U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Data Acquisition & Processing Report

Type of Survey *Multibeam and Sidescan Sonar*

Project No. *OPR-D302-SA-09*

Time Frame: *19 September 2009 – Ongoing*

LOCALITY

State *Virginia*

General Locality *Atlantic Ocean*

2009 -2010

CHIEF OF PARTY

Gary R. Davis
Science Applications International Corporation

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NOAA FORM 77-28 (11-72)
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGISTRY NO.

H12091
H12092
H12093
H12094

HYDROGRAPHIC TITLE SHEET

INSTRUCTIONS – When the Hydrographic Sheet is forwarded to the office, it should be accompanied by this form filled in as completely as possible.

FIELD NO**. O, P, Q, R**

State: Virginia
General Locality: Atlantic Ocean
Locality: *13 NM East of Assateague Island (H12091); 5 NM East of Assateague Island (H12092); 12 NM East Southeast of Chincoteague Inlet (H12093); 5 NM Southeast of Chincoteague Inlet (H12094)*

Scale: 1:20,000 Date of Survey *19 September 2009 - Ongoing*

Instructions Dated: 01 December 2008 and 18 June 2009 Project No. OPR-D302-SA-09

Vessel: *M/V Atlantic Surveyor*, D582365

Chief of Party: Gary R. Davis

Surveyed by: *Alex Bernier, Jediah Bishop, Dan Burgo, Gary Davis, Paul Donaldson, Chuck Holloway, Jason Infantino, Colette Lebeau, Rick Nadeau, Katie Offerman, Gary Parker, Evan Robertson, Eva Rosendale, Deb Smith, Bridget Williams*

Soundings taken by **echo sounder**, hand lead, pole: MULTIBEAM RESON SEABAT 7125 and 8101

Graphic record scaled by

Graphic record checked by Automated plot

Verification by

Soundings in fathoms, feet**,** **meters** at MLW, **MLLW**

REMARKS: **Contract**: DG133C-08-CQ-0003
Contractor: Science Applications International Corp., 221 Third Street; Newport, RI 02840 USA
Subcontractors:
Times: All times are recorded in UTC
UTM Zone: Zone 18
Purpose: To provide NOAA with modern, accurate hydrographic survey data for the purpose of updating the relevant nautical charts of the assigned areas: Sheet O (H12091), Sheet P (H12092), Sheet Q (H12093), and Sheet R (H12094) in the Atlantic Ocean, Coast of Virginia.

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ACRONYMS

Acronym	Definition
ASCII	**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange
BAG	**B**athymetric **A**ttributed **G**rid
CI	**C**onfidence **I**nterval
CMG	**C**ourse **M**ade **G**ood
CTD	**C**onductivity, **T**emperature, **D**epth profiler
CUBE	**C**ombined **U**ncertainty and **B**athymetric **E**stimator
DAPR	**D**ata **A**cquisition and **P**rocessing **R**eport
DGPS	**D**ifferential **G**lobal **P**ositioning **S**ystem
DPC	**D**ata **P**rocessing **C**enter
DR	**D**escriptive **R**eport
EPF	**E**rror **P**arameters **F**ile
GPS	**G**lobal **P**ositioning **S**ystem
GSF	**G**eneric **S**ensor **F**ormat
IHO	**I**nternational **H**ydrographic **O**rganization
IMU	**I**nertial **M**easurement **U**nit
ISO	International Organization for Standardization
ISS-2000	**I**ntegrated **S**urvey **S**oftware 2000
ISSC	**I**ntegrated **S**urvey **S**ystem **C**omputer
JD	**J**ulian **D**ay
kW	**K**ilo**w**att
MVE	**M**ulti-**V**iew **E**ditor
MVP	**M**oving **V**essel **P**rofiler
NAVOCEANO	**N**aval **OCEAN**ographic **O**ffice
NAS	**N**etwork **A**ttached **S**torage
NMEA	**N**ational **M**arine **E**lectronics **A**ssociation
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
NOS	**N**ational **O**cean **S**ervice
PFM	**P**ure **F**ile **M**agic
POS/MV	**P**osition **O**rientation **S**ystem/**M**arine **V**essels
RI	**R**hode **I**sland
RPM	**R**evolutions **P**er **M**inute
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
SSP	**S**ound **S**peed **P**rofile
SV&P	**S**ound **V**elocity and **P**ressure Sensor
TPE	**T**otal **P**ropagated **E**rror
TPU	**T**otal **P**ropagated **U**ncertainty
UPS	**U**ninterruptible **P**ower **S**upply
XTF	e**X**tended **T**riton **F**ormat

PREFACE

This Data Acquisition and Processing Report (DAPR) applies to sheets H12091, H12092, H12093, and H12094. Survey data were collected on H12091 in 2009 and 2010. All other sheets data were collected in 2010. Data collection will continue on H12092, H12093, and H12094 in 2010 after delivery of this DAPR and the Descriptive Report for H12091. Therefore this DAPR refers to the data collection and processing that took place on data collected in 2009 and 2010 up to the date of this report. Any variations that may occur subsequent to the delivery of this DAPR will be addressed in the appropriate sections of each sheet's Descriptive Report.

Data collection and processing was performed according to the April 2009 version of the NOS Hydrographic Surveys Specifications and Deliverables document (see the supplemental correspondence email string dated 21 May 2009 located in Appendix V of the Descriptive Report for H12091).

A. EQUIPMENT

DATA ACQUISITION

Central to Science Applications International Corporation's (SAIC) survey system was the Integrated Survey System Computer (ISSC). The ISSC consisted of a dual processor computer with the Windows XP (Service Pack 2) operating system, which ran SAIC's Integrated Survey Software 2000 (**ISS-2000**) software. This software provided survey planning and real-time survey control in addition to data acquisition and logging for multibeam and navigation data. An Applanix Position Orientation System/Marine Vessels (POS/MV) Inertial Measurement Unit (IMU) with Version 4 firmware was used to provide positioning, heave, and vessel motion data during these surveys. Klein 3000 sidescan sonar data were acquired using Klein's **SonarPro** software running on a computer with the Windows XP (Service Pack 2) operating system.

DATA PROCESSING

Data were stored on a Network Attached Storage (NAS) system that all computers were able to access. Post-acquisition multibeam processing was performed both on board the survey vessel and in the Newport, RI, office using a quad processor computer with the Linux operating system, which ran SAIC's **SABER** (Survey Analysis and Area Based EditoR) software. Sidescan sonar data were reviewed for targets, quality, and contact generation in Triton **Isis** software both on the survey vessel and in the Newport, RI, office. Subsequently, within **SABER**, sidescan mosaics were created and sidescan contacts were correlated with multibeam data.

THE SURVEY VESSEL

The platform used for data collection was the *M/V Atlantic Surveyor* (Figure A-1). The vessel was equipped with an autopilot, echo sounder, Differential Global Positioning System (DGPS), radars, and two 40 kW diesel generators. Accommodations for up to twelve surveyors were available within three cabins. Table A-1 presents the vessel characteristics for the *M/V Atlantic Surveyor*.

Figure A-1. The *M/V Atlantic Surveyor*

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

Vessel Name	LOA (Ft)	Beam (Ft)	Draft (Ft)	Max Speed	Gross Tonnage	Power (Hp)	Registration Number
M/V Atlantic Surveyor	110’	26’	9.0’	14 knots	Displacement 68.0 Net Tons Deck Load 65.0 Long Tons	900	D582365

Three 20-foot International Organization for Standardization (ISO) containers and a 50 kW generator were secured on the aft deck. The first container was used as the real-time, survey data collection office, the second container was used for the data processing office, and the third container was used for spares storage, maintenance, and repairs. The generator provided dedicated power to the sidescan winch, ISO containers, and associated survey equipment.

The POS/MV IMU was mounted below the main deck port of the keel. The RESON 7125 transducer was hull-mounted approximately amidships, port of the vessel’s keel. The RESON 8101 transducer was mounted to the same mounting plate as the 7125 when used during survey operations in 2010. A Brook Ocean Technologies Moving Vessel Profiler 30 (MVP-30) was mounted to the starboard stern quarter. Configuration parameters, offsets, and installation diagrams are included in Section C of this report.

SINGLEBEAM SYSTEMS AND OPERATIONS

SAIC did not utilize singlebeam sonar on this survey for verification of the recorded nadir beam depth from the multibeam system. Periodic leadline comparisons were made during port calls (approximately every 10-12 survey days) in lieu of a singlebeam sonar comparison in accordance with Section 5.1.3.1 of the NOS Hydrographic Surveys Specifications and Deliverables, April 2009. Leadline results are included with the survey data in Section I of the Separates of each sheet’s Descriptive Report (DR).

MULTIBEAM SYSTEMS AND OPERATIONS

The real-time multibeam acquisition system used for these surveys included each of the following unless further specified:

- Windows XP workstation (ISSC) for data acquisition, system control, survey planning, survey operations, and real-time quality control
- RESON SeaBat 7125 multibeam system

RESON SeaBat 7125		
Firmware	**Version/SN**	
	2009	**2010**
7k Upload Interface	3.7.2.5	3.10.2.7
7k Center	3.0.7.1	3.5.3.11
7k I/O	3.3.0.7	3.3.0.19

RESON SeaBat 7125		
Firmware	Version/SN	
	2009	2010
SVP-70 S/N	4408372	4408372

- RESON SeaBat 8101 multibeam system

RESON SeaBat 8101	
Firmware	Version/SN
8101 Dry End	2.09-E34D
8101 Wet End	1.08-C215

- POS/MV 320 Position and Orientation System Version 4 with a Trimble ProBeacon Differential Receiver (primary positioning sensor)

POS/MV 320	
System	Version/Model/SN
MV-320	Ver4
SERIAL NUMBER	S/N2575
HARDWARE	HW2.9-7
SOFTWARE	SW03.42-May28/07
ICD	ICD03.25
OPERATING SYSTEM	OS425B14
IMU TYPE	IMU2
PRIMARY GPS TYPE	PGPS13
SECONDARY GPS TYPE	SGPS13
DMI TYPE	DMI0
GIMBAL TYPE	GIM0
OPTION 1	THV-0

- Trimble 7400 GPS Receiver with a Trimble ProBeacon Differential Receiver (secondary positioning sensor)
- MVP 30 Moving Vessel Profiler with interchangeable Applied Microsystems Smart Sound Velocity and Pressure Sensors and a Notebook computer to interface with the ISSC and the deck control unit

MVP 30	
System	Version/Model/SN
MVP	30
Software	2.430
SV&P Sensors	5332 5454 4880 5455 4523

- Monarch shaft RPM sensors
- Notebook computer for maintaining daily navigation and operation logs

- Seabird Model SBE 19 Conductivity, Temperature, Depth (CTD) profiler

SBE CTD	
System	**Version/SN**
SBE-19	1920459-2710 194275-0648 193607-0565
Software	1.55

- Uninterrupted power supplies (UPS) for protection of the entire system

The RESON 7125 is a single frequency system at 400 kHz. The 7125 is capable of three beam configurations: 256 Equi-Angular, 512 Equi-Angular, or 512 Equi-Distant beams. In all configurations the beams are dynamically focused resulting in a 0.5 degree across-track receive beam width and a 1.0 degree along-track transmit beam width with a 130 degree swath (65 degrees per side). In December 2009 the 7125 was removed for cleaning and maintenance during the winter shut down. Prior to the start of survey operations in 2010, the RESON SeaBat 7125 multibeam system was upgraded to the 7125-SV configuration. This upgrade removed the subsurface Link Control Unit (LCU) and now has a single combined sonar interface and processing topside unit. The 7125 was re-installed in April 2010.

All sheets used both the 256 beams Equi-Angular and 512 beams Equi-Distant modes. When the system was configured for 512 beams equi-distant beams, the maximum ping rate was manually set to 10 or 11 hertz. For the 256 beams equi-angular mode, the maximum ping rate was manually set to 15-18 hertz. By manually setting the ping rate for each beam configuration, the size of the GSF files remained manageable while still ensuring adequate bottom coverage. Item investigations were collected at slower speeds, generally four to six knots and utilized the 512 beams equi-distant mode at the maximum achievable ping rate for the range selected.

The RESON SeaBat 7125 started to exhibit a degraded acoustic signal in the early part of July 2010. A technician from RESON joined the survey vessel on 17 July 2010 to determine the cause of the degraded acoustic signal. It was determined that the problem could have been in the transducer ceramic elements and additional factory testing was required. On 19 July 2010 the RESON SeaBat 7125 was replaced with the RESON SeaBat 8101. The RESON 8101 is a 240 kHz system with 101 beams. Beams are 1.5 degree along track and 1.5 degrees across track with a 150 degree swath (75 degrees per side). Range and ping rates are user selectable. The ping rate was set to a maximum of 40 pings per second and was regulated by the range scale selected. Range scale was selected by the operator to yield the highest ping rate while maintaining a 120 degree minimum usable swath (60 degree per side). The 7125 was re-installed in 12 August 2010 after it was returned from the factory.

All multibeam data and associated metadata were collected and stored on the real time survey computer (ISSC) using a dual logging architecture. This method ensured a copy of all real time data files were logged to separate hard drives during the survey operation. File names were changed at the end of each line at which time an automatic archiving routine was run to copy all files to an onboard network attached storage system (NAS) for processing and quality control review. At the end of each Julian Day real time data files were backed up to magnetic tapes. All processed data was backed up to an external hard drive and magnetic tapes approximately every one to two days. The external hard drive and copies of the magnetic tape backups were shipped to SAIC's data processing center in Newport, RI for final processing and archiving approximately every 10 to 12 days.

SIDESCAN SONAR SYSTEMS AND OPERATIONS

The sidescan system used for these surveys included each of the following:

- Klein 3000 digital sidescan sonar towfish with a Klein K1 K-wing depressor
- Klein 3000 Windows XP computer for data collection and logging of sidescan sonar data with Klein **SonarPro** software
- Klein 3000 Transceiver Processing Unit
- McArtney sheave with cable payout indicator
- Sea Mac winch with remote controller
- Uninterrupted power supplies (UPS) for protection of the computer system

The Klein 3000 is a conventional dual frequency sidescan sonar system. Data were collected at 100 kHz and 500 kHz concurrently. The sonar ping rate is automatically set by the transceiver based on the range scale setting selected by the user. At a range scale of 50 meters, the ping rate is 15 Hz and at a range scale of 75 meters, the ping rate is 10 Hz. Based on these ping rates, maximum survey speeds were established for each range scale setting to ensure that there were a minimum of three pings per meter in the along-track direction. The maximum allowable survey speeds were 9.7 knots at the 50-meter range and 6.5 knots at the 75-meter range therefore the survey speeds were typically less than 8.5 knots and 6 knots respectively. The 50-meter range scale was used exclusively on sheets H12092 and H12094. Both the 50-meter and 75-meter range scales were used on sheet H12091 while H12093 used only 75-meter range scale. In areas where the water depths were predominantly less than 18 meters (60 feet) the 50-meter range scale was used while the 75-meter range scale was used in areas where the water depths were consistently deeper that 18 meters (60 feet).

During survey operations, digital data from the Klein 3000 processor was acquired by the Klein 3000 computer and displayed and logged by Klein **SonarPro** software. Raw digital sidescan data from the Klein 3000 was collected in eXtended Triton Format (XTF) and maintained at full resolution, with no conversion or down sampling techniques applied. Sidescan data file names were changed automatically approximately every hour and manually at the completion of a survey line. These files were archived to the data NAS for initial processing and quality control review at the completion of each survey line. At the end of each Julian Day the raw XTF sidescan data files were backed up to magetic tapes. All processed data was backed up to an external hard drive and magnetic tape approximately every one to two days. The external hard drive and copies of the magnetic tape backups were shipped to SAIC's data processing center in Newport, RI for final processing and archiving approximately every 10 to 12 days.

Towfish positioning was provided by **ISS-2000** through a program module called "**rtcatnry**" that used a Payout and Towfish Depth method (Figure A-2) to compute towfish positions. The position of the tow point (or block) was continually computed based on the known offsets from the RESON 7125 or 8101 transducer's acoustic center to the tow point and the vessel heading. The towfish position was then calculated from tow point position using the measured cable out (received by **ISS-2000** from the cable payout meter), the towfish pressure depth (sent via a serial interface from the Klein 3000 computer to the **ISS-2000**), and the Course Made Good (CMG) of the vessel. The calculated towfish position was sent to the Klein 3000 data collection computer once per second in the form of a GGA (NMEA-183, National Marine Electronics Association, Global Positioning System Fix Data String) message where it was merged with the sonar data file. Cable adjustments were made using a remote winch controller inside the acquisition survey van in order to maintain acceptable towfish altitudes and sonar record quality. Changes to the amount of cable out were automatically saved to the **ISS-2000** message and payout files.

