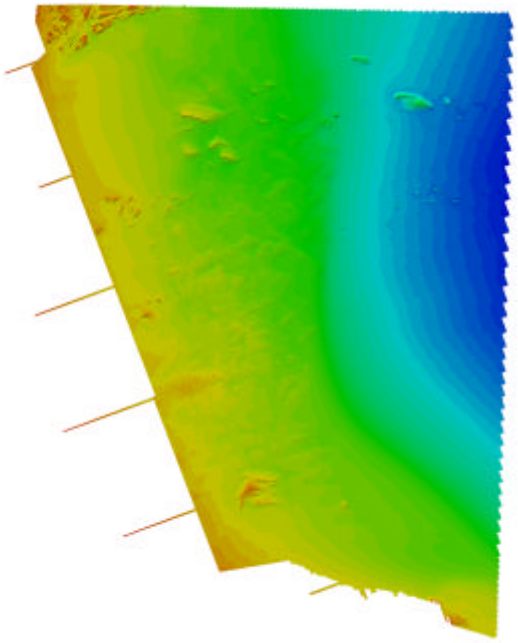
Southern Merrimack Embayment Multibeam Survey

Survey Report

April 30, 2004

Under contract to University of New Hampshire
Contract: 04-855

Prepared For:
U.S. Geological Survey, Woods Hole, MA



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Survey Report

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1. INTRODUCTION

Science Applications International Corporation (SAIC), under contract to the University of New Hampshire, conducted a multibeam survey within the Southern Merrimack Embayment to support the requirements of the US Geological Survey, Woods Hole, MA. This survey acquired bathymetry and imagery with the Reson 8101 multibeam echo sounder on the *R/V OceanExplorer* operated by SAIC. The project area off the north coast of Cape Ann, MA, shown in Figure 1, was surveyed in two phases 1.) the original survey area as presented in the Statement of Work, January 6, 2004, 2.) an additional survey area as agreed on March 5, 2004.

Vessel operation, data acquisition, initial data processing, and on board quality assurance were performed by SAIC. This report documents the field survey and data processing effort.

2. SURVEY PLAN

The survey bounds consisted of a rectangular area approximately 19 km by 25 km in dimension from Halibut Point, Cape Ann, MA to Breaking Rocks nun and out 17.6 km. The survey comprised 328 main scheme lines at 50, 75, 100, 125, 150 and 200-meter spacing and 6 cross lines at 3 kilometer spacing. The survey plan is presented in Figure 1.

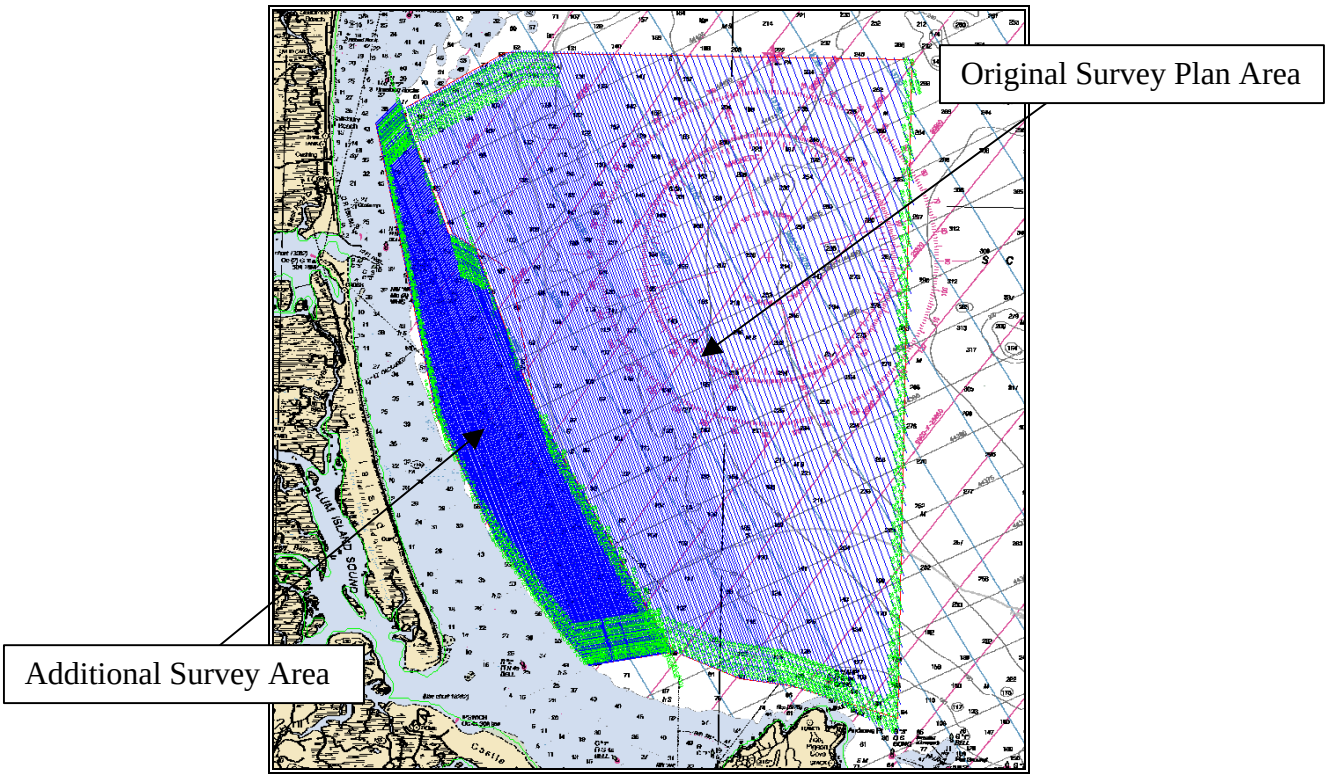

Figure 1. ***Cape Ann Survey Plan***

The area was surveyed with the Reson 8101 with the cutoff angles set at 57° (114° total swath) in order to provide approximately three times the water depth per swath. The area was covered with 100% multibeam coverage. Vessel speed for the survey was nominally 9 knots.

