets of lines were collected for the gyro bias calculation. Lines were run on either side of the charted wreck in opposite directions in order that separate comparisons could be made. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the gyro bias. Once a gyro bias was determined, the value was entered into the system, and an additional set of lines were run to verify the results. Figure 10 shows images of the SAT tool depicting data collected with the +2.1° gyro bias entered in the ISS-2000 system; therefore the indicated additional bias is zero thus confirming the entered bias.

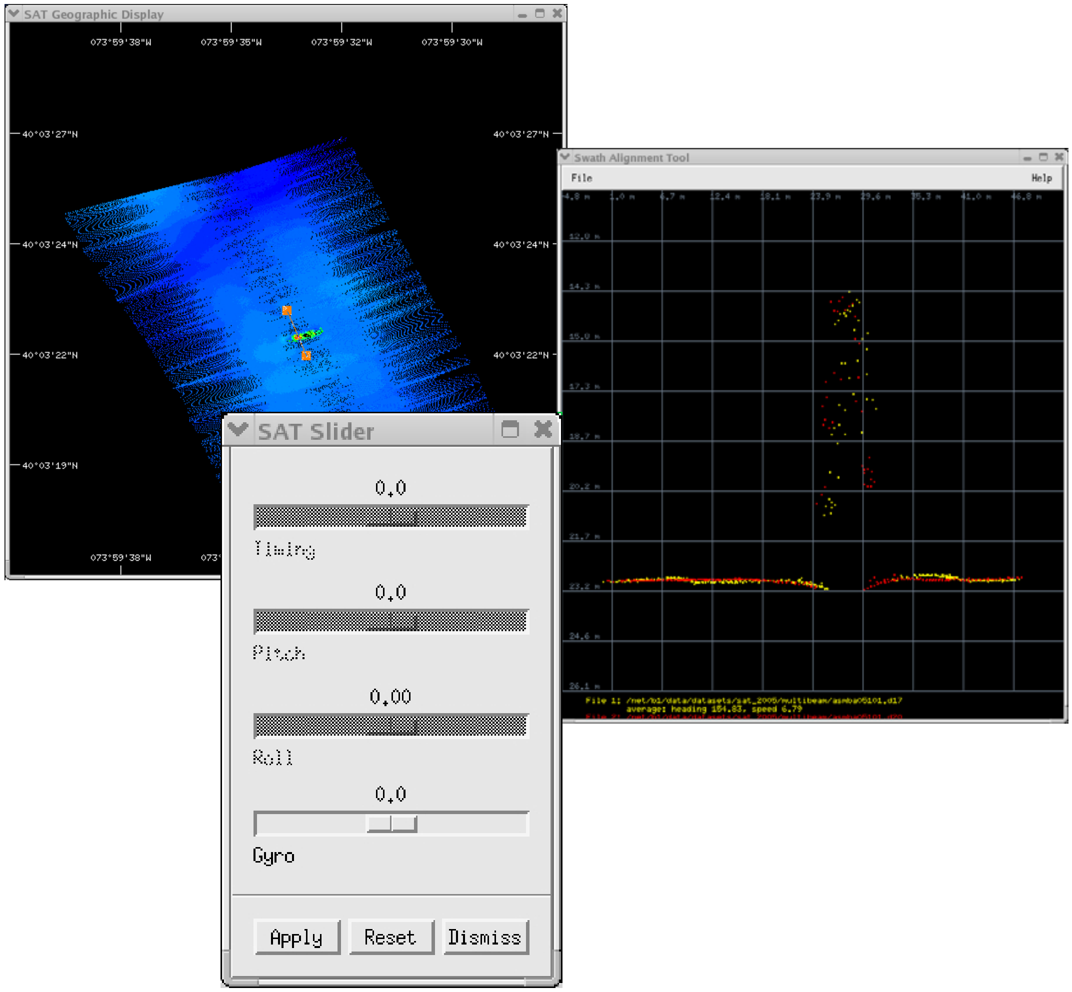

Figure 10. Swath Alignment Tool: Gyro Bias = +2.1°

On 06 September 2005 (JD 249) the *M/V Atlantic Surveyor* transited from New Jersey to Massachusetts. Roll, pitch, and yaw biases were verified on 07 September 2005 (JD 250). Alignment lines were run over a charted submerged pipe and adjacent flat bottom located at approximately 42° 37' 10.02"N, 073° 33' 23.55"W. Depths ranged from 42.28 meters to 48.25 meters. Table 6 lists the files used for the calibration of the survey system. The previously determined biases were confirmed during this patch test.