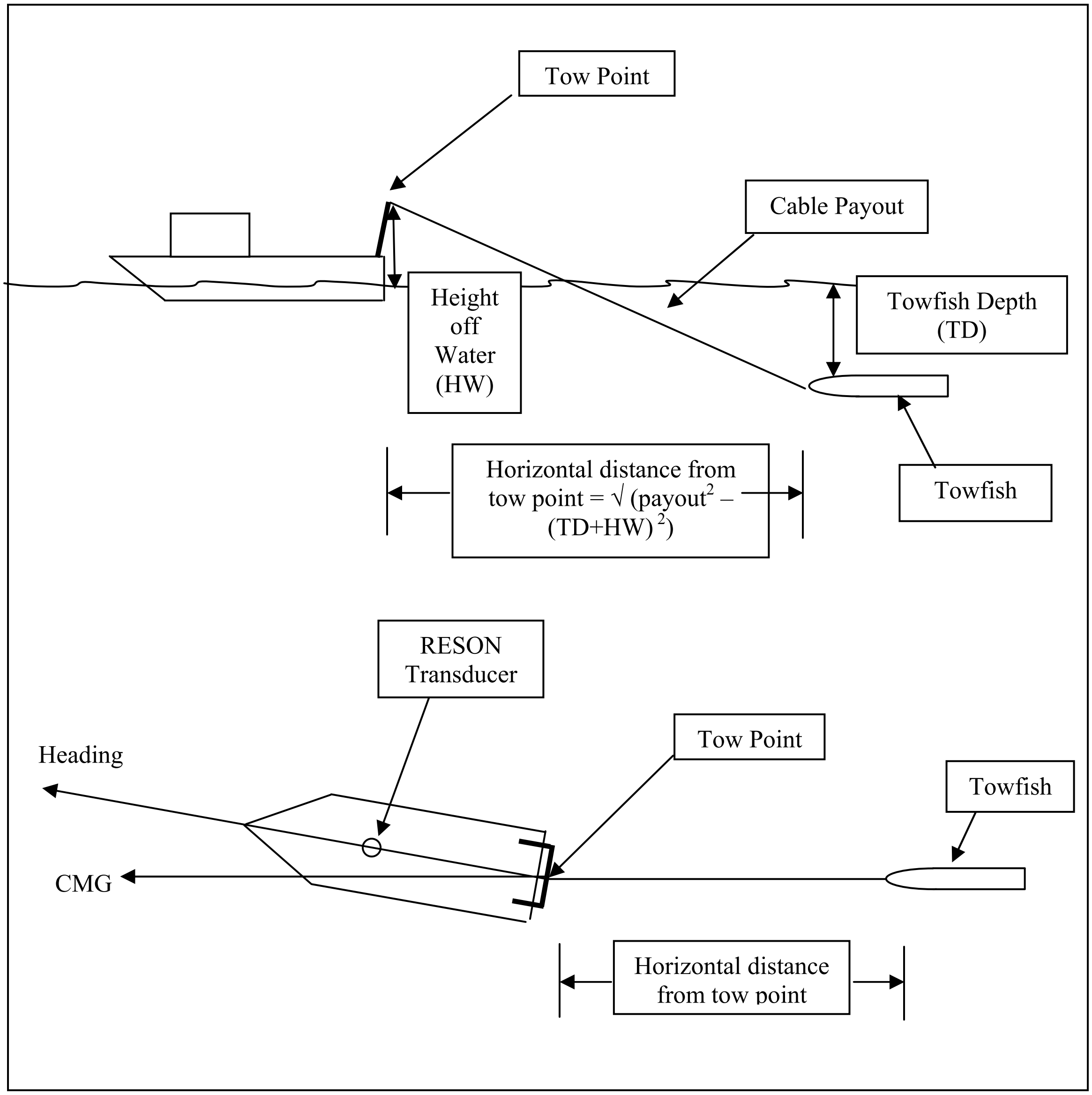

Figure A-2. Geometry of Sidescan Towfish Position Calculations Using the Payout and Depth Method.

Towfish altitude was maintained between 8% and 20% of the range scale (4-10 meters at 50-meter range; 6-15 meters at 75-meter range), when conditions permitted. For vessel, equipment, and personnel safety, data were occasionally collected at towfish altitudes outside the 8% to 20% of the range over shoal areas and in the vicinity of charted obstructions or wrecks. In some regions of the survey area, the presence of a significant density layer also required that the altitude of the towfish be maintained outside the 8% to 20% of the range to reduce the effect of refraction that could mask small targets in the outer sonar swath range. When the towfish altitude was outside of the 8% to 20% range, periodic confidence checks on linear features (e.g. trawl scars) or geological features (e.g. sand waves or sediment boundaries) were made to verify the quality of the sonar data across the full sonar record range.

For these surveys, a K-wing depressor was attached directly to the towfish and served to keep it below the vessel wake, even in shallow near shore waters at slower survey speeds. The use of the K-wing reduced the amount of cable out, which in turn reduced the positioning error of the towfish and increased vessel maneuverability in shallow water.

SOUND SPEED PROFILES

A Brooke Ocean Technology Moving Vessel Profiler (MVP) with an Applied Microsystems Smart Sound Velocity and Pressure (SV&P) sensor or a Seabird Electronics SBE-19 CTD was used to collect sound speed profile (SSP) data. SSP data were obtained at intervals frequent enough to reduce sound speed errors in the multibeam data. The frequency of casts was based on observed sound speed changes from the surface sound speed measurements at the multibeam transducer head, previously collected profiles, and time elapsed since the last cast. Periodically during a survey day, multiple casts were taken along a survey line to identify the rate and location of sound speed changes. Based on the observed trend of sound speed changes along a line, the cast frequency and location for subsequent lines were modified accordingly. Confidence checks of the sound speed profile data were periodically conducted (6 to 13 survey days) by comparing two consecutive casts taken with different Sound Velocity and Pressure sensors or with a Sound Velocity and Pressure sensor and a Seabird SBE-19 CTD.

Serial numbers and calibration dates are listed below. Sound speed data and calibration records are included with the survey data in Section II of the Separates for each sheet's Descriptive Report.

- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4523, Calibration Dates: 08 July 2009, 07 October 2009 and 15 March 2010
- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5332, Calibration Dates: 27 May 2009, 08 October 2009 and 15 March 2010
- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 4880, Calibration Dates: 08 July 2009 and 15 March 2010
- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5454, Calibration Dates: 27 May 2009 and 05 February 2010
- Applied Microsystems Ltd., SV&P Smart Sensor, Serial Number 5455, Calibration Dates: 01 September 2009 and 15 March 2010
- Seabird Electronics, Inc., CTD, Serial Number 0565, Calibration Date: 28 April 2010
- Seabird Electronics, Inc., CTD, Serial Number 0648, Calibration Date: 01 April 2010
- Seabird Electronics, Inc., CTD, Serial Number 2710, Calibration Date: 30 July 2009 and 24 February 2010

DATA ACQUISITION AND PROCESSING SOFTWARE

Data acquisition was carried out using the SAIC **ISS-2000** Version 4.1.0.11.0 (2009) and 4.2.0.5.0 (2010) software for Windows XP operating systems to control acquisition navigation, data time tagging, and data logging.

Survey planning, data processing and analysis were carried out using the SAIC **Survey Planning** and **SABER** Version 4.3.0.11.0 software for LINUX operating systems**.** Periodic upgrades to this software were installed both in the Newport, RI Data Processing Center and on the vessel. The version and installation dates used during the processing of these data in SAIC's Newport Data Processing Center (DPC) and onboard the survey vessel are listed in Table A-2.

Table A-2. SABER Versions and Installations Dates

Newport DPC SABER and Survey Planning Version	Date Version Installed In Newport, RI	Date Version Installed On Vessel
4.3.0.12.1		27 July 2009
4.3.0.12.2	20 August 2009	N/A
4.3.0.13.1	28 January 2010	N/A
4.3.0.13.2	10 February 2010	N/A
4.3.0.13.3	15 February 2010	N/A
4.3.0.16.1	26 March 2010	26 March 2010
4.3.0.16.2	26 May 2010	N/A
4.3.0.16.3	11 June 2010	11 June 2010
4.3.0.16.5	02 August 2010	05 August 2010

SonarPro version 9.6, running on a Windows XP platform was used for sidescan data acquisition in 2009. Version 11.3 was installed for the start of the 2010 survey season.

Isis version 6.06, running on a Windows XP platform was used for sidescan data quality review, target identification and contact generation.

B. QUALITY CONTROL

A systematic approach to tracking data has been developed to maintain data quality and integrity. Several logs and checklists have been developed to track the flow of data from acquisition through final processing. These forms are presented in the Separates section included with the data for each survey.

During data collection, survey watch standers continuously monitored the systems, checking for errors and alarms. Thresholds set in the **ISS-2000** system alerted the watch stander by displaying alarm messages when error thresholds or tolerances were exceeded. Alarm conditions that may have compromised survey data quality were corrected and noted in both the navigation log and the message files. Warning messages such as the temporary loss of differential GPS, excessive cross track error, or vessel speed approaching the maximum allowable survey speed were addressed by the watch stander and automatically recorded into a message file. Approximately every 2-3 hours the acquisition watch standers completed checklists to verify critical system settings and ensure valid data collection.

Following data collection, initial processing began on the vessel. This included the first level of quality assurance:

- Initial swath editing of multibeam data flagging invalid pings and beams
- Application of delayed heave
- Generation of a preliminary PFM CUBE surface
- Second review and editing of multibeam data PFM CUBE surface
- Open beam angles where appropriate to identify significant features outside the cut-off angle
- Identify significant features for investigation with additional multibeam coverage
- Turning unacceptable data “offline”
- Turning additional data “online”
- Identification and flagging of significant features
- Track plots
- Preliminary minimum sounding grids
- Cross line checks
- First review of sidescan data
- Generation of sidescan contact files
- Second review of sidescan data when practical
- Generation of preliminary sidescan coverage mosaics
- Identification of holidays in the sidescan coverage

On a daily basis, the multibeam data were binned to minimum depth layers, populating each bin with the shoalest sounding in that bin while maintaining its true position and depth. The following binned grids were created and used for initial cross line analysis, tide zone boundary comparisons, and day to day data comparisons.

- Main scheme, item, and holiday fill survey lines
- Cross lines using only near-nadir data (±5° from nadir)

These daily comparisons were used to monitor adequacy and completeness of data and sounding correctors.

During port calls a complete backup of all raw and processed multibeam data and sidescan data was sent to the Newport Data Processing Center (DPC). Analysis of the data at the Newport facility included the following steps:

- Generation of multibeam and sidescan track line plots
- Second review of sidescan data
- Verification of sidescan contact files
- Application of verified water level correctors to multibeam data

- Computation of Total Propagated Uncertainty (TPU) for each depth value in the multibeam data
- Generation of a one-meter CUBE PFM surface for analysis of coverage, areas with high TPU, and features.
- Cross line analysis of multibeam data
- Comparison with prior surveys
- Generation of final CUBE PFM surface(s)
- Generation of S-57 feature file
- Comparison with existing charts
- Quality control reviews of sidescan data and contacts
- Final Coverage mosaics of sidescan sonar data
- Correlation of sidescan contacts with multibeam features
- Generation of final Bathymetric Attributed Grid(s) (BAG) and metadata products
- Final quality control of all delivered data products

Details of the survey system uncertainty model, data processing and quality control procedures for multibeam and sidescan data are described in detail in the following sections.

SURVEY SYSTEM UNCERTAINTY MODEL

The Total Propagated Uncertainty (TPU) model that SAIC has adopted has its genesis at the Naval Oceanographic Office (NAVOCEANO), and is based on the work by Rob Hare and others ("Error Budget Analysis for NAVOCEANO Hydrographic Survey Systems, Task 2 FY 01", 2001, *HSRC FY01 Task 2 Final Report*). The terminology Total Propagated Error (TPE) has been replaced by Total Propagated Uncertainty (TPU). This was adopted by the International Hydrographic Organization in Special Publication No. 44, "*IHO Standards for Hydrographic Surveys, 5th Edition, February 2008".* The fidelity of any uncertainty model is coupled to the applicability of the equations that are used to estimate each of the components that contribute to the overall uncertainty that is inherent in each sounding. SAIC's approach to quantifying the TPU is to decompose the cumulative uncertainty for each sounding into its individual components and then further decompose those into the horizontal and vertical components. The model then combines the horizontal and vertical uncertainty components to yield an estimate of the system uncertainty as a whole. This cumulative system uncertainty is the Total Propagated Uncertainty. By using this approach, SAIC can easily incorporate future uncertainty information provided by sensor manufacturers into the model. This also allows SAIC to continuously improve the fidelity of the model as our understanding of the sensors increases or as more sophisticated sensors are added to a system.

The data needed to drive the error model were captured as parameters taken from the **SABER** Error Parameter File (EPF), which is an ASCII text file typically created during survey system installation and integration. The parameters were also obtained from values recorded in the multibeam Generic Sensor Format (GSF) file(s) during data collection and processing. While the input units vary, all uncertainty values that contributed to the cumulative TPU estimate were eventually converted to meters by the

SABER Errors program. The cumulative TPU estimates were recorded as the Horizontal Uncertainty and Vertical Uncertainty at the 95% confidence level in the GSF file. Individual soundings that had vertical and horizontal uncertainty values above IHO Order 1 were flagged as invalid during uncertainty attribution of the GSF files.

Table B-1 and Table B-2 show the values entered in the **SABER** errors parameter file used with the RESON 7125 during 2009 and 2010 for H12091. For H12092, H12093, and H12094 an updated RESON 7125 section of the EPF file was implemented which corrected the uncertainty values that were populated in the Transducer Offset Error (X, Y, and Z) fields. These values should have been zero and were corrected as shown in Table B-3. The impact of the erroneous uncertainty values being populated in the H12091 EPF file was negligible but served to overestimate the uncertainty not underestimate it. Table B-4 and Table B-5 show the values entered in the **SABER** errors parameter file used with the RESON 8101 during 2010. All parameter uncertainties in this file were entered at the one sigma level of confidence, but the outputs from **SABER's Errors** program are at the two sigma or 95% confidence level. Sign conventions are: X = positive forward, Y = positive starboard, Z = positive down.

Table B-1. *M/V Atlantic Surveyor* Error Parameter File (EPF) for the RESON 7125

Parameter	Value	Units
VRU Offset – X	0.34	Meters
VRU Offset – Y	0.29	Meters
VRU Offset – Z	-1.71	Meters
VRU Offset Error – X (uncertainty)	0.005	Meters
VRU Offset Error – Y (uncertainty)	0.011	Meters
VRU Offset Error – Z (uncertainty)	0.013	Meters
VRU Latency	0.00	milliseconds
VRU Latency Error (uncertainty)	1.00	milliseconds
Heading Measurement Error (uncertainty)	0.02	Degrees
Roll Measurement Error (uncertainty)	0.02	Degrees
Pitch Measurement Error (uncertainty)	0.02	Degrees
Heave Fixed Error (uncertainty)	0.05	Meters
Heave Error (% error of height) (uncertainty)	5.00	Percent
Antenna Offset – X	4.60	Meters
Antenna Offset – Y	-0.37	Meters
Antenna Offset – Z	-8.09	Meters
Antenna Offset Error – X (uncertainty)	0.013	Meters
Antenna Offset Error – Y (uncertainty)	0.012	Meters
Antenna Offset Error – Z (uncertainty)	0.025 (2009) 0.020 (2010)	Meters
Estimated Error in Vessel Speed (uncertainty)	0.0299	Knots
GPS Latency	0.00	milliseconds
GPS Latency Error (uncertainty)	1.00	milliseconds
Horizontal Navigation Error (uncertainty)	0.75*	Meters
Vertical Navigation Error (uncertainty)	0.20*	Meters
Static Draft Error (uncertainty)	0.01	Meters
Loading Draft Error (uncertainty)	0.02	Meters
Settlement & Squat Error (uncertainty)	0.02 (2009) 0.034 (2010)	Meters
Predicted Tide Measurement Error (uncertainty)	0.17	Meters

Parameter	Value	Units
Observed Tide Measurement Error (uncertainty)	0.07	Meters
Unknown Tide Measurement Error (uncertainty)	0.50	Meters
Tidal Zone Error (uncertainty)	0.10	Meters
Surface Sound Speed Error (uncertainty)	1.00	meters/second
SEP Uncertainty	0.15	Meters
SVP Measurement Error (uncertainty)	1.00	meters/second
Depth Sensor Bias	0.00	Meters
Depth Measurement Error (% error of depth) (uncertainty)	0.00	Percent
Wave Height Removal Error (uncertainty)	0.05	Meters

*NOTE: These values would only be used if not included in the GSF file

Table B-2. RESON 7125 Sonar Parameters used Prior to 16 September 2010

Parameter	Value	Units
Transducer Offset – X	0.00*	Meters
Transducer Offset – Y	0.00*	Meters
Transducer Offset – Z	0.00*	Meters
Transducer Offset Error – X (uncertainty)	0.02 (2009) 0.005 (2010)	Meters
Transducer Offset Error – Y (uncertainty)	0.02(2009) 0.011 (2010)	Meters
Transducer Offset Error – Z (uncertainty)	0.02(2009) 0.013 (2010)	Meters
Roll Offset Error (uncertainty)	0.005	Degrees
Pitch Offset Error (uncertainty)	0.05	Degrees
Heading Offset Error (uncertainty)	0.05	Degrees
Model Tuning Factor	6.00	N/A
Amplitude Phase Transition	1	Samples
Latency	0.00	milliseconds
Latency Error (uncertainty)	1.00	milliseconds
Installation Angle	0.0	Degrees

*NOTE: These values would only be used if not included in the GSF file

Table B-3. RESON 7125 Sonar Parameters used After to 16 September 2010

Parameter	Value	Units
Transducer Offset – X	0.00*	Meters
Transducer Offset – Y	0.00*	Meters
Transducer Offset – Z	0.00*	Meters
Transducer Offset Error – X (uncertainty)	0.00	Meters
Transducer Offset Error – Y (uncertainty)	0.00	Meters
Transducer Offset Error – Z (uncertainty)	0.00	Meters
Roll Offset Error (uncertainty)	0.005	Degrees
Pitch Offset Error (uncertainty)	0.05	Degrees
Heading Offset Error (uncertainty)	0.05	Degrees
Model Tuning Factor	6.00	N/A
Amplitude Phase Transition	1	Samples
Latency	0.00	milliseconds
Latency Error (uncertainty)	1.00	milliseconds
Installation Angle	0.0	Degrees