3. OPERATIONS

3.1 The Survey Vessel

SAIC used the *R/V OceanExplorer*, operated by Northeast Marine Services, as the survey vessel during the performance of this survey. Table 1 tabulates the vessel characteristics for the *R/V OceanExplorer* shown in Figure 2.

Table 1. Survey Vessel Characteristics, *R/V OceanExplorer*

Vessel Name	LOA	Beam	Draft	Max Speed	Gross Tonnage	Power (Hp)	Registration Number
R/V Ocean Explorer	60’	16’4”	6’	17 kts	56	1100	US905425

Figure 2. *The R/V OceanExplorer*

The main cabin of the vessel was configured as the data collection center. A POS/MV position and attitude sensor was used to provide vessel position and attitude data, while a Reson 8101 Multibeam Depth Sounder was used to acquire bathymetric and acoustic backscatter data. The Inertial Motion Unit (IMU) was mounted on the vessel centerline just forward and above the Reson 8101 multibeam transducer, below the main deck. The multibeam transducer was mounted on the keel, as shown in Figure 3. A Brooke Ocean Technology Moving Vessel Profiler (MVP) was used to provide sound velocity profiles while underway.

Figure 3. ***Reson 8101 Installation on the R/V OceanExplorer***

3.1.1 Acquisition Systems and Operations

The real time bathymetry/imagery acquisition system used for the USGS/UNH Cape Ann Survey is detailed in Table 2.

Table 2. R/V OceanExplorer Acquisition System

Subsystem	Components
Multibeam Data Acquisition and Display	
Multibeam Sonar	Reson 8101 24 kHz Multibeam Depth Sounder. 81P sonar processor.
Motion Sensor	TSS POS/MV Model 320 Position and Orientation System
Sound Velocity Profiler (SVP)	Brooke Ocean Technology: MVP 30 System and Applied Microsystems Smart Sound Velocity Sensor
Data Acquisition and Display	PC Computer (ISSC) running SAIC ISS2000 Integrated Survey System Software
Daily Log Reporting	PC Laptop Computer running iNavLog Real-Time operations log software.
Uninterrupted Power Supplies (UPS)	Protected the entire system.
Navigation	
Vessel Positioning	TSS POS/MV Model 320 Position and Orientation System
GPS	Trimble 7400 GPS Receiver (Quality Monitoring)
DGPS	Trimble DGPS Beacon Receiver
Integrated Navigation System	SAIC ISS2000
AutoPilot	Robertson AP9 MkII

Data acquisition was carried out using the SAIC ISS2000 system. Real-time navigation, data time tagging and data logging were controlled by the ISS2000 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 4000. 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.

3.1.2 Vessel Configuration Parameters

During SAIC's preparation for the 2003 survey season the acquisition system configuration aboard the *R/V OceanExplorer* was measured in reference to the IMU and converted to be relative to the Reson 8101 transducer, Figure 4.

The SAIC Integrated Survey System (ISS2000) and the Reson 8101 multibeam system utilize different coordinate systems. The ISS2000 considers "z" to be positive down, while both the Reson and POS/MV consider "z" positive up. Both the ISS2000 and POS/MV consider "x" positive forward, the Reson considers "x" as positive athwart ships to starboard. The SAIC ISS2000 considers "y" positive athwart ships to starboard, the POS/MV considers "y" positive athwart ships to port and the Reson considers "y" as positive forward. These differences are fully accounted for in the ISS2000 software.