Table 6. Multibeam Files Used for Alignment Bias Calculation in September 2005

Component	Multibeam files (pairs)		Result
Pitch	asmba05250.d03	asmba05250.d04	+2.2°
Roll	asmba05250.d03	asmba05250.d04	+0.59°
Gyro	asmba05250.d06	asmba05205.d07	+2.1°

3.1.5 Sound Velocity Profiles

Sound velocity profile (SVP) data were acquired using either a Brooke Ocean Technology Moving Vessel Profiler 30 (MVP-30) with an Applied Microsystems Smart Sound Velocity and Pressure sensors or a Seabird Electronics (SBE) 19 CTD. In deeper waters the vessel was stopped to take CTD or MVP-30 casts. The MVP-30 has a profile capability limit of approximately 125 meters with the vessel stopped due to the amount of cable on the unit. Therefore a SBE 19 CTD was used to obtain casts to a maximum of 180 meters depth in the deeper areas of the survey.

SVP data were obtained at frequent intervals to reduce sound velocity errors. The frequency of casts was based on observed sound velocity changes from previously collected profiles and time elapsed since the last cast. Multiple casts were taken along a survey line to identify the rate and location of sound velocity changes. The frequency and location of subsequent casts were made based on the observed trend of sound velocity changes. Confidence checks of the sound velocity profile casts were conducted approximately every 7-10 days by comparing two consecutive co-located casts taken with different Sound Velocity and Pressure sensors or with a Sound Velocity and Pressure sensor and a Seabird SBE-19 CTD. The taken and applied sound velocity profiles are presented in Appendix D.

4. DATA PROCESSING

4.1 Multibeam Bathymetry Data Processing

The majority of the multibeam data were initially edited onboard the vessel, using SAIC's Multi-View Editor (MVE) program. This tool is a geo-referenced editor, which allows for both plan and profile views with each beam in its true geographic position and depth. Each data file was edited to remove noise, fish, etc. At each port call, both the raw and processed data were backed up onto 4mm tapes and/or Ultrium LTO tapes and shipped to the Data Processing Center (DPC) in Newport, RI.

Once the data were in Newport and had been extracted to local machines, track lines were created by extracting the sounder position from the multibeam data. The tracks were reviewed to confirm that no errors in navigation existed and that the tracks extended to the outermost bounds of the survey area.

Correctors that were applied to the multibeam files included verified tides and interpolated draft. To perform a quality control check on the ping editing that had been done on the vessel, a 5-meter Pure File Magic (PFM) grid was generated and edited in area based mode using MVE. The 5-meter projected PFM allowed multiple line editing which enhances visualization and improves efficiencies in the editing/reviewing process to ensure data quality. If any anomalies were found in the sounding bins, the edited multibeam files were re-examined and re-edited as necessary. When all multibeam files were determined to be satisfactory, the data were binned to a 5-meter cell size, populating the bin with the foot printed average of all soundings in the bin at the position of the center of the bin.

4.1.1 Tides and Water Levels

Tide zones based on the NOAA tide station in Portland, ME (8418150) were used with predicted tides (Table 7, Figure 11) during the data acquisition effort. Tide zones based on the NOAA tide stations in Boston, MA (8443970) and Fort Point, NH (8423898) were used with verified water levels during the post processing effort (Table 8, Figure 12).

Table 7. The Zoning Parameters Created by SAIC Used for Data Collection

Zone Name	Tide Station Name	Tide Station ID	Time Corrector (minutes)	Range Ratio
gom_1.zne	Portland, ME	8418150	+ 8	0.986
gom_2.zne	Portland, ME	8418150	+ 8	0.976
gom_3.zne	Portland, ME	8418150	+ 2	0.960
gom_4.zne	Portland, ME	8418150	+ 00	0.950
gom_5.zne	Portland, ME	8418150	- 03	0.940
gom_6.zne	Portland, ME	8418150	- 06	0.960