*NOTE: These values would only be used if not included in the GSF file

Table B-4. *M/V Atlantic Surveyor* Error Parameter File (EPF) for the RESON 8101

Parameter	Value	Units
VRU Offset – X	0.34	Meters
VRU Offset – Y	0.12	Meters
VRU Offset – Z	-1.64	Meters
VRU Offset Error – X (uncertainty)	0.005	Meters
VRU Offset Error – Y (uncertainty)	0.011	Meters
VRU Offset Error – Z (uncertainty)	0.013	Meters
VRU Latency	0.00	millisecond
VRU Latency Error (uncertainty)	1.00	milliseconds
Heading Measurement Error (uncertainty)	0.02	Degrees
Roll Measurement Error (uncertainty)	0.02	Degrees
Pitch Measurement Error (uncertainty)	0.02	Degrees
Heave Fixed Error (uncertainty)	0.05	Meters
Heave Error (% error of height) (uncertainty)	5.00	Percent
Antenna Offset – X	4.60	Meters
Antenna Offset – Y	-0.54	Meters
Antenna Offset – Z	-8.02	Meters
Antenna Offset Error – X (uncertainty)	0.013	Meters
Antenna Offset Error – Y (uncertainty)	0.012	Meters
Antenna Offset Error – Z (uncertainty)	0.020	Meters
Estimated Error in Vessel Speed (uncertainty)	0.0299	Knots
GPS Latency	0.00	milliseconds
GPS Latency Error (uncertainty)	1.00	milliseconds
Horizontal Navigation Error (uncertainty)	0.75*	Meters
Vertical Navigation Error (uncertainty)	0.20*	Meters
Static Draft Error (uncertainty)	0.01	Meters
Loading Draft Error (uncertainty)	0.02	Meters
Settlement & Squat Error (uncertainty)	0.034	Meters
Predicted Tide Measurement Error (uncertainty)	0.17	Meters
Observed Tide Measurement Error (uncertainty)	0.07	Meters
Unknown Tide Measurement Error (uncertainty)	0.50	Meters
Tidal Zone Error (uncertainty)	0.10	Meters
Surface Sound Speed Error (uncertainty)	1.00	meters/second
SEP Uncertainty	0.15	Meters
SVP Measurement Error (uncertainty)	1.00	meters/second
Depth Sensor Bias	0.00	Meters
Depth Measurement Error (% error of depth) (uncertainty)	0.00	Percent
Wave Height Removal Error (uncertainty)	0.05	Meters

*NOTE: These values would only be used if not included in the GSF file

Table B-5. RESON 8101 Sonar Parameters

Parameter	Value	Units
Transducer Offset – X	0.00*	Meters
Transducer Offset – Y	0.00*	Meters
Transducer Offset – Z	0.00*	Meters
Transducer Offset Error – X (uncertainty)	0.00	Meters
Transducer Offset Error – Y (uncertainty)	0.00	Meters
Transducer Offset Error – Z (uncertainty)	0.00	Meters

Parameter	Value	Units
Roll Offset Error (uncertainty)	0.005	Degrees
Pitch Offset Error (uncertainty)	0.05	Degrees
Heading Offset Error (uncertainty)	0.05	Degrees
Model Tuning Factor	6.00	N/A
Amplitude Phase Transition	1	Samples
Latency	0.00	milliseconds
Latency Error (uncertainty)	1.00	milliseconds
Installation Angle	0.0	Degrees

*NOTE: These values would only be used if not included in the GSF file

MULTIBEAM DATA PROCESSING

At the end of each survey line, all data files were closed and new files opened for data logging. The closed files were then archived to the onboard processing computers where track lines were generated and the multibeam data files were reviewed to flag erroneous data such as noise, flyers, fish, etc. The multibeam data were reviewed and edited on-board the vessel using SAIC's **Multi-View Editor** (**MVE**) program. This tool is a geo-referenced editor, which can project each beam in its true geographic position and depth in both plan and profile views. Delayed heave and preliminary Total Propagated Uncertainty (TPU) attribution were applied to the GSF files and they were loaded into a one-meter PFM CUBE surface. Further review and edits to the data were performed from the PFM grid.

Once the data were in Newport and extracted to the Network Attached Storage (NAS) unit for the DPC, the initial processing step was to create track lines from the multibeam data. Once created, the tracks were reviewed to confirm that no navigational errors existed and that the tracks extended to the survey limits. Verified water levels, delayed heave, and if necessary, corrections to the draft were also applied to the data at this time. The final Total Propagated Uncertainty for each depth was then calculated and applied to the multibeam data.

For each survey sheet, all multibeam data were then processed into a one-meter node PFM CUBE surface for analysis using **SABER** and **MVE**. The one-meter node PFM CUBE surface was generated to demonstrate coverage for the entire sheet. All individual soundings used in development of the final CUBE depth surface had modeled vertical and horizontal uncertainty values at or below the allowable error specified in the April 2009 edition of the NOS Hydrographic Surveys Specifications and Deliverables.

Two separate uncertainty surfaces are calculated by the **SABER** software, CUBE Standard Deviation and Average Total Propagated Uncertainty (Average TPU). The CUBE Standard Deviation is a measure of the general agreement between all of the soundings that contributed to the best hypothesis for each node. The Average TPU is the average of the vertical uncertainty component for each sounding that contributed to the best hypothesis for the node. A third uncertainty surface is generated from the larger of these two uncertainties at each node and is referred to as the Final Uncertainty.

After creation of the initial one-meter PFM CUBE surfaces, the **SABER Check PFM Uncertainty** function was used to highlight all of the cases where computed final node uncertainties exceeded IHO Order 1. An initial review of the areas with final uncertainties exceeding IHO Order 1 revealed that most of these areas were around wrecks, obstructions, and on steep slopes where there tended to be much greater variability in the soundings that contributed to a particular node. In some cases, this uncertainty review resulted in the creation of additional features or designated soundings on reliable soundings that were shoaler than the CUBE depths by one-half the allowable uncertainty for that depth. In addition, the uncertainty review also highlighted some areas that required additional data cleaning. When all multibeam files and the PFM CUBE Surface were determined to be satisfactory, the PFM's CUBE Depth Surface and the Final Uncertainty Surface (the greater of either the CUBE standard deviation or the Average TPE for each node) were converted to Bathymetric Attributed Grids (BAGs) for delivery.

A junction analysis was conducted during data processing to assess the agreement between the main scheme and cross line data that were acquired during the survey. Because the cross lines were acquired at varying time periods throughout the survey period, the cross line analyses provided an indication of potential temporal issues (e.g., tides, speed of sound, draft) that may affect the data. For junction analysis, the data were binned using the CUBE algorithm. The following binned grids were created and used for junction analysis:

- Main scheme, item, and holiday fill survey lines
- Cross lines using only near-nadir (±5° from nadir)

A depth difference surface was then computed between the CUBE surfaces of the main scheme and cross line grids, and the **SABER Junction Analysis** and **Frequency Distribution** routines were used to summarize the results of the depth difference grid. Results of the junction analysis are presented in the Descriptive Report for each survey.

In addition to the surface comparison, a beam by beam comparison of cross line data to main scheme data was performed for each survey area. 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 file contains positional data for all crossings between the two file lists and can be displayed in **SABER**. Using **SABER's Analyze Crossings** utility, a subset of 25 crossings for each survey, was established by selecting crossings that were separated both temporally and spatially; and in relatively flat areas within each survey area.

The output from **SABER's Analyze Crossings** utility contains 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. Results are presented in Separates IV of each survey's Descriptive Report.

Multibeam coverage analysis was also conducted during data processing and on the final CUBE surface to identify areas where multibeam holidays exceeded the allowable three contiguous nodes. These survey operations were conducted at set line spacing optimized to achieve 200% sidescan sonar coverage; 100% multibeam coverage was not required. Main scheme lines were run at 40-meter line spacing (while running the sidescan at a 50-meter range scale) and 65-meter line spacing (while running the sidescan at a 75-meter range scale). The **SABER Gapchecker** routine was run on the CUBE surface to identify multibeam data holidays exceeding the allowable three contiguous nodes. In addition, the entire surface was visually scanned for holidays. While field operations were still underway, additional survey lines were run to fill any holidays that were detected. A limited number of small multibeam coverage gaps may have remained after data processing, resulting primarily from additional cleaning of noise in the outer beams caused by cavitation or schools of fish. Results of the multibeam coverage analysis are presented in the Descriptive Report for each survey.

SIDESCAN SONAR DATA PROCESSING

During data acquisition, the Klein 3000 digital sidescan data were recorded in XTF format on the hard disk of the Klein 3000 acquisition computer. After the file name change at the end of each line, the sidescan data files were archived to the onboard data processing computer. Onboard sidescan data processing included, at a minimum, generating towfish track plots and initial imagery mosaics for coverage verification and quality control. Some initial data review and contact generation was performed onboard the vessel as time permitted. All original and processed sidescan data files were backed up on digital tapes and external hard drives for transfer to the Data Processing Center.

Either on the vessel or at the DPC, initial processing also included re-navigating the towfish to apply more accurate towfish positions using the **SABER Navup** routine. This routine replaced the towfish positions recorded in the original sidescan XTF file with the towfish positions recorded in the acquisition catenary data file recorded by **ISS-2000**. The **Navup** routine also computed and applied a unique position and heading for each ping record (as opposed to the 1 Hz position data recorded during data acquisition). Each record in the catenary file included:

- Time
- Fish position
- Cable out
- Layback
- Fish velocity
- Fish heading
- Fish depth
- Tow angle

During examination of sidescan sonar data, a sidescan review log was generated and maintained throughout the process. This review log initially incorporated all of the relevant information about each sidescan data file, including the line begin and line end times, survey line name, corresponding multibeam and sidescan file names, line azimuth, and any operator notations made during data acquisition. During the subsequent sidescan data review stages, the review log was updated to reflect data quality concerns, highlight data gaps (due to refraction, fish, etc.), to identify significant sidescan contacts, and address any other pertinent issues regarding interpretation of the sidescan data. The sidescan review log is included in Separates I of the Descriptive Report for each sheet.

Sidescan Quality Review

During the sidescan review, an experienced sonar data analyst conducted a quality review of each sidescan file using Triton **Isis** to replay the data. During this review, the processor assessed the overall quality of the data and defined holidays in the data where the quality was insufficient to clearly detect seafloor contacts across the full range scale. The times of and reasons for these data holidays were entered into the sidescan review log. The times of all noted sidescan data gaps were incorporated into the sidescan data time window files that were then used to depict the data gap within the applicable sidescan coverage mosaic. Data holidays were generally characterized by:

- Surface noise (vessel wakes, sea clutter, and/or waves)
- Towfish motion (yaw and heave)
- Electrical noise
- Acoustic noise
- Large, dense schools of fish
- Density layers (refraction)

Sidescan Coverage Analysis

A time window file listing the times of all valid online sidescan data was created, along with separate sidescan file lists for the first and second 100% coverage mosaics. The time window file and file lists were then used to create one-meter cell size mosaics using **SABER.** The first and second 100% coverage mosaics were reviewed using tools in **SABER** to verify swath coverage and to plan additional survey lines to fill in any data gaps.

Sidescan Contact Analysis

During sidescan review, sonar contacts were selected and measured using the **Isis Target** utility. Significant sidescan contacts were chosen based on size and height, or a unique sonar signature. In general, contacts with a computed target height greater than 50 centimeters were selected. Within charted fish havens, contacts were made on objects with a least depth less than the authorized minimum depth, wrecks, or unusually large objects. Contacts with a unique sonar signature (e.g. size, shape, and reflectivity) were typically selected regardless of height. Contacts made within **Isis** were saved as ".CON" files, which included a snapshot of the image and the following contact information:

- Year and JD
- Time
- Position
- Fish altitude
- Slant range to contact (Note: port = negative #, starboard = positive #)

- Contact length, width, and height (based on shadow length, fish altitude, and slant range)

During sidescan data review in **Isis**, the Average Display Down Sample Method was used because it provided the best general-purpose review setting. This setting specifies how the data will be sampled for display in the waterfall display. Down sampling is necessary since the number of pixels displayed is constrained by the width of the display window and the screen resolution. The Triton **Isis Target** utility does not down sample the sidescan data to display the sonar image. If the number of samples contained in the sidescan data record exceeds the number of pixels available on the screen, the software will only show a portion of the record at a single time and provides a scroll bar to be able to view the remaining part of the record. When measuring contacts within Triton **Isis Target**, the length is always the along track dimension and the width is always the across track dimension. Therefore you can have a width measurement that is longer than the length measurement.

Wrecks and large objects were positioned at their highest point based on the observed acoustic shadow. Similarly, contacts for debris fields were positioned at the highest object in the debris field. Additional contacts were made on other man-made objects such as exposed cables, pipelines, and sewer outfalls, if present. In addition to contacts, the sidescan review log also includes entries for many non-significant seafloor objects (e.g., fishing gear, small objects, etc.) that were identified during the sidescan review. The sidescan review log is included in Separates I of the Descriptive Report for each sheet.

After a second independent review of the sidescan files was completed; the contact files were converted into a sidescan contact (CTV) file and tiff images using a **SABER** program called **isis2ctv**. The CTV file lists all of the contact attributes contained in the individual contact files. In **SABER**, the CTV file was viewed as a separate data layer along with a gridded depth layer. By comparing the multibeam bathymetry with the sidescan contact data, both datasets could be evaluated to determine the significance of a contact and the need to create additional sidescan contacts or multibeam features. Positions and depths of features were determined directly from the multibeam data in SAIC's **MVE** swath editor by flagging the least depth on the object. A multibeam feature file (CNT) was created using the **SABER get_ds_features** routine. The CNT file contains the position, depth, type of feature, and attributes extracted from the flagged features in the GSF multibeam data. The final correlation of the sidescan contacts and multibeam features was done in **SABER** which updated the CNT file with the type of feature (obstruction, wreck, etc.) and the CTV file with the feature-to-contact information.

C. CORRECTIONS TO ECHO SOUNDINGS

The data submitted are fully corrected with uncertainties associated with each sounding; therefore, the vessel file will be all zeros.

VESSEL CONFIGURATION PARAMETERS

Figure C-1 and Figure C-2 depicts the *M/V Atlantic Surveyor* sensor configuration and the vessel offsets for the RESON 7125 and 8101 respectively. The vessel offsets are tabulated in Table C-1. All measurements are in meters. For the surveys, either the 7125 transducer or the 8101 transducer was hull-mounted. Offset measurements were made from the IMU with the final position being computed and reported as the acoustic center of the RESON 7125 or 8101 transducer. The reference point for the entire system was located at the RESON 7125 or 8101 transducer acoustic center.

The SAIC Integrated Survey System (**ISS-2000**) and the POS/MV utilize 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. Sensor offsets were entered into either the POS/MV or **ISS-2000** and all sensors connected to **ISS-2000** have their coordinate system transformed to match the one used by **ISS-2000**.