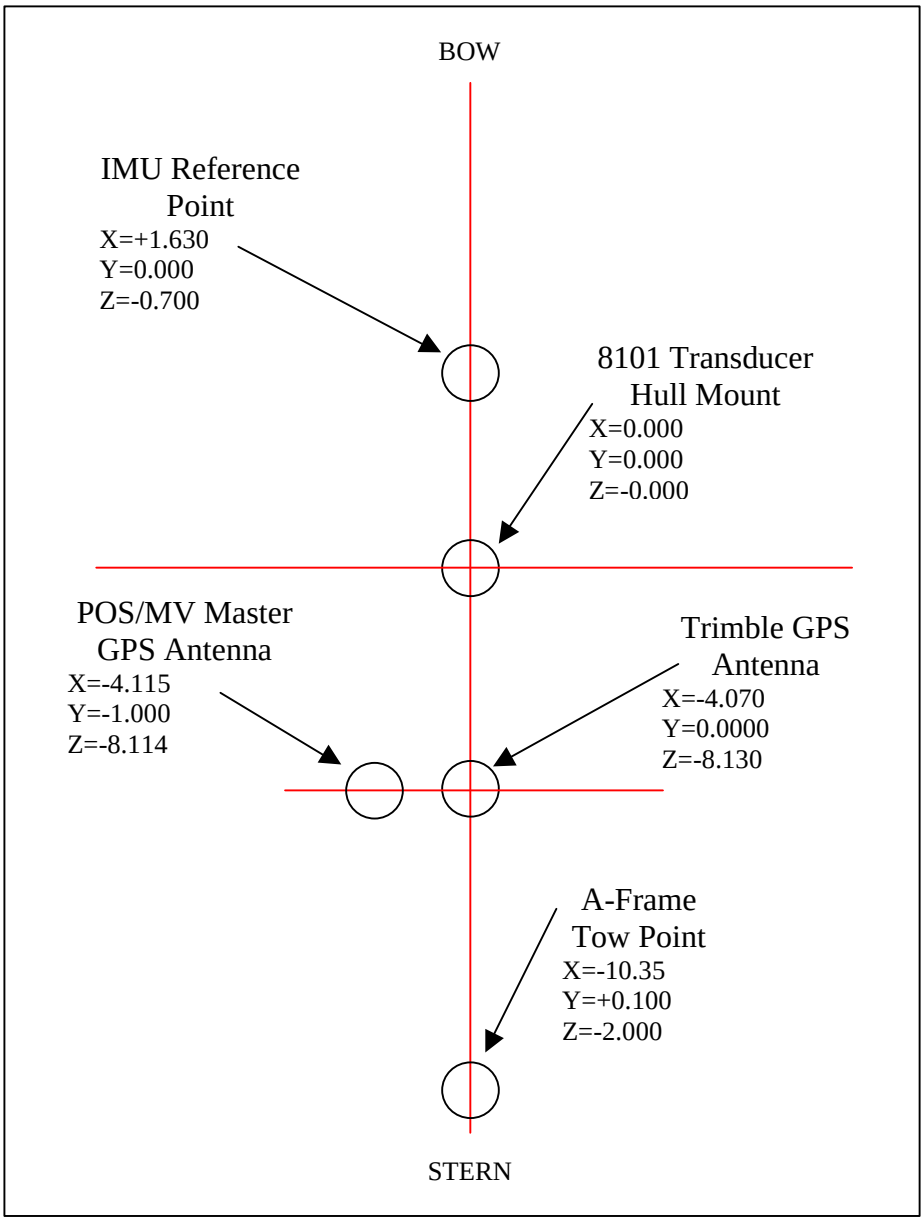

Figure 4. ***Equipment Locations on the R/V OceanExplorer, Meters***

3.1.3 Static and Dynamic Draft Measurements

Figure 5 shows the draft calculations for the *R/V OceanExplorer*. Depth of the transducer below the deck was determined from measurements made while the boat was hauled in May 2000 and confirmed when the vessel was hauled in July 2002. The transducer depth was recorded as 3.07 meters below the vessel's main deck. The distance below the boat deck to the water surface was measured and subtracted from the transducer hull depth to determine the draft of the transducer's electronic center.

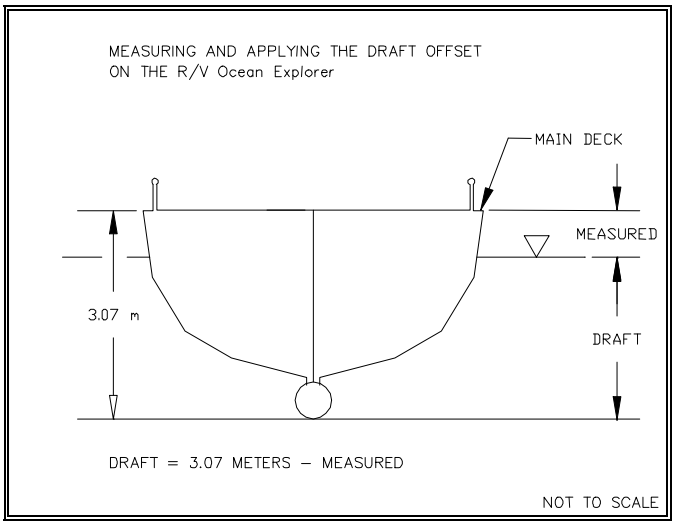

Figure 5. ***R/V OceanExplorer Draft Determination***

The static draft was observed at the beginning and end of each survey leg, by measuring from the main deck to the waterline and subtracting that measurement from the transducer distance below the deck. The measured static draft value was recorded in the real time Watchstander Log, refer to APPENDIX B. If the static draft value changed from the previously noted value, the new value was entered into the ISS2000 system. Draft was interpolated to derive daily correctors, applied during post processing, as discussed in Section 4.1.2.

3.1.4 Sound Velocity Profiles

A Brooke Ocean Technology Ltd. Moving Vessel Profiler (MVP), with an Applied Microsystems, Ltd. Smart Sound Velocity & Pressure sensor was used to determine Sound Velocity Profile (SVP) for corrections to multibeam sonar soundings. Serial numbers and calibration dates for the SVP sensors are presented in Table 3. The system is mounted on the starboard stern of the vessel, as shown in Figure 6.