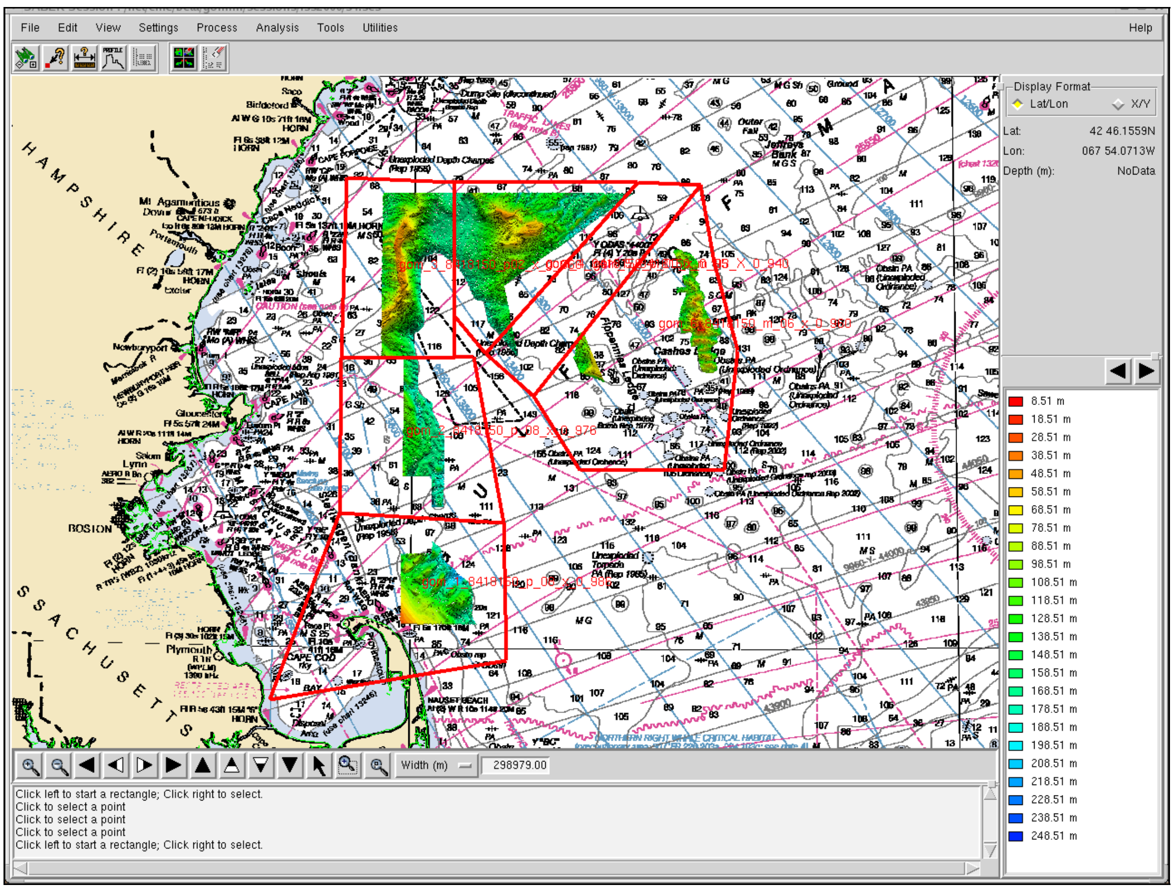

Figure 11. The Zoning Parameters Created by SAIC Used for Data Collection

This change in zoning and tide stations occurred as a result of the survey efforts being conducted by the NOAA ship *Thomas Jefferson*. The use of common zones and tide stations will allow a better match between data collected by SAIC and data collected by the *Thomas Jefferson*. For survey areas where zoning was not provided by NOAA, new zones were created using the NOAA tide stations in Boston, MA (8443970) and Fort Point, NH (8423898) (Table 8, Figure 12). NOAA provide zones are indicated in Table 8 by the prefix "NA", while SAIC generated zones are indicated by the prefix "WS". Preliminary and verified tide data for the stations were downloaded from the NOAA CO-OPS web page (http://co-ops.nos.noaa.gov/data_res.html). All tide data were annotated with Coordinated Universal Time (UTC). Complete zoning parameters used for data collection and post processing can be found in Appendix E.