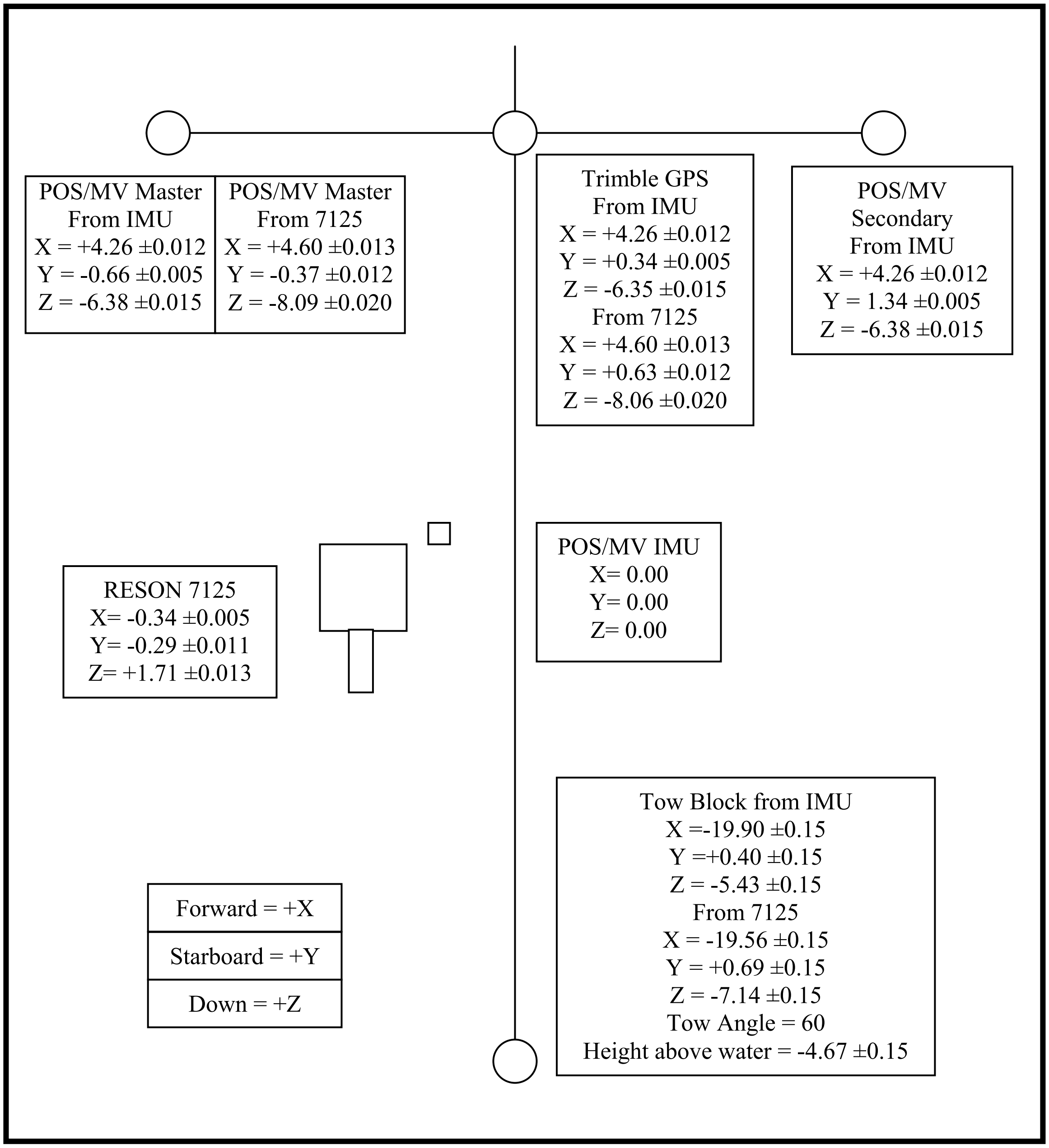

Figure C-1. Configuration and Offsets of *M/V Atlantic Surveyor* Sensors for the RESON 7125 (measurements in meters with 68% CI measurement errors)

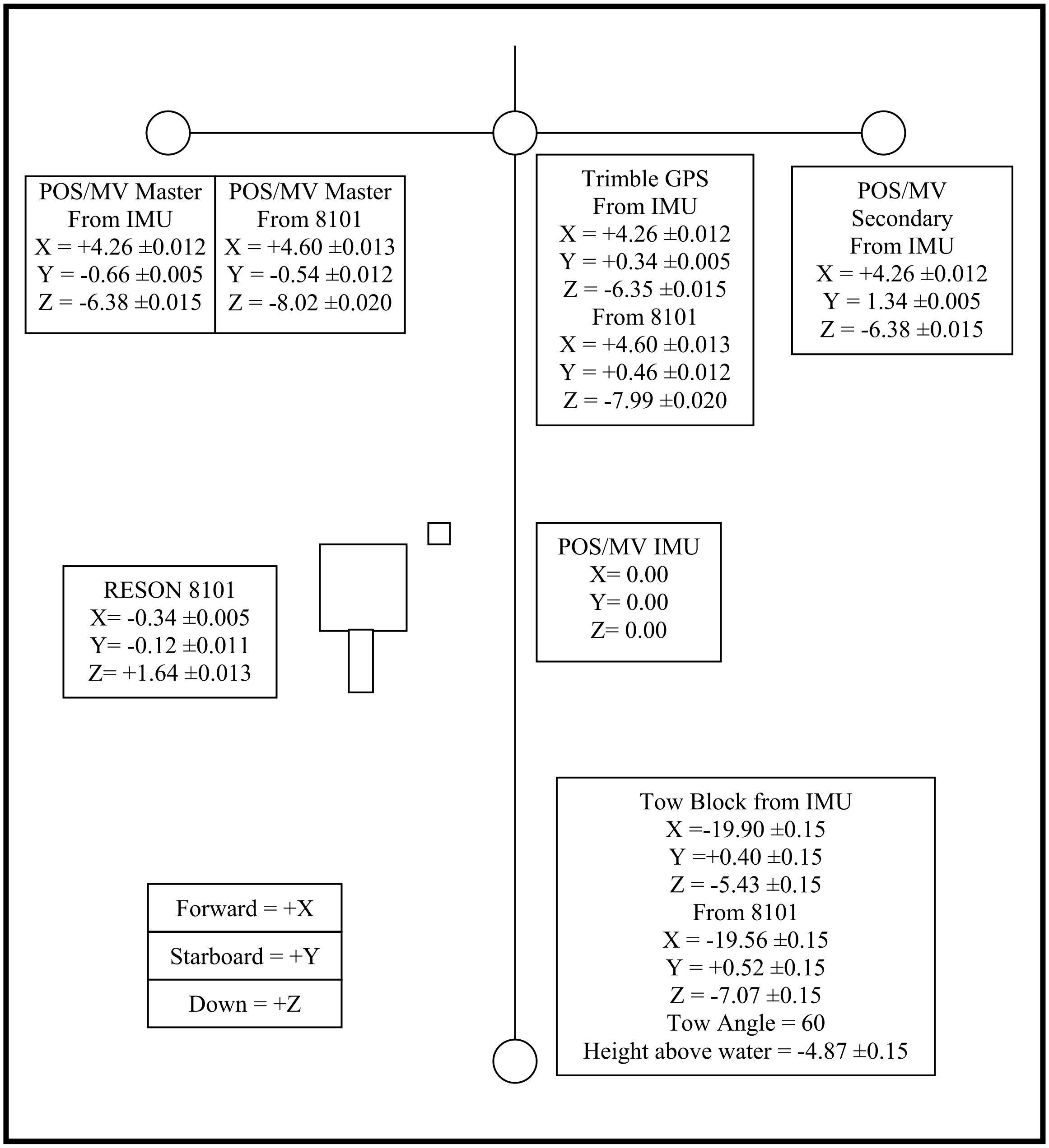

Figure C-2. Configuration and Offsets of *M/V Atlantic Surveyor* Sensors for the RESON 8101 (measurements in meters with 68% CI measurement errors)

Table C-1. *M/V Atlantic Surveyor* Antenna and Transducer Offsets Relative to the POS/MV IMU Vessel Reference Point, measurements in meters

Sensor	Offset in ISS-2000		Offset in POS/MV	
Multibeam RESON 7125 Transducer Hull Mount			X	-0.34 ±0.005
			Y	-0.29 ±0.011
			Z	+1.71 ±0.013
Multibeam RESON 8101 Transducer Hull Mount			X	-0.34 ±0.005
			Y	-0.12 ±0.011
			Z	+1.64 ±0.013
Reference to Heave			X	0.00
			Y	0.00
			Z	0.00
Reference to Vessel (RESON 7125)			X	-0.34 ±0.005
			Y	-0.29 ±0.011
			Z	+1.71 ±0.013
Reference to Vessel (RESON 8101)			X	-0.34 ±0.005
			Y	-0.12 ±0.011
			Z	+1.64 ±0.013
POS/MV GPS Master Antenna			X	4.26 ±0.012
			Y	-0.66 ±0.005
			Z	-6.38 ±0.015
Trimble GPS Antenna From RESON 7125 Transducer	X	+4.60 ±0.013		
	Y	+0.63±0.012		
	Z	-8.06 ±0.020		
Trimble GPS Antenna From RESON 8101 Transducer	X	+4.60 ±0.013		
	Y	+0.46±0.012		
	Z	-7.99 ±0.020		
A-Frame Tow Block (X and Y from RESON 7125 Transducer. Z is height above water).	X	-19.56 ±0.150		
	Y	+0.69 ±0.150		
	Z	-4.67 ±0.150		
A-Frame Tow Block (X and Y from RESON 8101 Transducer. Z is height above water).	X	-19.56 ±0.150		
	Y	+0.52 ±0.150		
	Z	-4.87 ±0.150		

STATIC AND DYNAMIC DRAFT MEASUREMENTS

Static Draft

Figure C-3 shows the draft calculations for the *M/V Atlantic Surveyor*. The RESON 7125 transducer was hull-mounted 3.44 meters below the vessel's main deck while the RESON 8101 transducer was hull mounted 3.30 meters below the vessel's main deck. To determine the draft a 0.02 meter square metal bar is placed on the deck so that it extends out far enough to allow a direct measurement to the water line. The distance below the top of the metal bar to the water surface is measured and subtracted from the transducer hull depth plus the thickness of the bar to determine the draft of the transducer's electronic center.

Static 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 draft value was then recorded in the acquisition Navigation Log. If the static draft value changed from the previously noted value, the new value was entered into the **ISS-2000** system. The observed and prorated static draft for each survey is included with the survey data in Section I of the Separates of each Sheet's Descriptive Report.

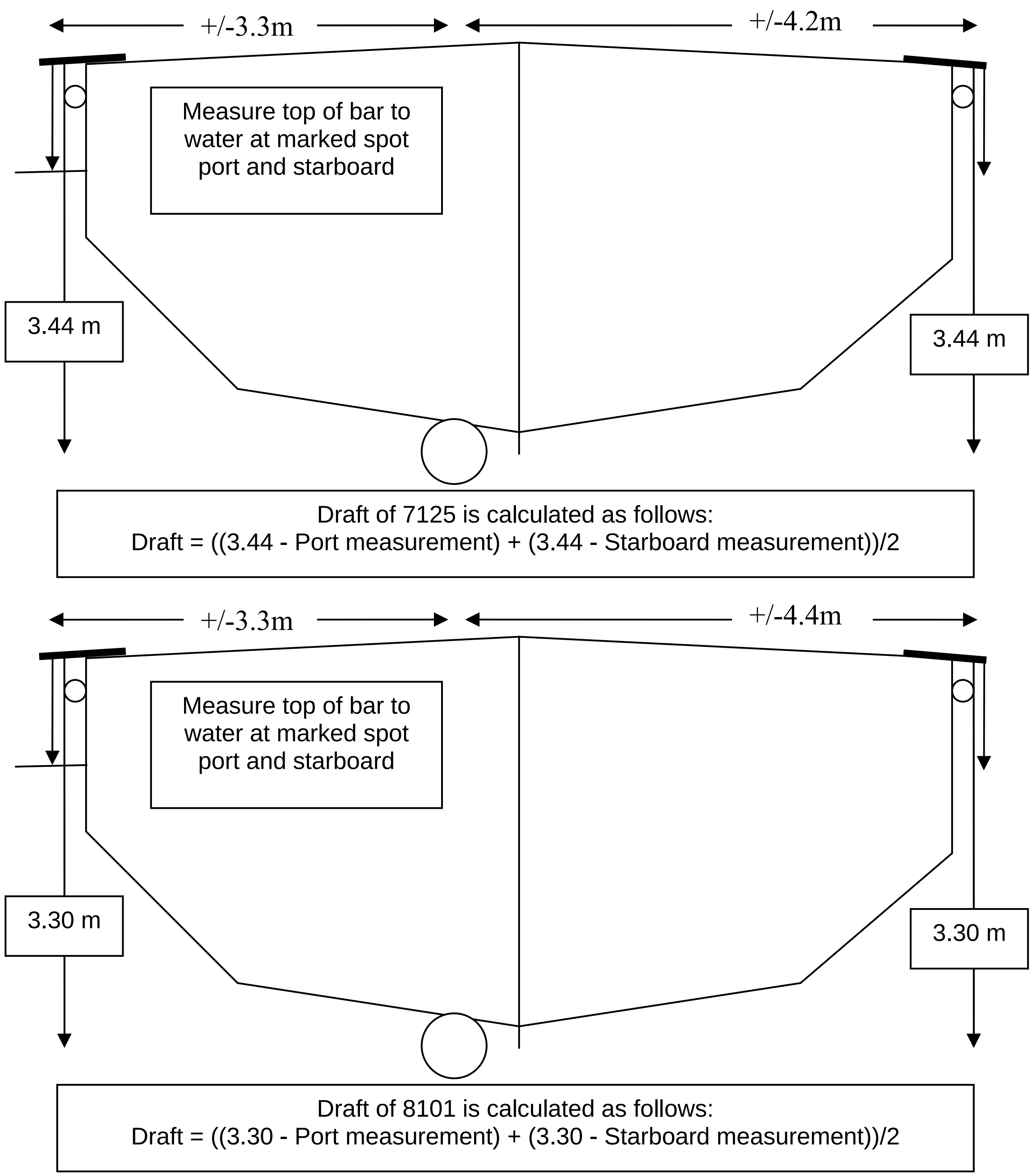

Figure C-3. ***M/V Atlantic Surveyor*** **Draft Determination**

Dynamic Draft

Dynamic draft values were confirmed during the 2009 Sea Acceptance Test (SAT). An initial depth reference surface was created by stopping the vessel and acquiring multibeam data as the vessel drifted with the prevailing current. A survey transect was then established perpendicular to the reference surface. This transect was run twice (once in each direction) at each of the six shaft rpm settings. This test was done on JD 189 to determine the settlement and squat correctors and repeated on JD 190 to verify the settlement and squat correctors entered into the vessel configuration file. A 0.5 meter average grid was created for the drift line and each of the RPM pairs. Difference grids were then created between the average grid from drift reference line and the average grid for each of the RPM pairs. Only the near-nadir (5 degree) beams were used to create the average grids. The settlement and squat values were computed by averaging the measured grid differences for each of the RPM settings. Table C-2 summarizes the shaft RPM, depth corrector, approximate speed and 2009 SAT multibeam files used. A shaft RPM counter provides automatic input to the Settlement and Squat look up table in the **ISS-2000** system.

Table C-2. *M/V Atlantic Surveyor* Settlement and Squat Determination 2009

Shaft RPM	Depth Corrector	Approximate Speed (Kts)	1-Sigma	Files	
				Julian Day 189	Julian Day 190
0	0.00	0	N/A	asmba09189.d02	asmba09190.d06
140	0.02	4	0.01445	asmba09189.d03 asmba09189.d04	asmba09190.d07 asmba09190.d08
180	0.03	5	0.01530	asmba09189.d15 asmba09189.d16	asmba09190.d09 asmba09190.d10
250	0.04	6	0.01121	asmba09189.d06 asmba09189.d07	asmba09190.d11 asmba09190.d12
300	0.07	8	0.01735	asmba09189.d09 asmba09189.d10	asmba09190.d13 asmba09190.d14
340	0.09	9	0.01276	asmba09189.d11 asmba09189.d12	asmba09190.d15 asmba09190.d16
380	0.10	10	0.01526	asmba09189.d13 asmba09189.d14	asmba09190.d17 asmba09190.d18

Dynamic draft values were re-established during the 2010 Sea Acceptance Test (SAT). An initial depth reference surface was created by stopping the vessel and acquiring multibeam data as the vessel drifted with the prevailing wind and current. A survey transect was then established perpendicular to the reference surface. This transect was run twice (once in each direction) at each of the six shaft rpm settings. This test was conducted on JD 096 to determine the settlement and squat correctors and then re-run on JD 097 to verify the settlement and squat values entered into the vessel configuration file. Separate 0.5-meter PFM and minimum grids were created using the near-nadir (5 degree) beams for the drift reference line and each of the RPM pairs. Difference grids were then created between the CUBE depth in the PFM grid as well as from the minimum grids from the drift reference line and each of the RPM pairs. The resulting difference grids were then analyzed using **SABER's Frequency Distribution** tool. This tool allowed the

Hydrographer to visually and numerically view the distribution of depth differences between each RPM pair and the reference drift line. Settlement and Squat values were determined to the nearest centimeter to satisfy the 0.05-meter precision requirement outlined in the April 2009 NOS Hydrographic Surveys Specifications and Deliverables. Table C-3 summarizes the shaft RPM, depth corrector, approximate speed and 2010 SAT multibeam files used. The values determined from the analysis were entered into a look up table within the **ISS-2000** system. A shaft RPM counter provides automatic input to the **ISS-2000** system which in conjunction with the look up table applies a dynamic settlement and squat value as data are collected.

Table C-3. *M/V Atlantic Surveyor* Settlement and Squat Determination 2010

Shaft RPM	Depth Corrector	Approximate Speed (Kts)	1-Sigma	Files	
				Julian Day 096	Julian Day 097
0	0.00	0	N/A	asmba10096.d49	asmba10097.d98
140	-0.02	4	0.018567	asmba10096.d50	asmba10097.d97 asmba10097.d47
180	-0.01	5	0.017429	asmba10096.d51	asmba10097.d48
250	0.01	6	0.018893	asmba10096.d52	asmba10097.d49
300	0.06	8	0.003952	asmba10096.d53 asmba10096.d54	asmba10097.d50
340	0.010	9	0.008186	asmba10096.d55	asmba10097.d51
380	0.12	10	0.009858	asmba10096.d56 asmba10096.d57	asmba10097.d52

Speed of Sound

A Moving Vessel Profiler (MVP), constructed by Brooke Ocean Technology Ltd., with an Applied Microsystems Ltd. Smart Sound Velocity and Pressure (SV&P) sensor, was used to determine sound speed profiles for corrections to multibeam sonar soundings. During repairs of the MVP or upon failure of the instrument, a Seabird Electronics SBE-19 CTD was used to obtain sound speed profiles.

Periodic (every 6-13 days) confidence checks were obtained using consecutive casts with two different SV&P sensors or with a Seabird Electronics SBE-19 CTD. After downloading the sound speed profile (SSP) casts, graphs and tabulated lists were used to compare the two casts for discrepancies.

During multibeam acquisition, SSP casts were uploaded to **ISS-2000** immediately after they were taken. In ISS-2000, the profiles were reviewed for quality and edited as necessary, compared to the preceding casts, and then "applied" to the system. Once applied, **ISS-2000** used the cast for speed and ray tracing corrections to the multibeam sounding data. If sounding depths exceeded the cast depth, the **ISS-2000** used the deepest sound speed value of the cast to extend the profile to the maximum depth.