Table 3. SV&P Sensor Calibrations

Instrument	Serial Number	Calibration Report/Date	Next Cal Due	Comments
Applied Microsystems, Ltd, Smart SV & P Sensor	4880	10/14/03	10/14/04	New Instrument
Applied Microsystems, Ltd, Smart SV & P Sensor	4881	10/14/03	10/14/04	New Instrument

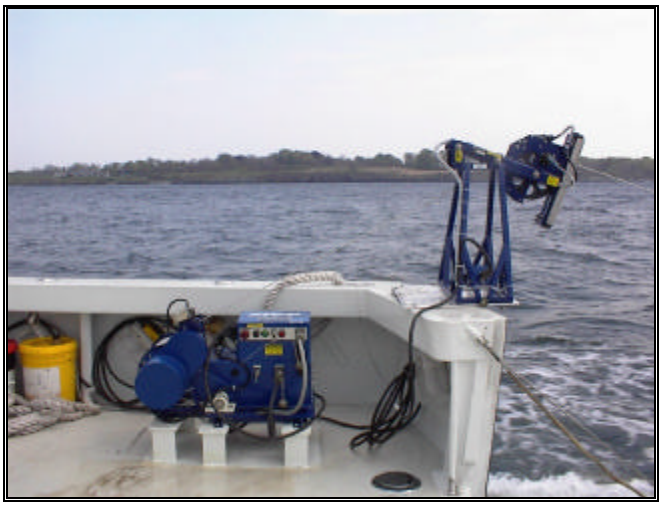

Figure 6. ***MVP Installation on the R/V OceanExplorer***

3.2 Survey Operations

Survey operations were conducted in 3 legs: February 17 to February 18 (JD 048,049), February 23 to March 1 (JD 054 to 061) and March 14 to March 16, 2004 (JD 074 to 076). Prior to the beginning of each leg a Leadline Comparison was conducted. During each leg a SVP Comparison Cast was conducted to verify SVP Sensor accuracy. Draft was recorded at the start and end of each leg.

3.2.1 Leg 1: Patch Test

Upon crew arrival on February 17, 2004, all acquisition and processing machines were powered on and performance checks were conducted. All systems were deemed functional and ready for survey operations to commence February 18, 2004. The Patch Test was conducted on the way to the survey site. Weather deteriorated upon arrival at the survey site and after two hours SAIC halted all survey operations and returned to Cape Ann Marina. Section 3.3.3 presents the Alignment Results obtained on 18 February.

3.2.2 Leg 2: Cape Ann Survey

The survey crew arrived February 22, 2004. All systems were deemed functional and the vessel headed to the survey site on the morning of February 23, 2004. Weather remained favorable for the next 8 days. Upon completion of the main survey lines, defining the Statement of Work (SOW) area on March 1, 2004, the vessel halted survey operations headed to Cape Ann Marina and all systems were shutdown. Data were reviewed for gaps and additional survey lines required to complete the original survey area were defined. Additional survey area coverage was discussed with the USGS and a survey extension of one day was agreed.

3.2.3 Leg 3: Gap Fills and Additional Survey

The survey crew arrived March 13, 2004. All systems were deemed functional and the survey vessel headed to the survey site on the morning of March 14, 2004. There was a narrow weather window for the remaining three days of survey in which the gap fills were completed and

additional survey was conducted an area in-shore of the original SOW area, as shown above in Figure 1.

Survey Logs developed during the course of the survey are provided as appendices to this report, as follows:

APPENDIX A for Daily Reports,
APPENDIX B for Watchstander Logs
APPENDIX C for Sound Velocity Profile (SVP) Log
APPENDIX D for Leadline Comparison Log
APPENDIX E for Times of Hydrography

3.3 Multibeam Bias Calibration Results (Patch Test)

SAIC conducted Settlement, Squat and Alignment calibrations from May 9-20, 2003 prior to the commencement of the survey season. On February 18, 2004 a subsequent alignment was conducted in route to the survey area to ensure the Reson 8101 was not damaged during transit to Gloucester, MA from Newport, RI.

3.3.1 Timing Test

A ping-timing test was completed on May 9, 2003 to verify there were no time latencies occurring in ISS2000. To perform this test, the user logs ping times from an IRIG-B timing card triggered from the Reson 81P ping trigger. A standard multibeam file is logged simultaneously. While logging, the ping rate is slowly increased from 1 ping/sec to 14.9 pings/sec. The times in each file are compared. The difference in like time tags was no more than 3 milliseconds. Timing tests of ISS2000 were successfully completed prior to any other calibration tests.