Table 8. The Zoning Parameters Created by NOAA and SAIC Used for Data Processing

Zone Name	Tide Station Name	Tide Station ID	Time Corrector (minutes)	Range Ratio
NA155.zne	Fort Point, NH	8423898	- 24	0.99
NA177.zne	Boston, MA	8443970	- 12	0.87
NA178.zne	Boston, MA	8443970	- 30	0.87
NA183.zne	Boston, MA	8443970	- 30	0.85
NA184.zne	Boston, MA	8443970	- 12	0.85
NA199.zne	Boston, MA	8443970	- 6	0.83
NA200.zne	Boston, MA	8443970	- 12	0.83
NA207.zne	Boston, MA	8443970	- 12	0.81
NA208.zne	Boston, MA	8443970	- 6	0.81
NA209.zne	Boston, MA	8443970	+ 00	0.79
WS210.zne	Boston, MA	8443970	- 12	0.79
WS211.zne	Boston, MA	8443970	+ 6	0.79
WS212.zne	Fort Point, NH	8423898	- 36	0.99
WS213.zne	Boston, MA	8443970	- 36	0.87
WS214.zne	Boston, MA	8443970	- 36	0.85

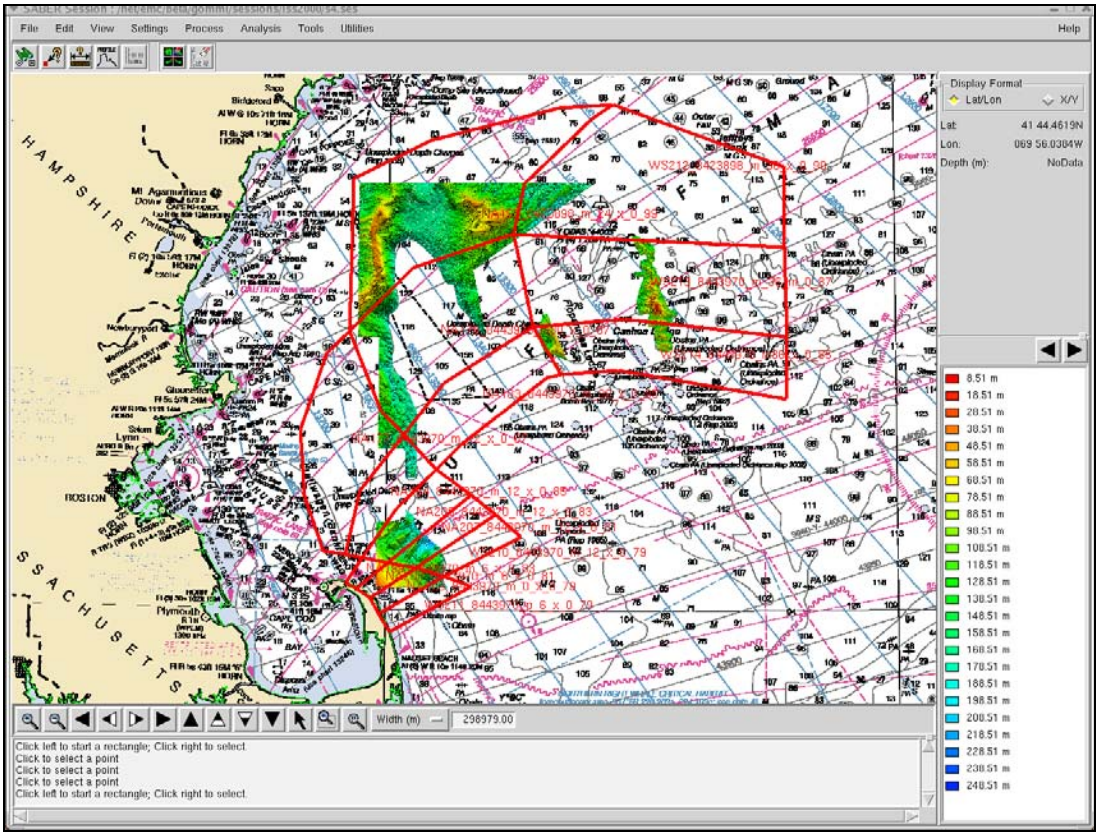

Figure 12. The Zoning Parameters Created by NOAA and SAIC Used for Data Processing

All bathymetry data collected during the survey were corrected for water level variations using water level files. Water level files for each tide zone were created from downloaded verified NOAA tide data using the SABER Create Water Level Files tool. Water level files contain water level heights that are subtracted algebraically from depths to correct the sounding for tide and water level. These water level files were applied to the multibeam data using the Apply Tides tool within the SABER software.