Factors considered in determining how often a SSP cast was needed included shape and proximity of the coastline, sources and proximity of freshwater, seasonal changes, wind, sea state, cloud cover, and observed changes from the previous profiles. Casts were taken at the beginning of each survey leg, approximately one-hour intervals thereafter, and upon moving to a different survey area.

Quality control tools in **ISS-2000**, including real-time displays of color-coded coverage and a multibeam swath waterfall display, were used to monitor how the sound speed affected the multibeam data. By using these techniques any severe effects due to sound speed profiling could clearly be seen when viewing multibeam data in an along-track direction. Proper sound speed application and effects were also analyzed throughout the survey by using SAIC's **Analyze Crossings** software.

A table including all SSP casts, date, location, application times, and maximum depth is located in Section II of the Separates of each sheet's Descriptive Report.

MULTIBEAM CALIBRATIONS

Navigation positioning, heading, heave, roll and pitch were provided by the Applanix POS/MV 320 Inertial Navigation System. Resolution and accuracy of this system are:

- Heave Resolution 1 cm, Accuracy greater of 5 cm or 5% of heave amplitude
- Roll Resolution 0.01º, Accuracy 0.02º
- Pitch Resolution 0.01º, Accuracy 0.02º

The Applanix True Heave option was used to record delayed heave for application in post processing.

Timing Test

A ping timing test was completed in July 2009 and again in April 2010 for the RESON SeaBat 7125 to verify that no timing errors exist within the survey system. The fundamental 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 ISSC. The pulses of interest are the transmit trigger of the RESON 7-P and the 1PPS timing pulses from the POS/MV. These tests demonstrated that all GSF ping times matched the corresponding IRIG-B event times to within 2.0 milliseconds or less (Figure C-4 and Figure C-5). The same procedures were repeated in July 2010 for the RESON SeaBat 8101 after it was installed to replace the RESON 7125 (Figure C-6). Following factory repairs, the RESON 7125 was re-installed in August 2010 and another timing test was conducted (Figure C-7).

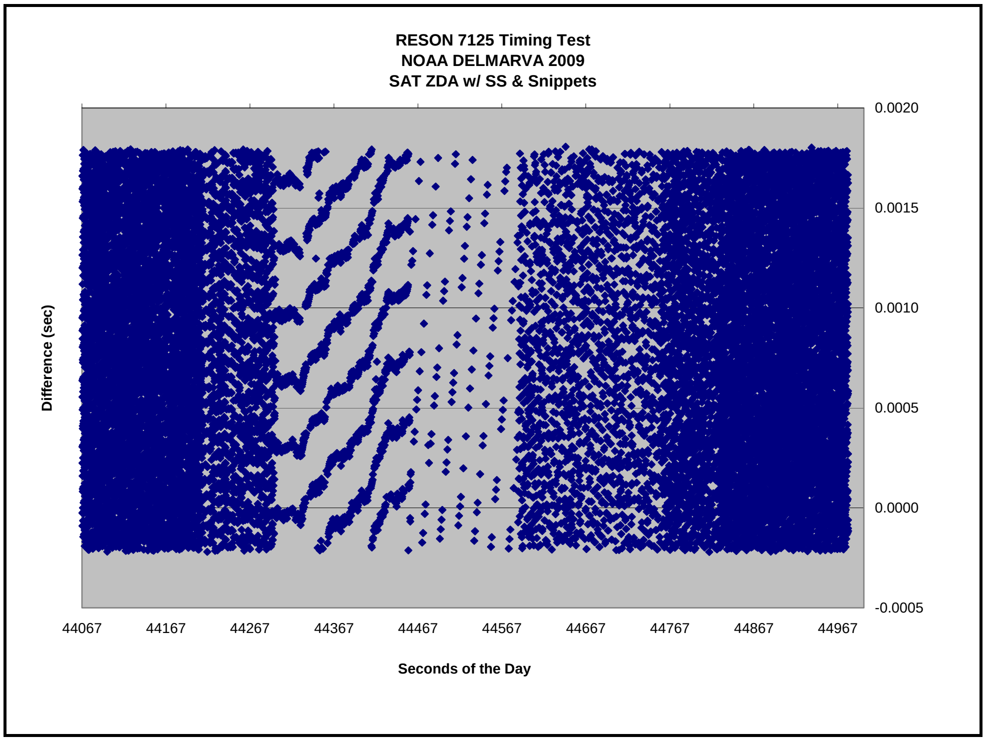

Figure C-4. 2009 RESON 7125 Timing Test Results (time differences of ping trigger event vs. ping time tag from GSF)

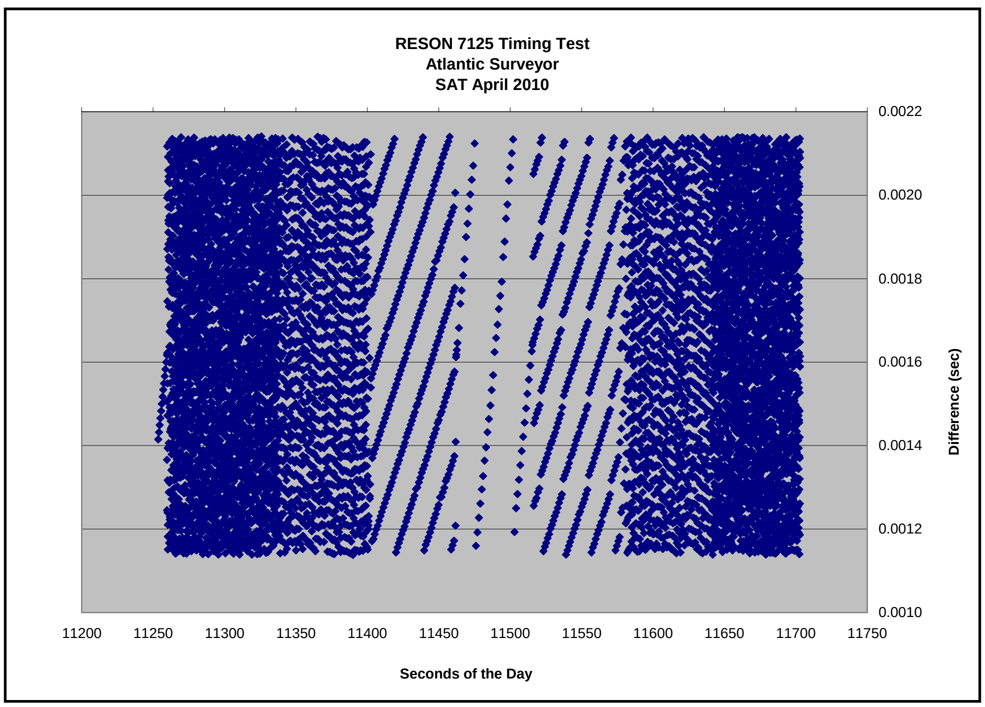

Figure C-5. April 2010 RESON 7125 Timing Test Results (time differences of ping trigger event vs. ping time tag from GSF)

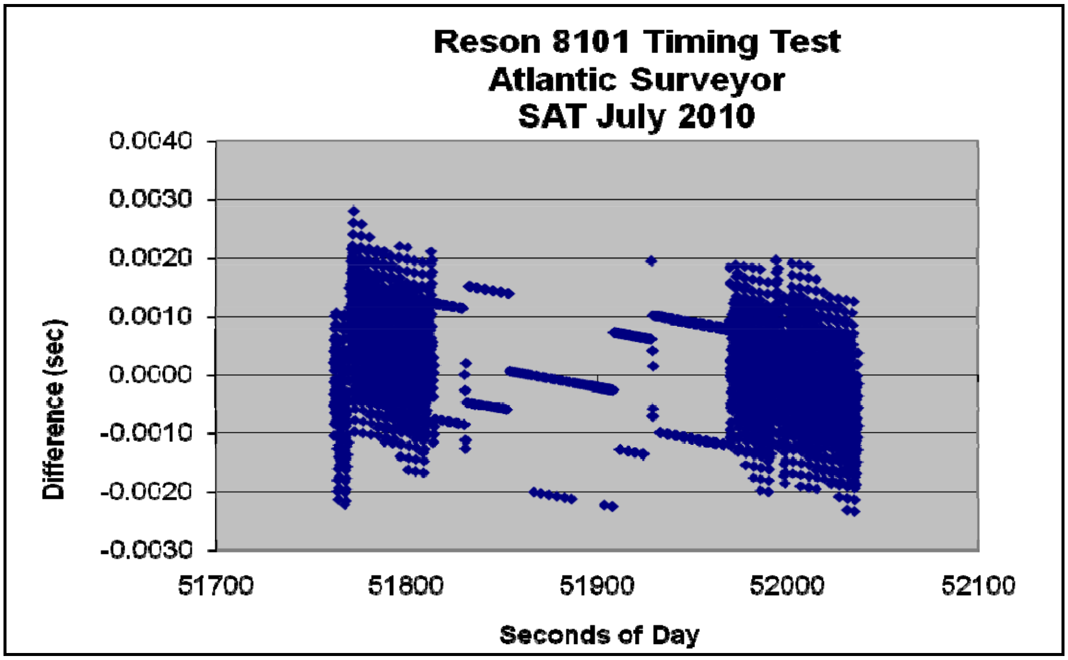

Figure C-6. July 2010 RESON 8101 Timing Test Results (time differences of ping trigger event vs. ping time tag from GSF)

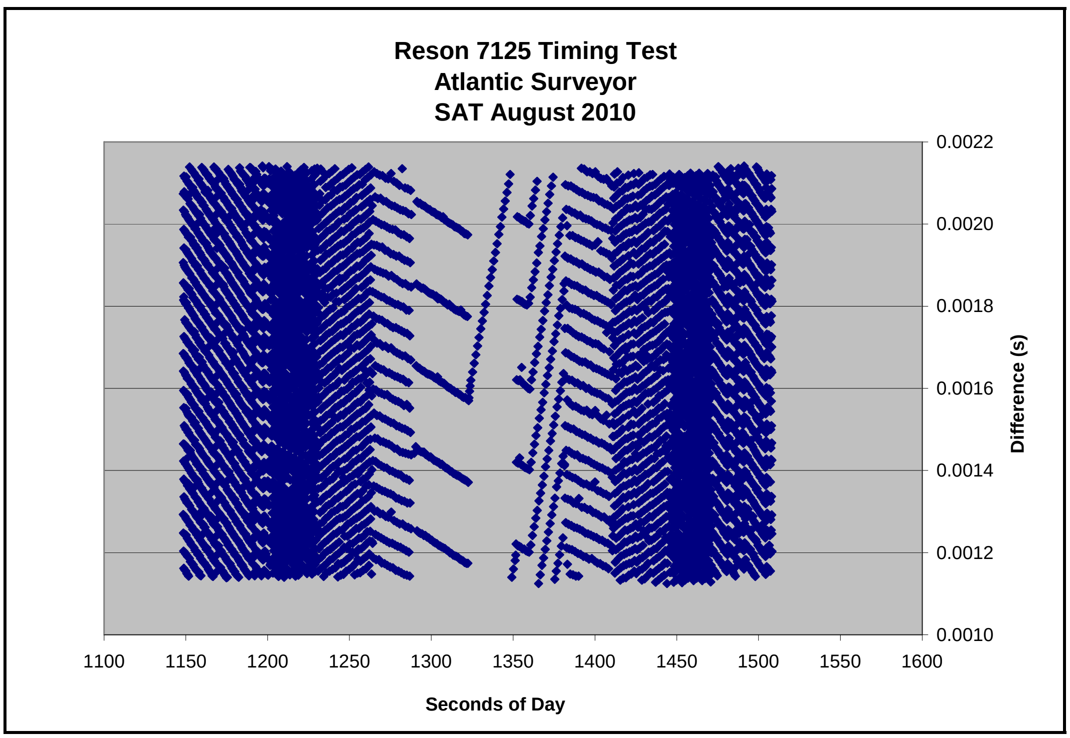

Figure C-7. August 2010 RESON 7125 Timing Test Results (time differences of ping trigger event vs. ping time tag from GSF)

Multibeam Bias Calibration

Roll, pitch, and heading biases were determined on the following dates:

- 08 July 2009 (2009 SAT)
- 07 April 2010 (2010 SAT)
- 21 June 2010 (following a 3-day transit from Georgia)
- 20 July 2010 (installation of the RESON 8101)
- 15 August 2010 (Re-installation of the RESON 7125)

A 47 foot wreck charted in 40° 03.3925'N 073° 59.5541'W within the fish haven approximately 6 kilometers southeast of Manasquan Inlet was used for all alignments noted above with the exception of the alignment conducted on 21 June 2010. The alignment conducted 21 June 2010 was performed over a known fish haven wreck positioned in 38˚ 17.455'N 074˚ 54.659"W. This wreck was located on the eastern edge of survey sheet H11872 previously surveyed and delivered to NOAA.

08 July 2009 RESON 7125 Alignment

The alignment conducted on 08 July 2009 was preformed prior to the start of the 2009 survey season utilizing the RESON 7125. The results are presented in Table C-4 and Figures C-8 through C-13.

Table C-4. Multibeam Files Verifying Alignment Bias Calculated using the Swath Alignment Tool (SAT) - 08 July 2009 RESON 7125

Component	Multibeam Files		Bias
Pitch	asmba09189.d36	asmba09189.d39	+2.1°
Roll	asmba09189.d36	asmba09189.d39	+0.14°
Heading	asmba09189.d41	asmba09189.d42	+1.4°

Two sets of lines were collected for pitch bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-8 and Figure C-9 are images of the **SABER Swath Alignment** tool (**SAT** tool) depicting data collected with the +2.1° pitch bias entered in the **ISS-2000** system; therefore the indicated pitch bias is zero.

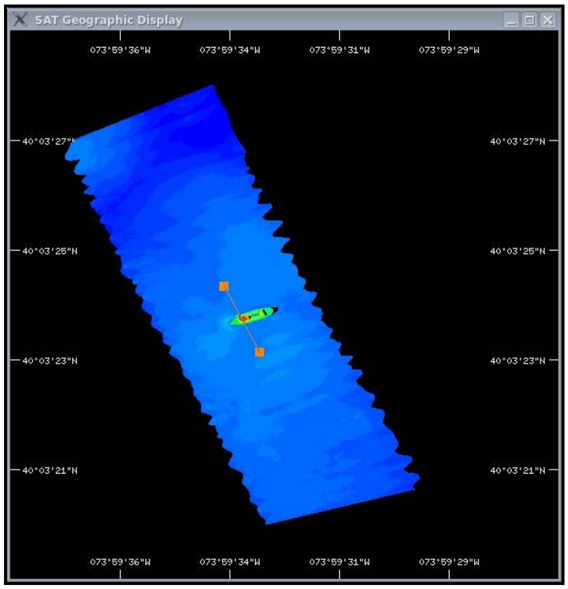

Figure C-8. SAT Tool, Plan View Depicting +2.1° Pitch Bias

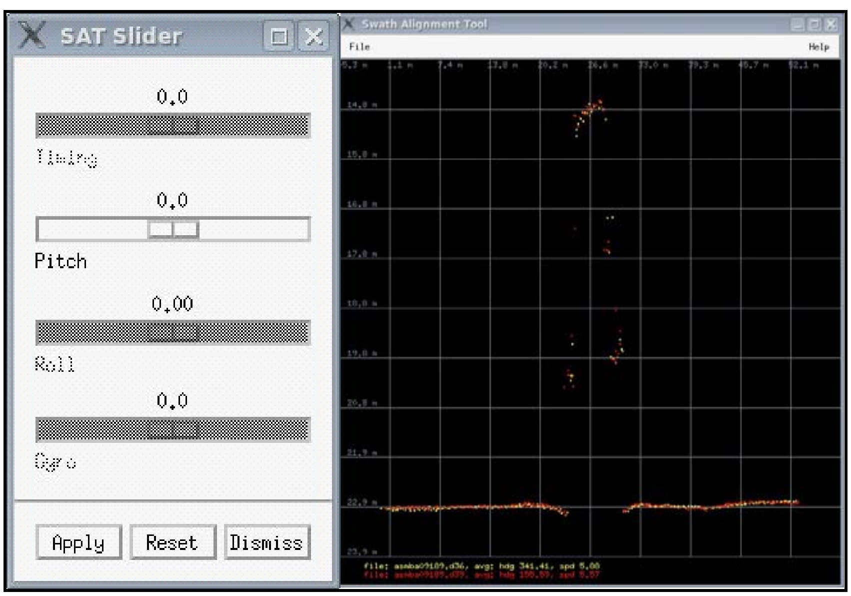

Figure C-9. SAT Tool, Depth vs. Distance Plot Depicting +2.1° Pitch Bias

Two sets of lines were collected for roll bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-10 and Figure C-11 are images of the **SAT** tool depicting data collected with the +0.14° roll bias entered in the ISS200 system; therefore the indicated bias is zero.