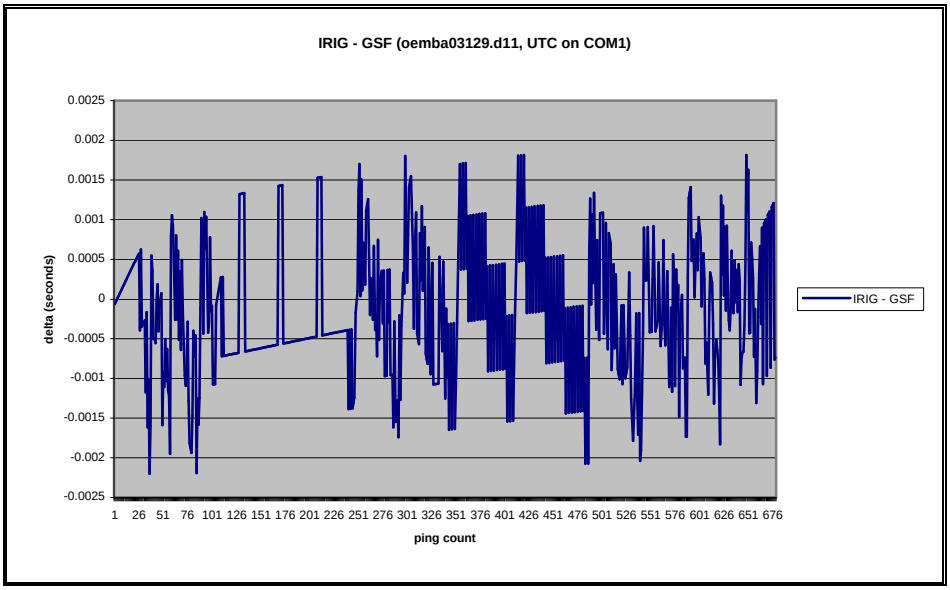

Figure 7. ***Timing Test Results (9 May 2003)***

3.3.2 Settlement and Squat

Settlement and squat of the vessel was conducted May 15-18, 2003, using a land survey level set up at the end of a jetty; drifting, at 600, 800, 1000, 1200, 1600, and 2000 rpm (Table 4). Reference speeds were observed at the rpm setting and recorded.

Table 4. Settlement Results for the *R/V OceanExplorer*

Engine RPM	Speed Knots*	Settlement Meters
0	1	0.00
600	5	–0.03
800	7	–0.02
1000	8	–0.04
1200	9	–0.03
1600	12	–0.08
2000	15	–0.22

*NOTE: The speed in knots listed in Table 4 were not used in the Settlement and Squat Lookup Table, but are given here as approximate average values for reference. In practice, the RPM values are used because they more closely correspond to speed through the water.

3.3.3 Alignment Results

Multibeam alignment calibration operations were conducted on board the *R/V OceanExplorer* on February 18, 2004. These tests were off Cape Ann, Massachusetts over a charted wreck. The calibration tests resulted in no bias changes to the previous values of: Pitch = –1.4°, Roll = +0.47°, and Gyro = +0.8°, presented in Table 6.

Table 5. Alignment Bias Calculated using Swath Alignment Tool

Component	Multibeam files (pairs)		Result
Pitch	oemba04049.d08	oemba04049.d09	–1.4°
Roll	oemba04049.d08	oemba04049.d09	+0.47°
Gyro	oemba04049.d10	oemba04049.d11	+0.8°

3.3.3.1 Roll Alignment

Roll alignment data were collected with +0.47° entered into the acquisition system. Multibeam files oemba04049.d08 and oemba04049.d09 were used for determining roll bias. The following are images of the SABER: Swath Alignment Tool (SAT) depicting data with +0.47° roll bias entered into ISS2000, therefore the indicated bias shown is set to 0.0°.

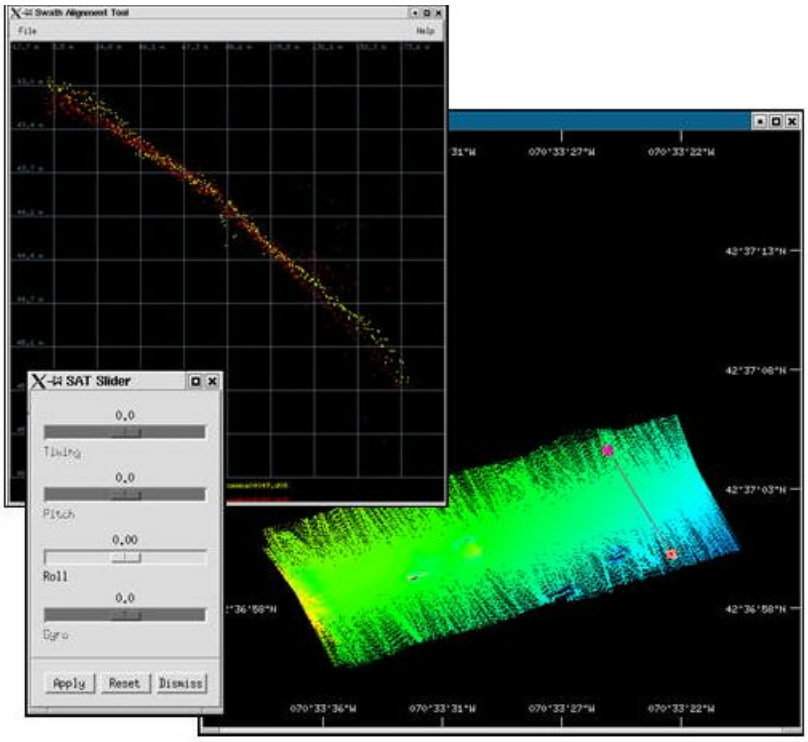

Figure 8. ***Swath Alignment Tool: Roll Bias = +0.47 °***

3.3.3.2 Pitch Alignment

Pitch alignment data were collected with –1.4° entered into the acquisition system. Multibeam files oemba04049.d08 and oemba04049.d09 were used for determining pitch alignments. The following are images of the SABER: Swath Alignment Tool depicting data with –1.4° pitch bias entered into ISS2000, therefore the indicated bias shown is set to 0.0°.