When the verified water level zoned heights file was applied to the GSF files, the program removed the predicted tide corrector and applied the new corrector. Each time a routine was run on the GSF multibeam data file, a history record was written at the end of the GSF file. For quality assurance the Check Tides program was run on all GSF files to confirm that the verified water level corrector had been applied to each online GSF file.

4.1.2 Draft

Draft was observed at the beginning and the end of each port call (leg) and recorded in the Navigation Log (Appendix B) and in the ISS-2000 system. Applied draft was determined by taking the difference of the draft from the start of the leg and the draft at the end each leg and incremented for the days of the leg. The draft was applied to each necessary multibeam file using Apply Correctors/Offsets within the SABER software and are presented in Appendix C.

4.2 Multibeam Imagery Data Processing

Two formats of multibeam imagery were acquired during this survey. Multibeam side scan data were acquired as separate data files in Extended Triton Format (XTF), while multibeam "snippet" data were logged within the standard multibeam Generic Sensor Format (GSF) files. The logged side scan data (XTF) were used to develop imagery mosaics, while no further processing was performed on the "snippet" data.

The default extension given to the Reson 8101 multibeam data collected using the ISS-2000 system was *.d* (i.e. *.d01, *.d02, numbered consecutively as files are created). The multibeam side-scan XTF data files were given a standard .xtf extension while retaining the *_d* naming convention within the name (i.e. *.d01 correlates with *_d01.xtf, *.d02 correlates with *_d02.xtf, etc). This naming convention allows different data file types to be easily correlated with one another.

During the first several days of acquisition a 5-meter mosaic was generated in SABER to check for data quality; throughout the survey this mosaic was appended to at convenient intervals to confirm data quality was being maintained. At each port call the files were copied to LTO tapes in tar format for transfer to the data processing facility for further processing.

4.2.1 Imagery Coverage Mosaic

The XTF data files were bottom tracked in Triton Isis to allow for slant range correction during the mosaic process. Time window files were created and used to create track lines to check for proper navigation and along track coverage. The time windows were then used to generate a preliminary 5-meter mosaic. The XTF data files contain full swath data. In some areas, this yields 200% to 300% coverage. In deeper water the outer ranges of the imagery swath is lighter than the data closer to nadir due to reduced return signal strengths. During the mosaic generation process, the data were clipped based on ground range using the SABER mosaic tool. By clipping the outer swath of the data, 100% imagery coverage is achieved utilizing the highest quality data. The resulting mosaics were then reviewed using SABER tools to verify swath coverage, bottom tracking accuracies, and gain continuity. After edits were made to the bottom tracking, time windows and gain settings, the final 5-meter mosaic was generated, quality controlled and exported as a tiff image (with TFW file) from SABER.

4.2.2 Imagery Quality

During data collection, changes in the multibeam range scale and transmit power were made only as needed to maintain quality data. Scale, gain and transmit power settings were made at the beginning of a line, and these settings were maintained, to the extent possible, throughout the line. This technique yielded imagery data that was more uniform within any given data file.

The image quality was good throughout the survey area. The multibeam side-scan data depicts distinct bottom type boundaries as well as small-scale features such as benthic scaring and small rocks. Changes in the sediment reflectivity are clearly defined in the data with most changes occurring in the southwestern corner and along the western edge of the survey area. Scaring of the bottom can be identified in many areas of the survey. The southwestern areas around Platt's Bank, the northern portion of Wildcat Knoll and the southeast margin of Jeffries Ledge all have notable bottom scaring.

Because of the steep slopes and rapidly changing depths across Cashes Ledge, range scale and transmit power were changed more frequently than across the rest of the survey area. As a result of the increased need to change settings, more variance in the tone is present. During post processing range and gain settings logged in the multibeam records within the GSF files were extracted and inserted into two auxiliary fields within the side scan XTF data files for this area. The power and gain settings were used during the mosaic building process to normalize the backscatter along lines where power and range changes occurred.

4.3 Annotated Track Lines

Track lines were generated in SABER, exported as a DXF and then brought into AutoCAD to clean and add Line Name Annotations, then exported as a DXF file for delivery.