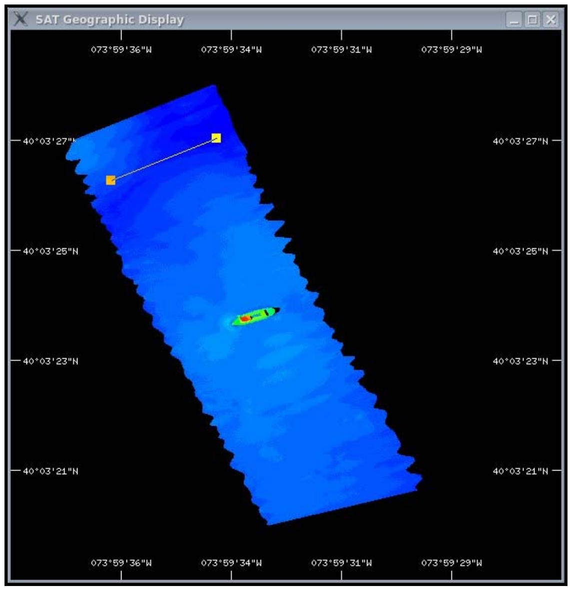

Figure C-10. SAT Tool, Plan View Depicting +0.14° Roll Bias

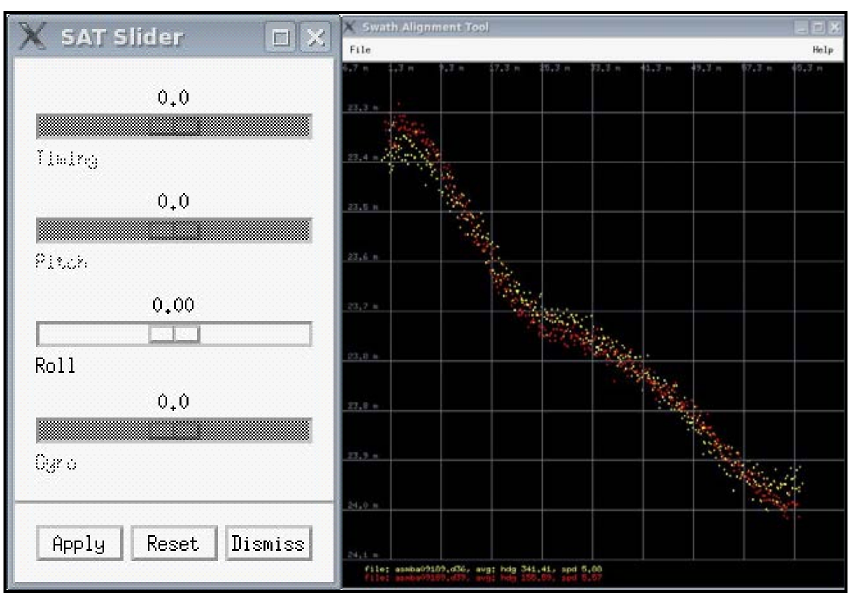

Figure C-11. SAT Tool, Depth vs. Distance Depicting +0.14° Roll Bias

Two sets of lines were collected for heading bias calculation. Lines were run on either side of the charted wreck in opposite directions so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-12 and Figure C-13 are images of the **SAT** tool depicting data collected with the +1.4° heading bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

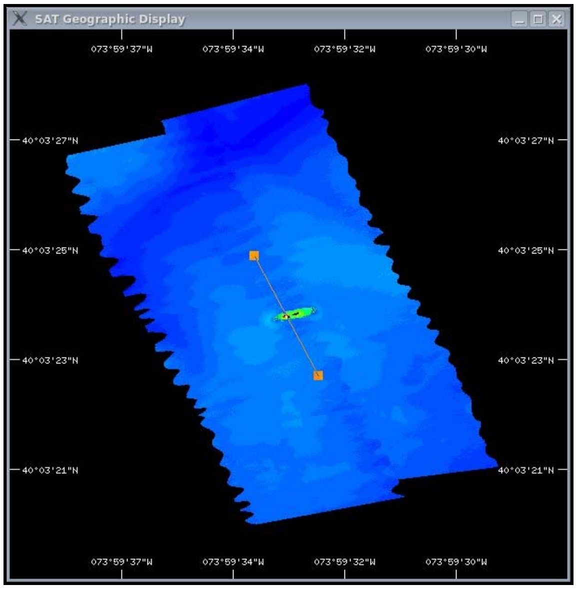

Figure C-12. SAT Tool, Plan View Depicting +1.4° Heading Bias

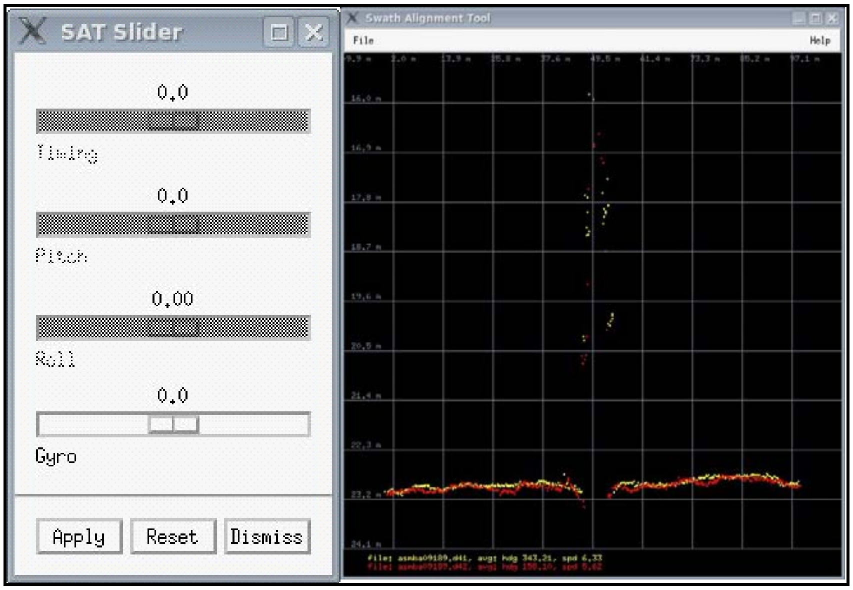

Figure C-13. SAT Tool, Depth vs. Distance Depicting +1.4 Heading Bias

07 April 2010 7125 Alignment

The alignment conducted on 07 April 2010 was preformed prior to the start of the 2010 survey season with the RESON 7125. The results are presented in Table C-5 and Figures C-14 through C-19.

Table C-5. Multibeam Files Verifying Alignment Bias Calculated using the Swath Alignment Tool (SAT) - 07 April 2010 RESON 7125

Component	Multibeam Files		Result
Pitch	asmba10097.d03	asmba10097.d04	+2.46°
Roll	asmba10097.d03	asmba10097.d04	+0.25°
Heading	asmba10097.d05	asmba10097.d06	+1.80°

Two sets of lines were collected for pitch bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-14 and Figure C-15 are images of the **SAT** tool depicting data collected with the +2.46° pitch bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

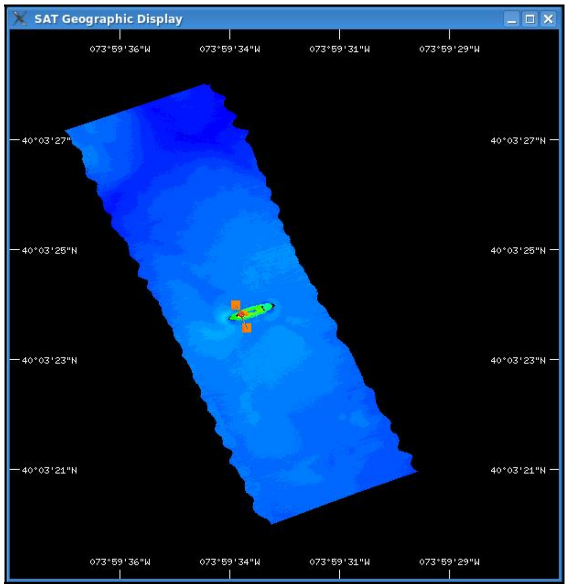

Figure C-14. SAT Tool, Plan View Depicting +2.46° Pitch Bias

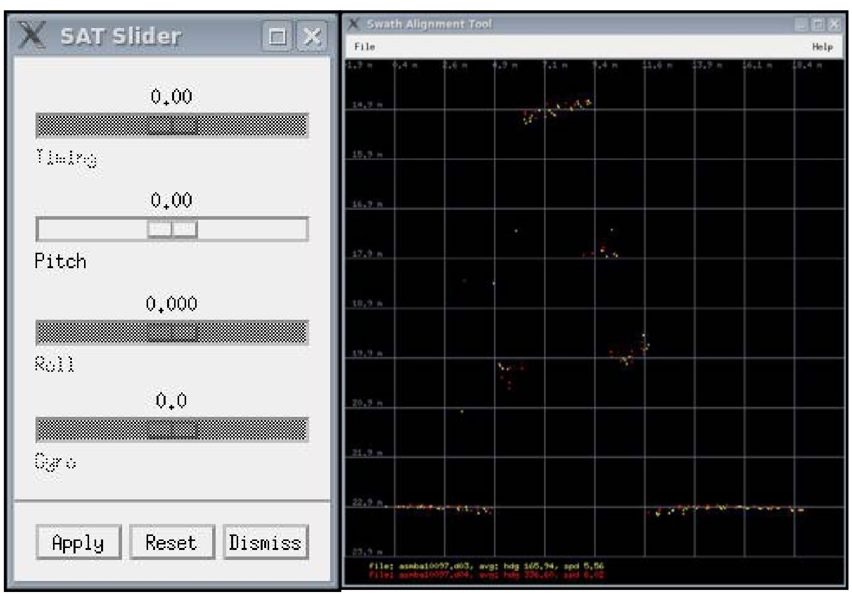

Figure C-15. SAT Tool, Depth vs. Distance Plot Depicting +2.46° Pitch Bias

Two sets of lines were collected for roll bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-16 and Figure C-17 are images of the **SAT** tool depicting data collected with the +0.25° roll bias entered in the ISS200 system; therefore the indicated bias is zero.

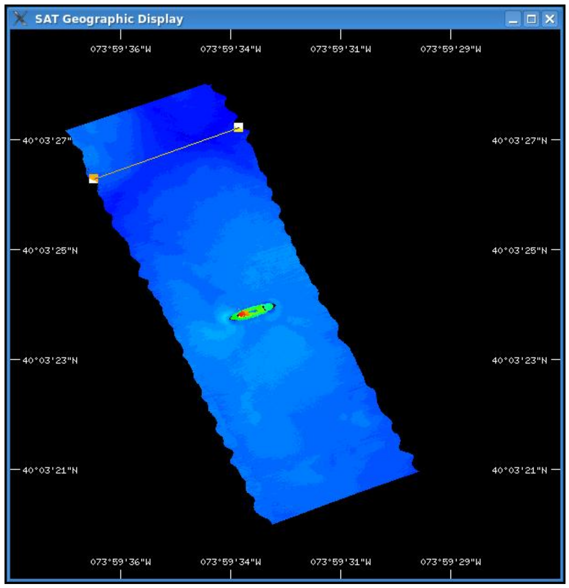

Figure C-16. SAT Tool, Plan View Depicting +0.25° Roll Bias

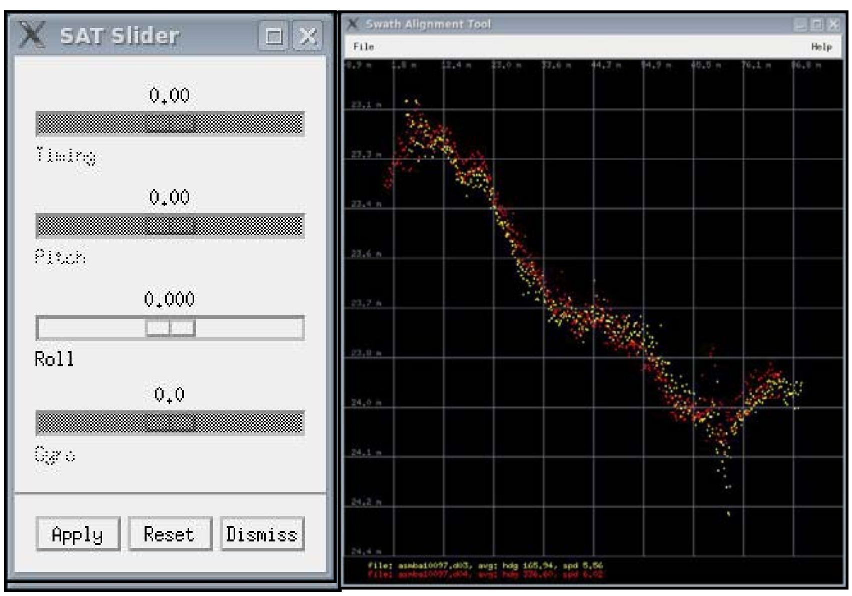

Figure C-17. SAT Tool, Depth vs. Distance Depicting +0.25° Roll Bias

Two sets of lines were collected for heading bias calculation. Lines were run on either side of the charted wreck in opposite directions so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-18 and Figure C-19 are images of the **SAT** tool depicting data collected with the +1.80° heading bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

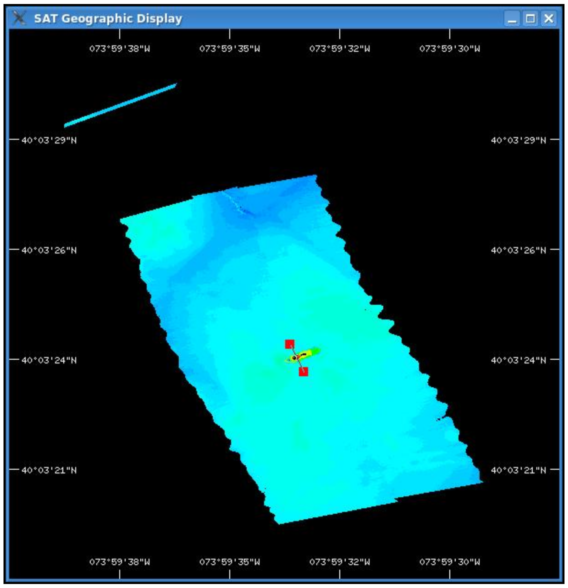

Figure C-18. SAT Tool, Plan View Depicting +1.80° Heading Bias

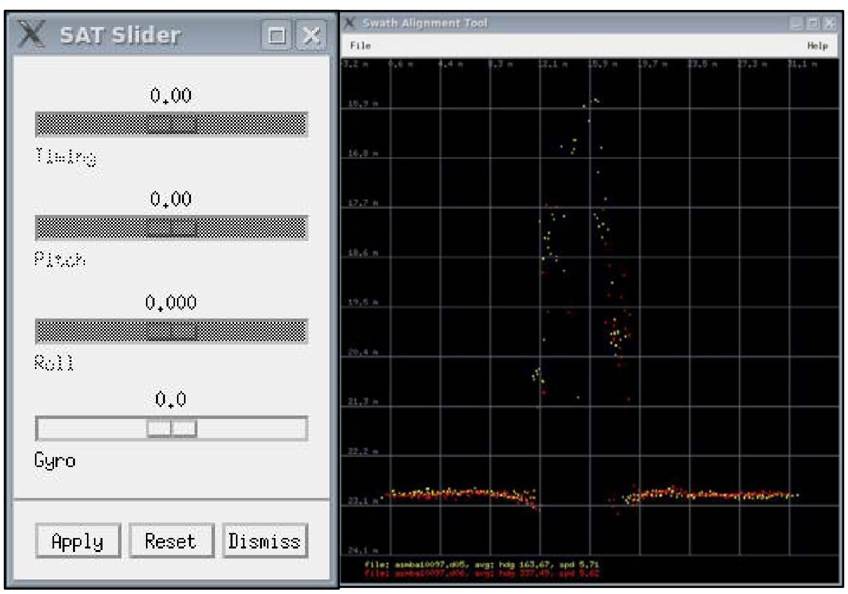

Figure C-19. SAT Tool, Depth vs. Distance Depicting +1.80 Heading Bias

21 June 2010 RESON 7125 Alignment

On 23 April 2010 survey operations along the Virginia coast were suspended. The vessel transited to Florida to conduct additional survey operations for the Georgia approaches. The survey vessel returned to New Jersey on 18 June 2010 to resume survey operations along the Virginia coast. On 21 June 2010, prior to resuming survey operations, additional alignments were conducted using the RESON 7125. The results are presented in Table C-6 and Figures C-20 through C-25.