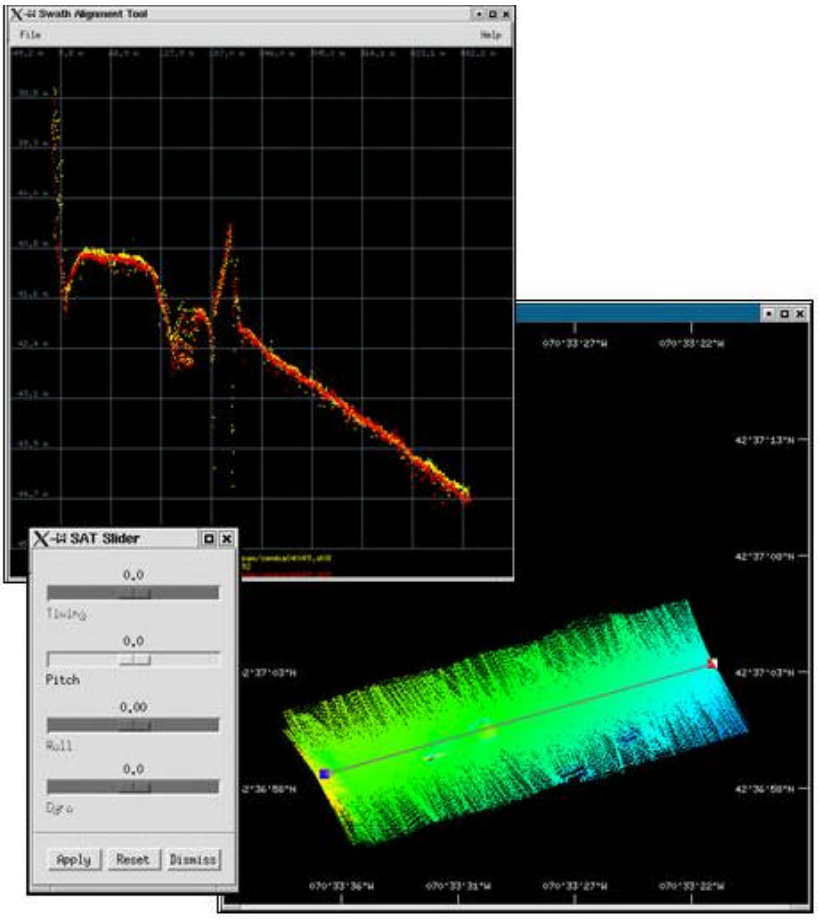

Figure 9. ***Swath Alignment Tool: Pitch Bias = –1.4°***

3.3.3.3 Heading Alignment

Heading alignment data were collected with a +0.8° entered into the acquisition system. Survey lines were run on either side of the wreck in opposite directions. Multibeam files oemba04049.d10 and oemba04049.d11 were used to determine the input bias was correct for gyro. The following are images of the SABER: Swath Alignment Tool depicting data with +0.8° gyro bias entered in the ISS2000 system; therefore the indicated bias shown is set to 0.0°.

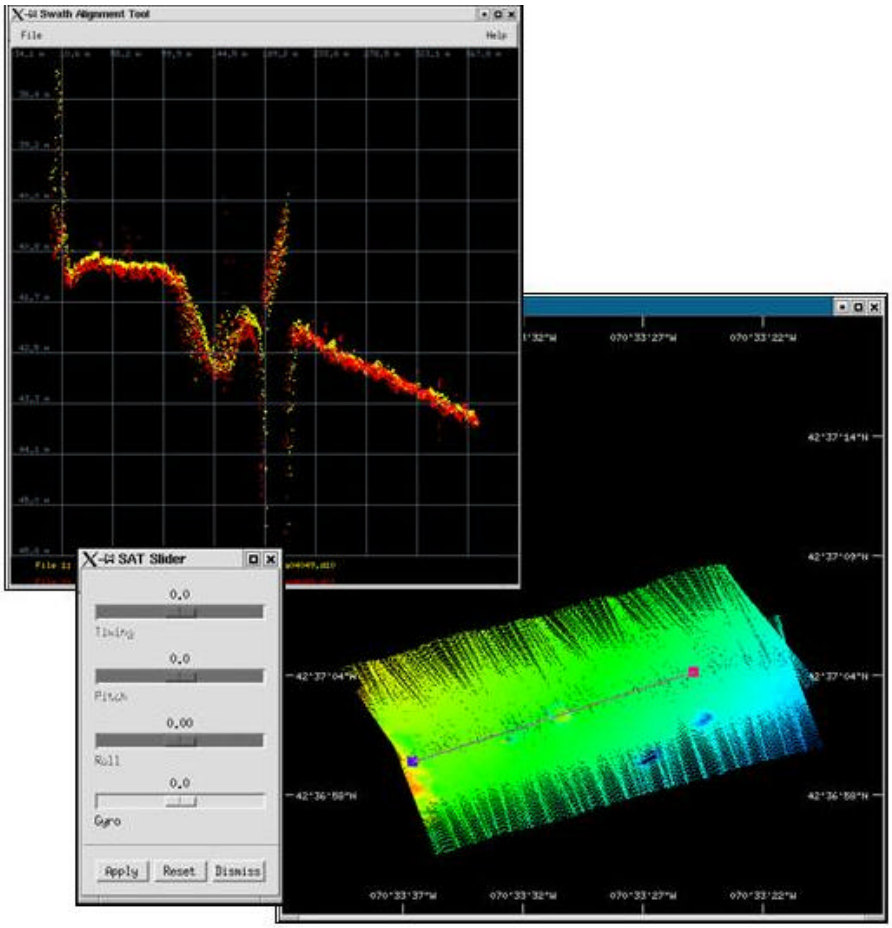

Figure 10. ***Swath Alignment Tool: Gyro Bias = +0.8°***

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 the end of each leg, both the raw and processed data were backed up onto 4mm tapes and shipped to the Data Processing Center 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.