4.4 Junction Analysis and Crossing Analysis

Comparison of cross line data to main scheme data was performed using two different methods available in the SABER software package. The first method is referred to as Junction Analysis and compares the depth differences between two overlapping grids of data. The second method is referred to as Analyze Crossings and performs a beam-to-beam comparison at the intersections of cross lines and main scheme lines.

4.4.1 Junction Analysis

Two overlapping grids were built for the entire survey area, one of main scheme line data and one of cross line data. Both grids were built using class 2 swath data from all applicable lines. These two grids were used to generate a third depth difference grid. The cells of the depth difference grids contained the depth difference between overlapping cells from the cross line grid and the main scheme grid. The SABER Junction Analysis tool displays the difference grid and allows the analyst to select either the entire difference grid or specific regions of a grid by drawing a polygon around an area of interest. The result is an ASCII text file listing the total number of observations (count), the number of positive and negative differences for various depth difference ranges (<5 cm, 5-10 cm, 10-15 cm, etc), and the percent of the total observations encompassed by each depth difference range.

A Junction analysis was performed of the entire difference grid as well as selected areas of differing bathymetry. This comparison of the cross line soundings and main scheme soundings for the entire survey area shows that 95.22% of the depth differences are less than 60 cm (Table 9). Comparisons greater than 200 centimeters were located in areas consisting of steep slopes of prominent geologic features. In general, depth comparisons in areas having steep topography produce slightly larger differences, as compared to areas of relatively flat topography, as a result of normal small DGPS position fluctuations. All comparisons greater than 550 cm are related to the Cashes Ledge survey area which consisted of the most variation in geological features. Appendix F provides more junction analysis results for discrete areas.

Table 9. Junction Analysis of All Main Scheme vs. Cross Line Data

Depth Difference Range		**All**		**Positive**		**Negative**		**Zero**
		Count	**Percent**	**Count**	**Percent**	**Count**	**Percent**	**Count**
0 cm to	5 cm	417087	13.11	185600	11.21	184996	12.51	
5 cm to	10 cm	445612	27.12	224703	24.78	220909	27.45	
10 cm to	15 cm	496591	42.73	250805	39.93	245786	44.07	
15 cm to	20 cm	298365	52.11	152124	49.12	146241	53.96	
20 cm to	25 cm	328537	62.44	170596	59.43	157941	64.64	
25 cm to	30 cm	323361	72.61	173252	69.89	150109	74.79	
30 cm to	35 cm	210974	79.24	117390	76.99	93584	81.11	
35 cm to	40 cm	135237	83.49	76323	81.6	58914	85.1	
40 cm to	45 cm	132316	87.65	75405	86.15	56911	88.95	
45 cm to	50 cm	99780	90.79	57112	89.6	42668	91.83	
50 cm to	60 cm	141050	95.22	83194	94.63	57856	95.74	
60 cm to	70 cm	68344	97.37	41555	97.14	26789	97.55	
70 cm to	80 cm	33273	98.42	20323	98.36	12950	98.43	
80 cm to	90 cm	19918	99.04	11886	99.08	8032	98.97	
90 cm to	100 cm	10690	99.38	6019	99.45	4671	99.29	
100 cm to	110 cm	6256	99.58	3329	99.65	2927	99.49	
110 cm to	120 cm	4093	99.71	2001	99.77	2092	99.63	
120 cm to	130 cm	1988	99.77	898	99.82	1090	99.7	
130 cm to	140 cm	1861	99.83	770	99.87	1091	99.78	
140 cm to	150 cm	1068	99.86	423	99.89	645	99.82	
150 cm to	160 cm	888	99.89	351	99.92	537	99.86	
160 cm to	170 cm	739	99.91	305	99.93	434	99.88	
170 cm to	180 cm	476	99.93	200	99.95	276	99.9	
180 cm to	190 cm	446	99.94	160	99.96	286	99.92	
190 cm to	200 cm	319	99.95	134	99.96	185	99.94	
200 cm to	220 cm	519	99.97	228	99.98	291	99.95	
220 cm to	240 cm	293	99.98	109	99.98	184	99.97	
240 cm to	260 cm	205	99.98	90	99.99	115	99.98	
260 cm to	280 cm	138	99.99	57	99.99	81	99.98	
280 cm to	300 cm	98	99.99	36	99.99	62	99.98	
300 cm to	320 cm	74	99.99	26	100	48	99.99	
320 cm to	340 cm	67	99.99	20	100	47	99.99	
340 cm to	360 cm	39	100	12	100	27	99.99	
360 cm to	380 cm	35	100	7	100	28	99.99	
380 cm to	400 cm	18	100	6	100	12	100	
400 cm to	420 cm	21	100	5	100	16	100	
420 cm to	440 cm	10	100	3	100	7	100	
440 cm to	460 cm	11	100	3	100	8	100	
460 cm to	480 cm	13	100	1	100	12	100	
480 cm to	500 cm	5	100	0	100	5	100	
500 cm to	1100 cm	20	100	5	100	15	100	
	Totals	3180835	100%	1655466	100%	1478878	100%	46491
								1.36%