Table C-6. Multibeam Files Verifying Alignment Bias Calculated using the Swath Alignment Tool (SAT) - 21 June 2010 RESON 7125

Component	Multibeam Files		Result
Pitch	asmba10172.d03	asmba10172.d06	+2.46°
Roll	asmba10172.d03	asmba10172.d06	+0.25°
Heading	asmba10172.d03	asmba10172.d04	+1.30°

Two sets of lines were collected for pitch bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-20 and Figure C-21 are images of the **SAT** tool depicting data collected with the +2.46° pitch bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

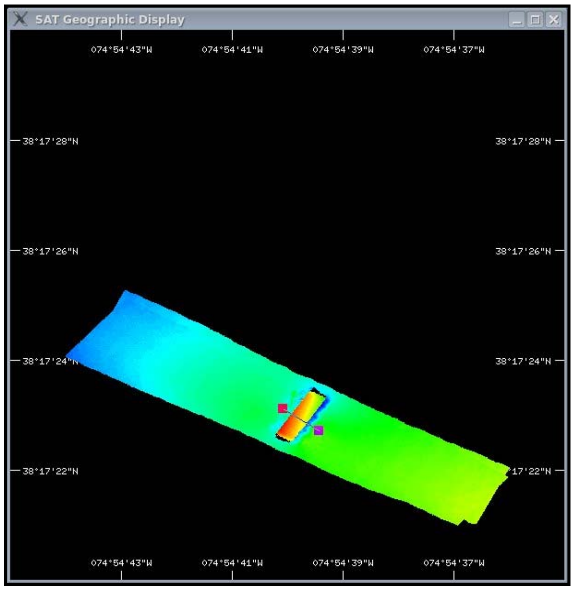

Figure C-20. SAT Tool, Plan View Depicting +2.46° Pitch Bias

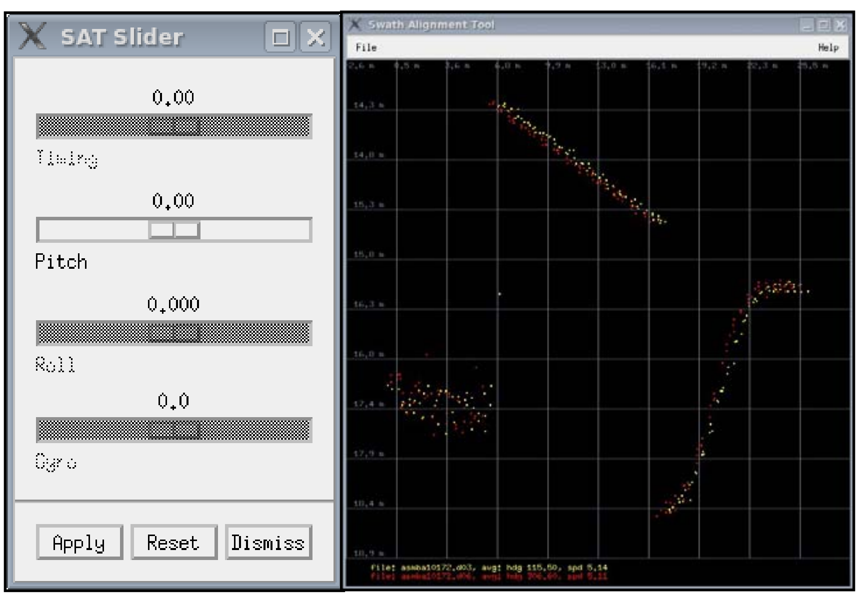

Figure C-21. SAT Tool, Depth vs. Distance Plot Depicting +2.46° Pitch Bias

Two sets of lines were collected for roll bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-22 and Figure C-23 are images of the **SAT** tool depicting data collected with the +0.25° roll bias entered in the ISS200 system; therefore the indicated bias is zero.

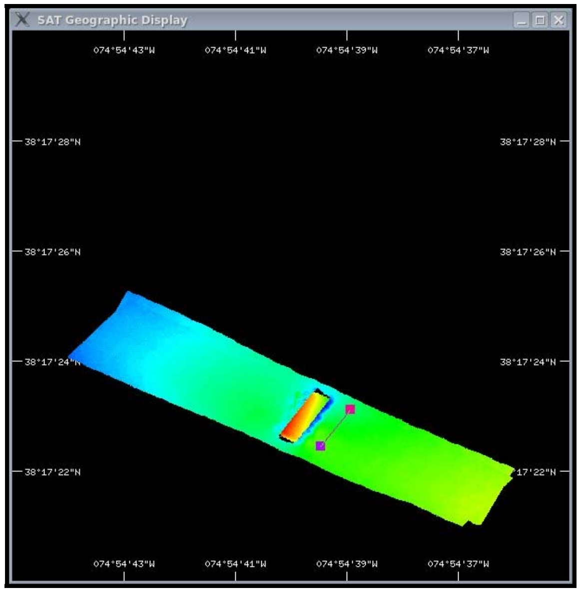

Figure C-22. SAT Tool, Plan View Depicting +0.25° Roll Bias

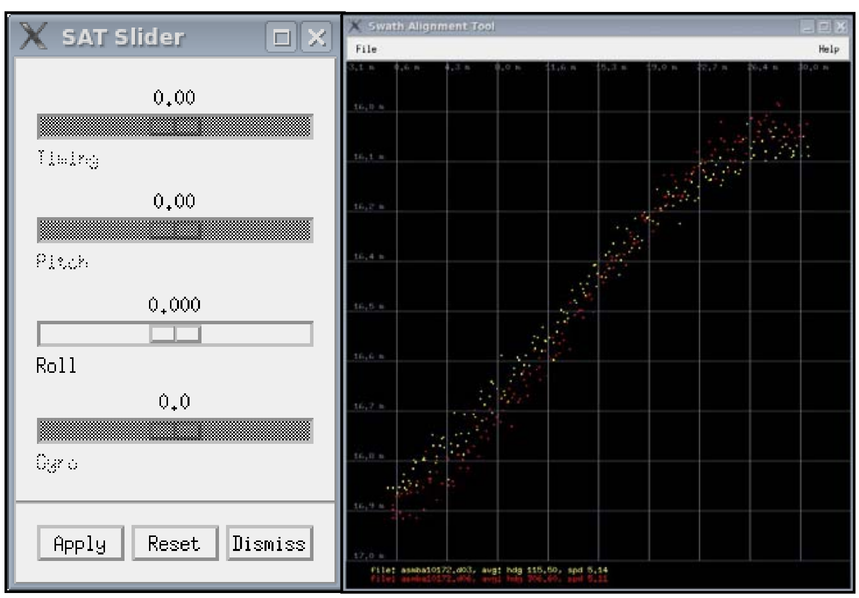

Figure C-23. SAT Tool, Depth vs. Distance Depicting +0.25° Roll Bias

Two sets of lines were collected for heading bias calculation. Lines were run on either side of the charted wreck in opposite directions so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-24 and Figure C-25 are images of the **SAT** tool depicting data collected with the +1.30° heading bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

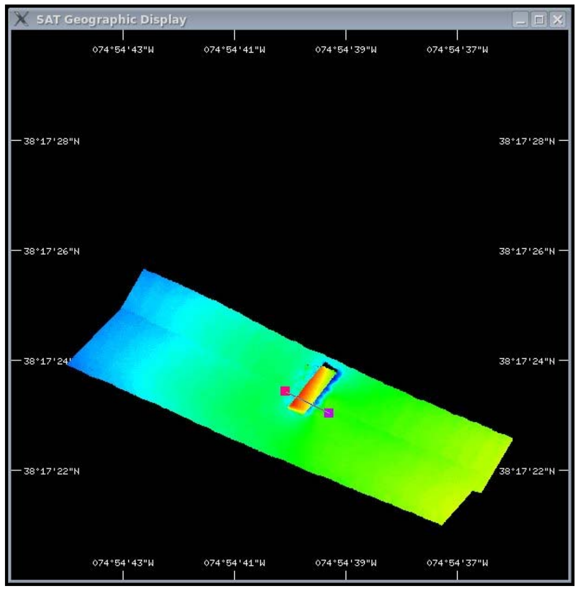

Figure C-24. SAT Tool, Plan View Depicting +1.30° Heading Bias

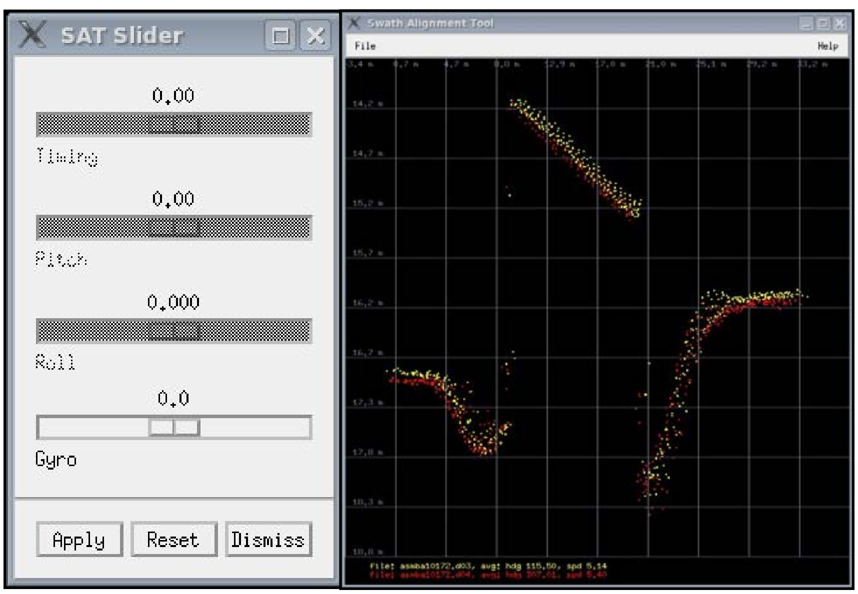

Figure C-25. SAT Tool, Depth vs. Distance Depicting +1.30 Heading Bias

20 July 2010 RESON 8101 Alignment

The RESON 7125 was removed from the vessel on 19 July 2010 and was replaced with a RESON 8101. After swapping the sonar systems additional alignments were conducted on 20 July 2010 with the RESON 8101 prior to resuming survey. The results are presented in Table C-7 and Figures C-26 through C-31.

Table C-7. Multibeam Files Verifying Alignment Bias Calculated using the Swath Alignment Tool (SAT) - 20 July 2010 RESON 8101

Component	Multibeam Files		Bias
Pitch	asmba10201.d18	asmba10201.d19	+2.37°
Roll	asmba10201.d18	asmba10201.d19	+0.57°
Heading	asmba10201.d13	asmba10201.d14	+1.40°

Two sets of lines were collected for pitch bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-26 and Figure C-27 are images of the **SAT** tool depicting data collected with the +2.37° pitch bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

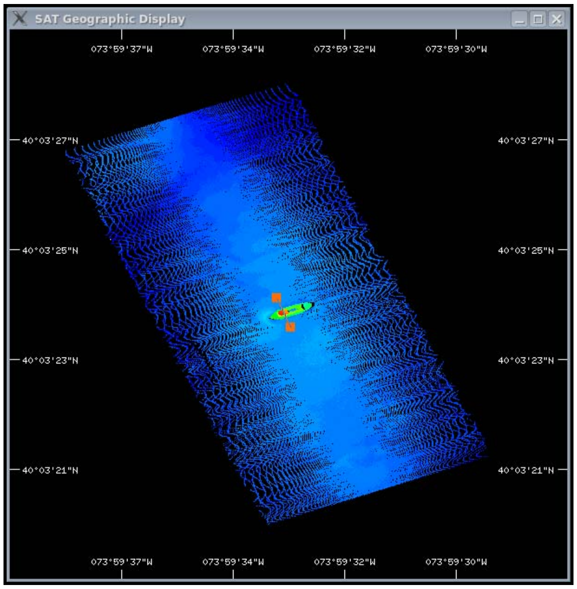

Figure C-26. SAT Tool, Plan View Depicting +2.37° Pitch Bias

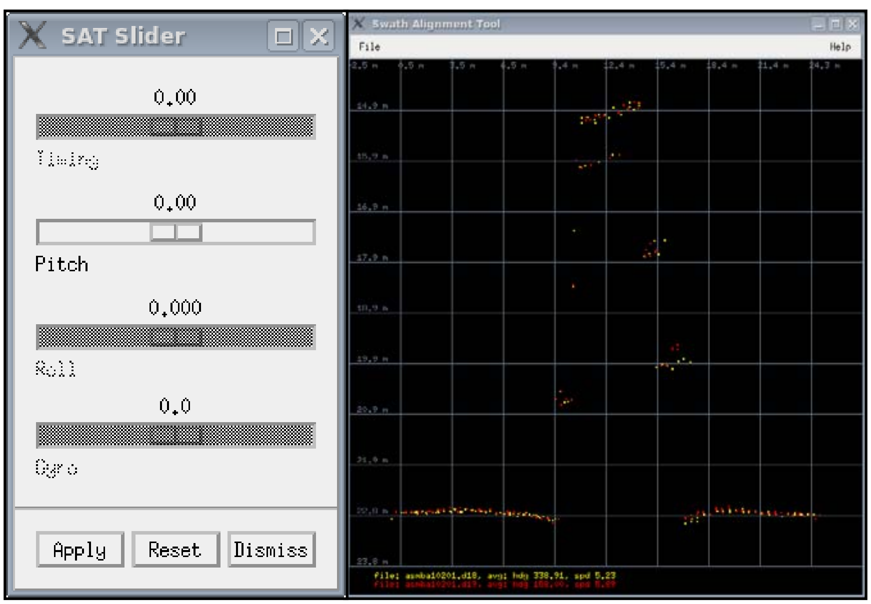

Figure C-27. SAT Tool, Depth vs. Distance Plot Depicting +2.37° Pitch Bias

Two sets of lines were collected for roll bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-28 and Figure C-29 are images of the **SAT** tool depicting data collected with the +0.57° roll bias entered in the ISS200 system; therefore the indicated bias is zero.

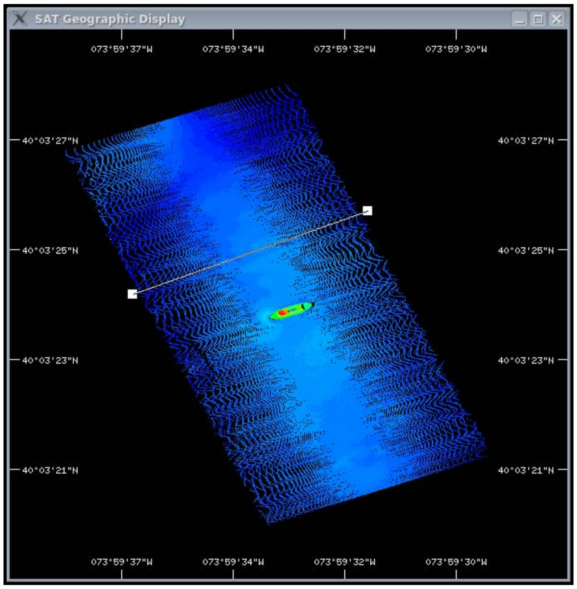

Figure C-28. SAT Tool, Plan View Depicting +0.57° Roll Bias

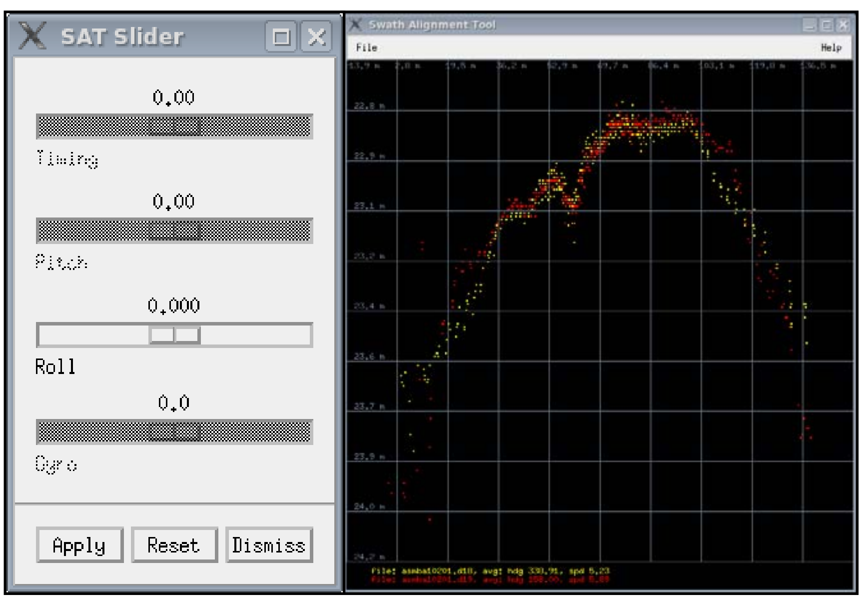

Figure C-29. SAT Tool, Depth vs. Distance Depicting +0.57° Roll Bias

Two sets of lines were collected for heading bias calculation. Lines were run on either side of the charted wreck in opposite directions so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-30 and Figure C-31 are images of the **SAT** tool depicting data collected with the +1.40° heading bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

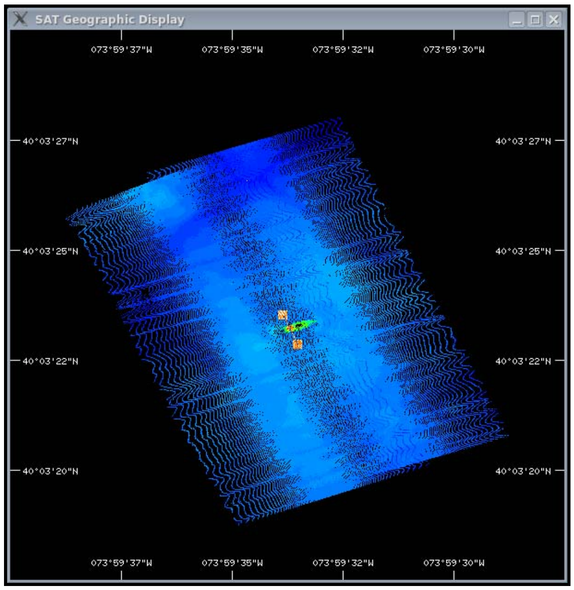

Figure C-30. SAT Tool, Plan View Depicting +1.40° Heading Bias

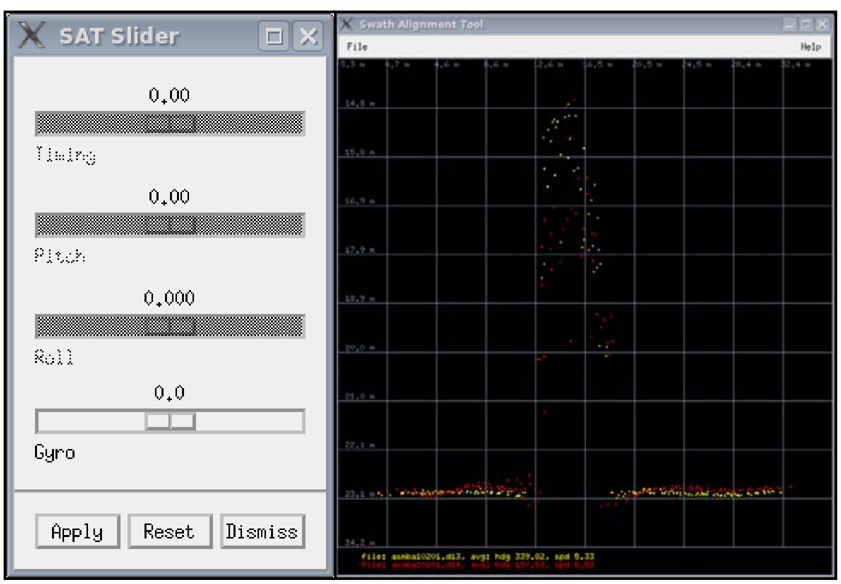

Figure C-31. SAT Tool, Depth vs. Distance Depicting +1.40 Heading Bias

15 August 2010 RESON 7125 Alignment

The RESON 7125 was re-installed on the *M/V Atlantic Surveyor* on 12 August 2010. Roll, pitch, and heading biases were determined on 15 August 2010 over a 47 foot wreck in the fish haven approximately six kilometers southeast of Manasquan Inlet. The wreck is charted in 40° 03.3925'N 073° 59.5541'W. Final Biases are presented in Table C-8 and Figures C-32 through C-37.