After the application of preliminary tides and interpolated draft, multibeam binned-depth grids were generated. 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 proves efficient in the MVE 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 and 2-meter cell size, populating the bin with the average of all soundings in the bin and maintaining the position of the center of the bin.

4.1.1 Tides and Water Levels

The NOAA tide station in Portland, ME 8418150 was the source of preliminary water level heights for this Southern Merrimack Embayment Multibeam Survey. Preliminary tide data for this station were downloaded from the NOAA CO-OPS web page (http://www.co-ops.nos.noaa.gov/hydro.html). All tide data were annotated with Coordinated Universal Time (UTC). An alternative tide station Boston Light, MA 8444162 was monitored in case the Portland station was inactive. There were no problems with the Portland, ME data. SAIC created two tide zones for the survey area with the following parameters:

The zoning parameters SAIC created were:

On Portland, ME	(8418150)	+ 8 minutes	ratio 0.964
On Boston Light, MA	(8444162)	+2 minutes	ratio 0.972

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 preliminary 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.

Comparison of the zoned 6-minute water level heights computed from Boston Light, MA (8444162) to those computed from Portland, ME (8418150) shows an average height difference of 0.009 meters and a standard deviation of 0.042 meters. The maximum and minimum differences were +0.125 meters and -0.078 meters. Because the Portland, ME (8418150) gauge is a NOAA Primary Control Tide Station water level zoned heights from that station were used to correct the soundings.

When the preliminary 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 appropriate water level corrector had been applied to the GSF file.

4.1.2 Draft

Draft was observed at the beginning and the end of each leg and recorded in the Watchstander Log, shown in APPENDIX B, and the ISS2000 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 drafts applied to each necessary multibeam file using Apply Correctors/Offsets in SABER is presented in Table 7.

Table 6. Draft Applied to the Multibeam Files in SABER

Calendar	JD	Recorded Draft	Applied Draft	Notes
02/17/04	048	1.40	1.40	Arrival
02/18/04	049	1.41	1.41	Start & End
02/23/04	054	1.41	1.41	Start Leg
02/24/04	055		1.41	
02/25/04	056		1.41	
02/26/04	057	1.41	1.41	End Leg
02/26/04	057	1.43	1.43	Start Leg
02/27/04	058		1.43	
02/28/04	059		1.43	
02/29/04	060		1.42	
03/01/04	061	1.42	1.42	End Leg
03/14/04	074	1.44	1.44	Start Leg
03/15/04	075		1.44	
03/16/04	076	1.43	1.43	End Leg

4.2 Multibeam Imagery Data Processing

Digital side-scan data were recorded in Extended Triton Format (XTF), in real time, from the Reson 8101. During the first day of acquisition a 1-meter mosaic was generated in SABER to check for data quality; throughout the survey this mosaic was appended to at convenient intervals. At the end of each survey leg the files were copied to 4mm tapes in tar format for transfer to the data processing facility. The XTF data was bottom tracked in Triton ISIS and a 5-meter mosaic was generated.

4.2.1 Imagery Coverage Mosaic

The raw XTF data underwent further processing in order to generate a 5-meter side-scan mosaic. The default extension given to data collected using the ISSC system was *.d* (i.e. *.d03, *.d04, numbered consecutively as files are created), the side-scan XTF data file names were changed to reflect the standard *.xtf extension before further processing was completed. The XTF data was first bottom tracked in Triton ISIS. A time window file, was created for the side scan coverage. These time window files were then used to create track lines to check navigation. A preliminary 5-meter mosaic was created and viewed using the SABER tools to verify swath coverage, bottom tracking, and gain changes by line. 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 from SABER.

4.2.2 Imagery Quality

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 trawl scars and small rocks. Features, such as rock outcrops were clearly delineated out to the deepest areas of the survey.

Three areas of note on the final 5-meter side-scan mosaic include:

1. In the eastern section of the mosaic there are prominent geologic features where the slant range corrections are not correct, despite the accurate application of bottom tracking. This is due to the rapidly changing slope over these features. Mosaic parameters in SABER were set to generate the best possible output.
2. A few highly reflective areas (usually those over prominent geologic features) of the mosaic showed gain changes toward the outer edge of the side-scan swath. Changes to gain and TVG settings were minimized during acquisition and post-processing to create the most consistent image possible. In areas where the bottom type was primarily soft, less reflective bottom with occasional hard, highly reflective features, the TVG settings were optimized for the more prevalent less reflective bottom type. In all cases the highly reflective features are fully delineated.
3. During acquisition, differences in the appearance of multibeam imagery between port and starboard channels were evident. These differences are magnified in the 5-meter mosaic as evidenced by the different textures between the two channels. Both channels clearly show small scale features such as the trawl scars, sediment boundaries, sand waves and other geologic features.

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. The format of the dxf file was mutually agreed upon by SAIC and USGS.