4.4.2 Analyze Crossings

Beam by beam comparison of cross line data to main scheme data was performed on 86 of the 1230 crossings for the survey. This two-step process begins by finding all beam-to-beam crossings that occur between the main scheme lines and cross lines within a given area. This was accomplished by running SABER's Find Crossings utility on two file lists, one containing main scheme files and one containing cross line files. The resulting ASCII file contains positional data for all crossings between the two file lists and can be displayed in SABER. The second step of the process was to compare the near nadir beams of one multibeam file to the associated full swath beams of another multibeam file for each crossing. Using SABER's Analyze Crossings utility, a subset consisting of approximately 7% of all identified crossings was analyzed. The subset of crossings was established by selecting crossings that were separated both temporally and spatially and in relatively flat areas across the survey area.

The ASCII file generated from SABER's Analyze Crossings utility tabulates the number of comparisons, number and percentage of comparisons that meet an operator specified criteria for acceptable depth difference, maximum difference, minimum difference and statistics which include mean, standard deviation, and R95, for each beam-to-beam comparison. Each crossing generates two analysis reports. One report is for near nadir beams of the main scheme line as compared to the full swath beams of the cross line, and the second is for the near nadir beams of the cross line as compared to the full swath beams of the main scheme line. The crossing analysis results for each survey area are presented in Appendix G.

4.5 Deliverables

SAIC is delivering the digital survey data and supporting materials on 3 external USB hard drives as well as a hard copy version of the survey report and appendices.

Drive 1 (400 GB) contains the following:
- Raw Multibeam Bathymetry GSF files

Drive 2 (400 GB) contains the following:
- Processed Multibeam Bathymetry GSF files

Drive 3 (300 GB) contains the following:
- Annotated Track Line Files:
  - Annotated Track Lines AutoCAD R14 DXF
  - Annotated Track Lines AutoCAD 2000 DXF
  - Track Lines Read Me Text
- ASCII Sound Velocity Profile Data Files:
  - SVP ASCII files
- Media Listings
- Multibeam Calibration Files
- Multibeam Coverage Grid XYZ File:
  - 5 Meter Average Depth (MLLW) XYZ
  - (Comma Delimited, Latitude Longitude, Positive Z)

Multibeam Grid TIF Images:
- 5 Meter Hill-Shaded 040° TIFF with TFW
- 5 Meter Hill-Shaded 130° TIFF with TWF

Multibeam Side-Scan TIF Images:
- Cashes Ledge
- Fippennies Ledge
- Northern
- Southwest Corner

Multibeam Side-Scan XTF Files:
- Multibeam Side-Scan Imagery XTF files

Survey Report with Appendices:
- Gulf of Maine Mapping Initiative Priority 1 Area Survey Report
    - APPENDIX A Lead Line Log
    - APPENDIX B Navigation Logs
    - APPENDIX C Static Draft Log
    - APPENDIX D Sound Velocity Profile Log
    - APPENDIX E Tide Zoning Parameters
    - APPENDIX F Junction Analysis
    - APPENDIX G Analyze Crossings

Tide Corrector Files:
- NOAA Tide Gauge Files
- Water Level Files

APPENDIX A: LEAD LINE LOG

APPENDIX B. NAVIGATION LOGS

APPENDIX C. STATIC DRAFT LOG

APPENDIX D. SOUND VELOCITY PROFILE LOG

APPENDIX E. TIDE ZONING PARAMETERS

APPENDIX F. JUNCTION ANALYSIS

APPENDIX G. ANALYZE CROSSINGS