4.4 Junction Analysis

The Table 8 comparisons of all crossing data in the Southern Merrimack Embayment Multibeam Survey show that 95.80% of comparisons are within 50 centimeters. Comparisons greater than 200 centimeters were located in the northwest area of the survey on steep slopes of prominent geologic features and result from normal small DGPS position fluctuations. Junction Analysis is performed in SABER.

Table 7. Junction Analysis All Main Scheme vs. Cross Lines Near Nadir

Depth Difference Range		All		Positive		Negative		Zero
		Count	Percent	Count	Percent	Count	Percent	Count
0 cm to	5 cm	9110	26.88	4498	21.07	3736	32.01	
5 cm to	10 cm	7058	47.71	4199	40.75	2859	56.51	
10 cm to	15 cm	4611	61.31	2927	54.46	1684	70.94	
15 cm to	20 cm	4107	73.43	2684	67.04	1423	83.14	
20 cm to	25 cm	2601	81.11	1874	75.82	727	89.37	
25 cm to	30 cm	1979	86.95	1488	82.79	491	93.57	
30 cm to	35 cm	1165	90.38	915	87.07	250	95.72	
35 cm to	40 cm	695	92.43	556	89.68	139	96.91	
40 cm to	45 cm	664	94.39	532	92.17	132	98.04	
45 cm to	50 cm	475	95.8	395	94.02	80	98.72	
50 cm to	60 cm	604	97.58	523	96.47	81	99.42	

Depth Difference Range		All		Positive		Negative		Zero
		Count	Percent	Count	Percent	Count	Percent	Count
60 cm to	70 cm	257	98.34	240	97.6	17	99.56	
70 cm to	80 cm	190	98.9	181	98.44	9	99.64	
80 cm to	90 cm	119	99.25	111	98.96	8	99.71	
90 cm to	100 cm	79	99.48	70	99.29	9	99.79	
100 cm to	110 cm	66	99.68	64	99.59	2	99.8	
110 cm to	120 cm	24	99.75	23	99.7	1	99.81	
120 cm to	130 cm	24	99.82	23	99.81	1	99.82	
130 cm to	140 cm	20	99.88	18	99.89	2	99.84	
140 cm to	150 cm	9	99.9	7	99.93	2	99.85	
150 cm to	160 cm	6	99.92	1	99.93	5	99.9	
160 cm to	170 cm	2	99.93	1	99.93	1	99.91	
170 cm to	180 cm	3	99.94	1	99.94	2	99.92	
180 cm to	190 cm	4	99.95	2	99.95	2	99.94	
190 cm to	200 cm	3	99.96	2	99.96	1	99.95	
200 cm to	220 cm	2	99.96	1	99.96	1	99.96	
220 cm to	240 cm	3	99.97	0	99.96	3	99.98	
240 cm to	260 cm	2	99.98	2	99.97	0	99.98	
260 cm to	280 cm	0	99.98	0	99.97	0	99.98	
280 cm to	300 cm	0	99.98	0	99.97	0	99.98	
300 cm to	320 cm	2	99.98	1	99.98	1	99.99	
320 cm to	340 cm	2	99.99	2	99.99	0	99.99	
340 cm to	360 cm	0	99.99	0	99.99	0	99.99	
360 cm to	380 cm	2	99.99	2	100	0	99.99	
380 cm to	400 cm	1	100	0	100	1	100	
400 cm to	420 cm	0	100	0	100	0	100	
420 cm to	440 cm	0	100	0	100	0	100	
440 cm to	460 cm	1	100	1	100	0	100	
	Totals	33890	100%	21344	62.98%	11670	34.43%	876
								2.58%

4.5 Chart Comparison

A display of selected soundings in feet (MLLW), 1:20,000 scale, was generated from a 5 meter average grid in SABER and compared to NOAA Chart 13278_1, 1:80,000 scale 2nd edition March 7, 1998. There are subtle changes along the depth curves and the water depths near the N "2" Breaking Rocks buoy are deeper than charted. Based on the average depths generated from the data collected in this survey, there has not been a great deal of change in the area compared to Chart 13278_1.

4.6 Deliverables

SAIC is delivering on 300 GB Hard-Drive the following:

Multibeam GSF Files:

Raw Multibeam Bathymetry GSF files

- Processed Multibeam Bathymetry GSF files
- Side-Scan XTF Files:
  - Multibeam Side-Scan Imagery XTF files
- ASCII Sound Velocity Profiles:
  - SVP ASCII files
- Tide Corrector Files:
  - NOAA Gauge File
  - Water Level File
- Multibeam XYZ Files:
  - 5 Meter Average Depth (MLLW) XYZ
  - 2 Meter Average Depth (MLLW) XYZ
- Annotated Track Line File:
  - Annotated Track Lines R14 DXF
- Multibeam TIFF Images:
  - 5 Meter Hill-Shaded Along-Track 339° TIFF with TWF
  - 5 Meter Hill-Shaded Cross-Track 249° TIFF with TWF
- Side-Scan TIFF Image:
  - 5 Meter Imagery Mosaic TIFF with TWF
- Survey Report with Appendices:
  - Southern Merrimack Embayment Multibeam Survey Report
    - Daily Reports
    - Watchstander Logs
    - SVP Log
    - Leadline Comparison Log
    - Times of Hydrography

SAIC is delivering a hard-copy version of the following:

- Southern Merrimack Embayment Multibeam Survey Report
  - Daily Reports
  - Watchstander Logs
  - SVP Log
  - Leadline Comparison Log
  - Time of Hydrography

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