Table C-8. Multibeam Files Verifying Alignment Bias Calculated using the Swath Alignment Tool (SAT) - 15 August 2010 RESON 7125

Component	Multibeam Files		Result
Pitch	asmba10227.d06	asmba10227.d09	+2.46°
Roll	asmba10227.d06	asmba10227.d09	+0.25°
Heading	asmba10227.d11	asmba10227.d12	+1.80°

Two sets of lines were collected for pitch bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the pitch bias. Figure C-32 and Figure C-33 are images of the **SAT** tool depicting data collected with the +2.46° pitch bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

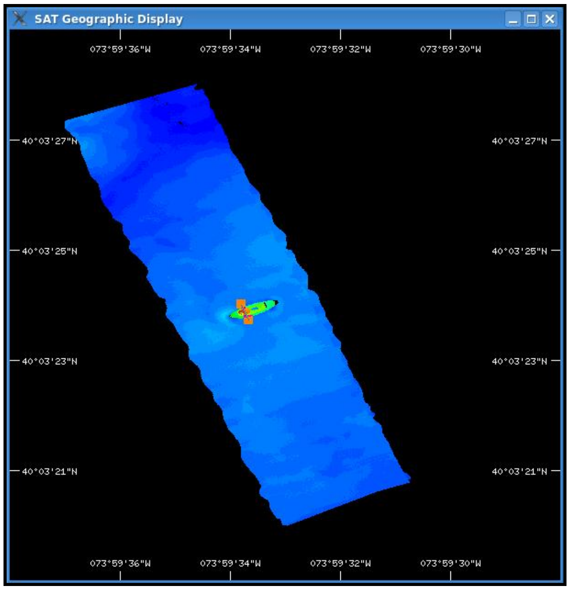

Figure C-32. SAT Tool, Plan View Depicting +2.46° Pitch Bias

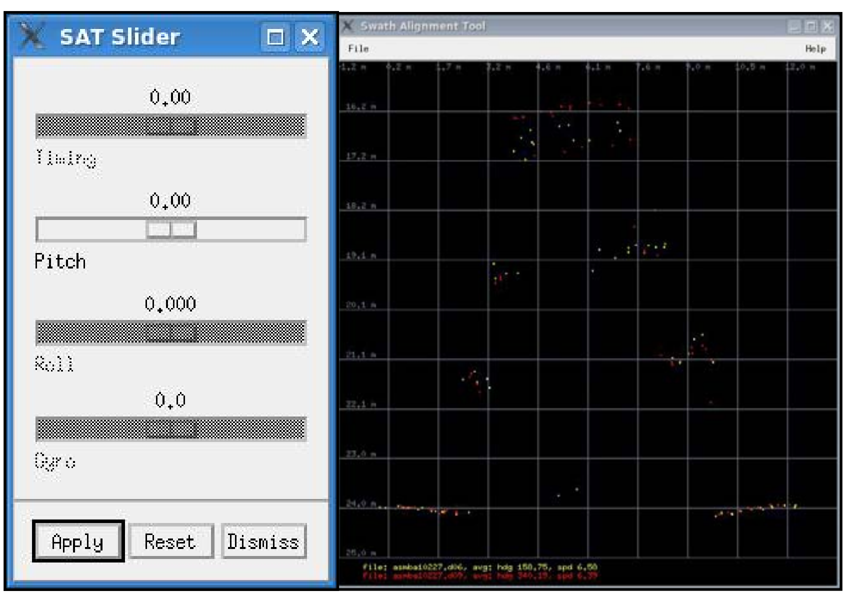

Figure C-33. SAT Tool, Depth vs. Distance Plot Depicting +2.46° Pitch Bias

Two sets of lines were collected for roll bias calculation. Lines were run along the same survey transect so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the roll bias. Figure C-34 and Figure C-35 are images of the **SAT** tool depicting data collected with the +0.25° roll bias entered in the ISS200 system; therefore the indicated bias is zero.

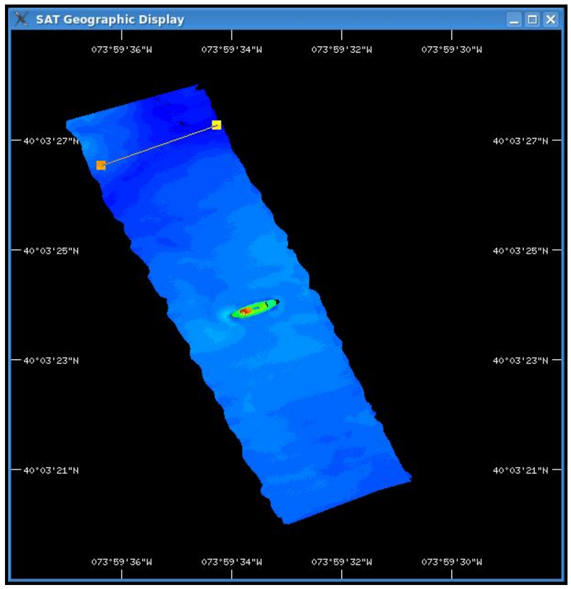

Figure C-34. SAT Tool, Plan View Depicting +0.25° Roll Bias

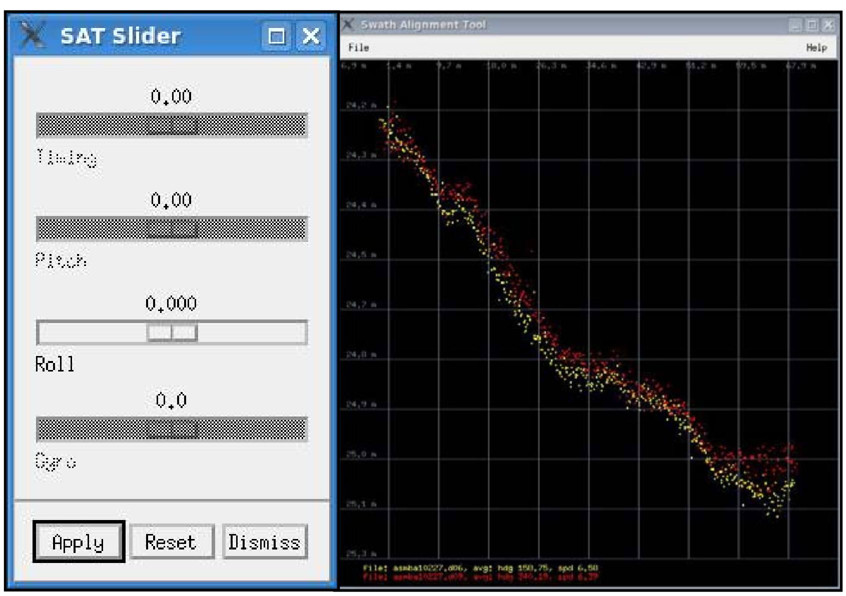

Figure C-35. SAT Tool, Depth vs. Distance Depicting +0.25° Roll Bias

Two sets of lines were collected for heading bias calculation. Lines were run on either side of the charted wreck in opposite directions so that comparisons could be made between lines run in opposite directions. Several samples were viewed for each set of comparison lines in order to determine an accurate measurement of the heading bias. Figure C-36 and Figure C-37 are images of the **SAT** tool depicting data collected with the +1.80° heading bias entered in the **ISS-2000** system; therefore the indicated bias is zero.

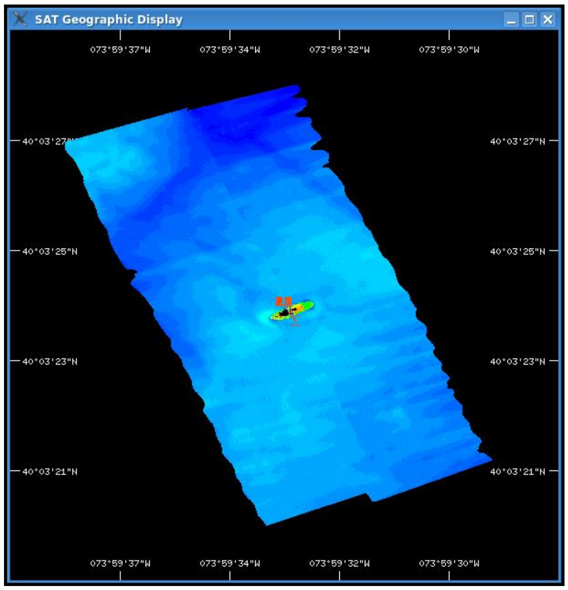

Figure C-36. SAT Tool, Plan View Depicting +1.80° Heading Bias

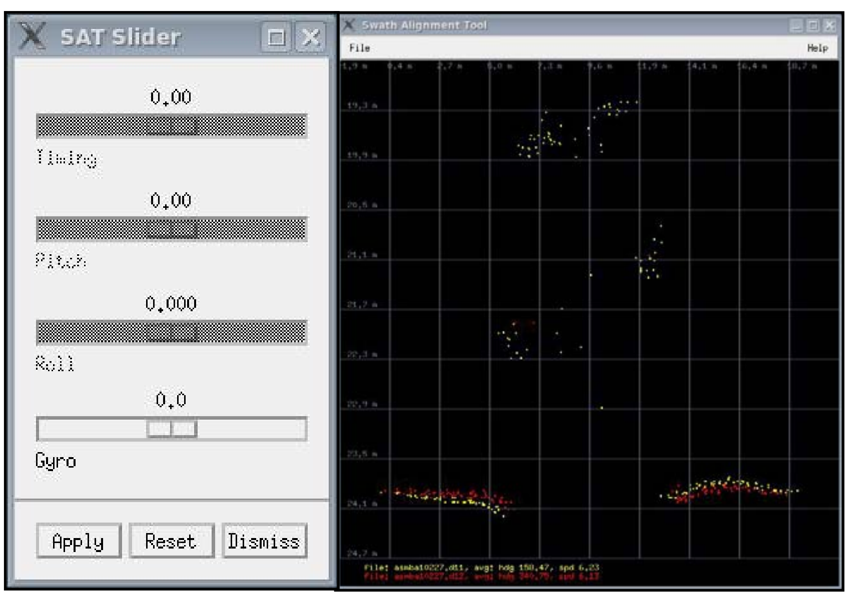

Figure C-37. SAT Tool, Depth vs. Distance Depicting +1.80° Heading Bias

Multibeam Accuracy

July 2009 SAT

During the July 2009 SAT, a survey was run in the vicinity of the wreck alignment site consisting of 19 main scheme lines and three cross lines centered on the wreck. All depths were corrected for predicted tides and zoning using the Atlantic City tide gauge, 8534720. Class 1 cutoff angle was set to 5° and class 2 cutoff set to 60°. Standard multibeam data processing procedures were followed to clean the data, apply delayed heave, and calculate errors. One meter minimum grids of main scheme lines, class one cross lines, and all lines were created. A one-meter PFM of all the data was also generated and gap checker and check uncertainty were run on the PFM CUBE depth layer. Multibeam features, sidescan contacts, and selected soundings in feet were generated. The resulting minimum grid with selected soundings is shown in Figure C-38. The PFM with CUBE depths and Uncertainties are shown in Figure C-39 and Figure C-40 respectively. The junction analysis results for the depth differences between the main and cross lines are shown in Table C-9.

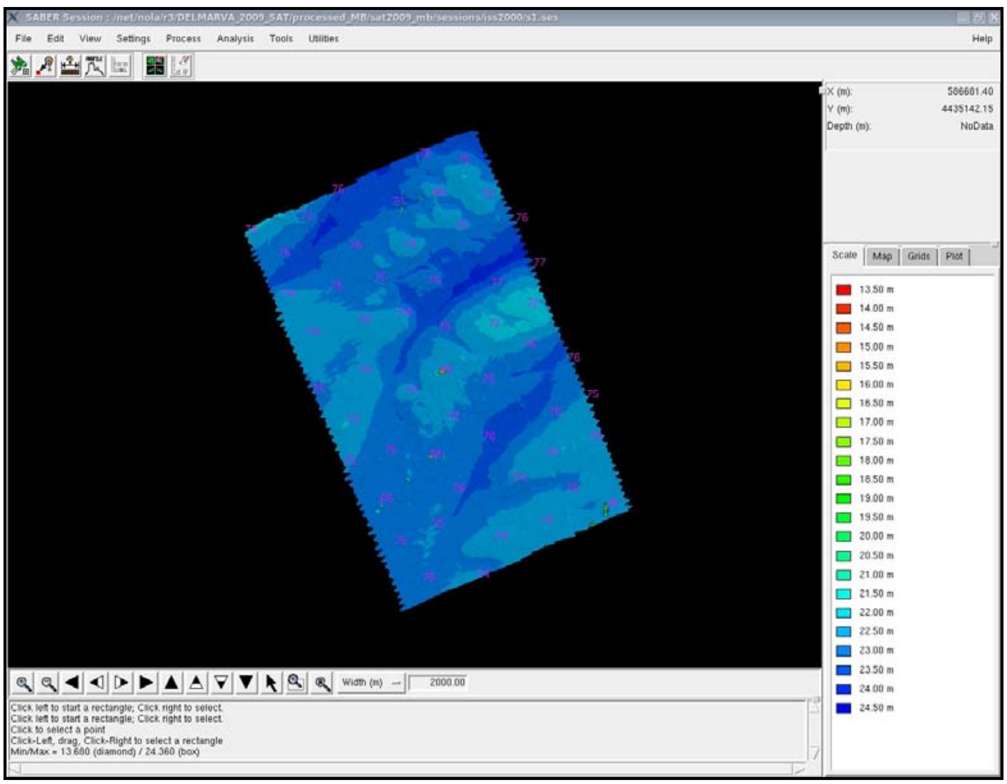

Figure C-38. July 2009 SAT - RESON 7125 Minimum Depth Grid and Selected Soundings

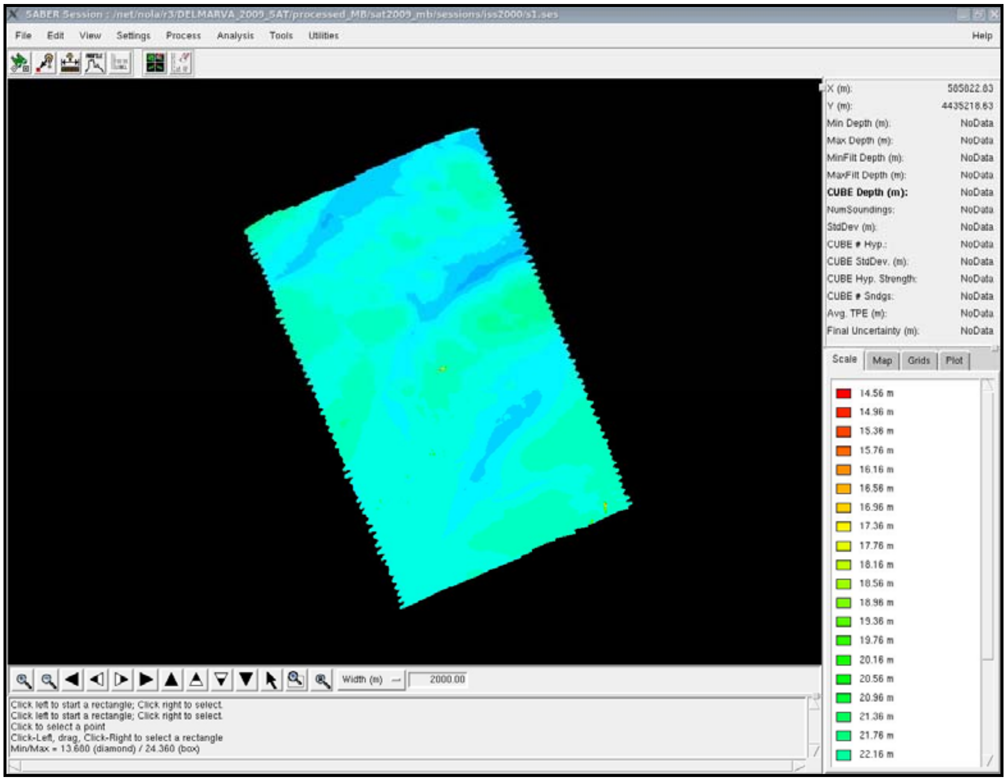

Figure C-39. July 2009 SAT - RESON 7125 PFM CUBE Depths

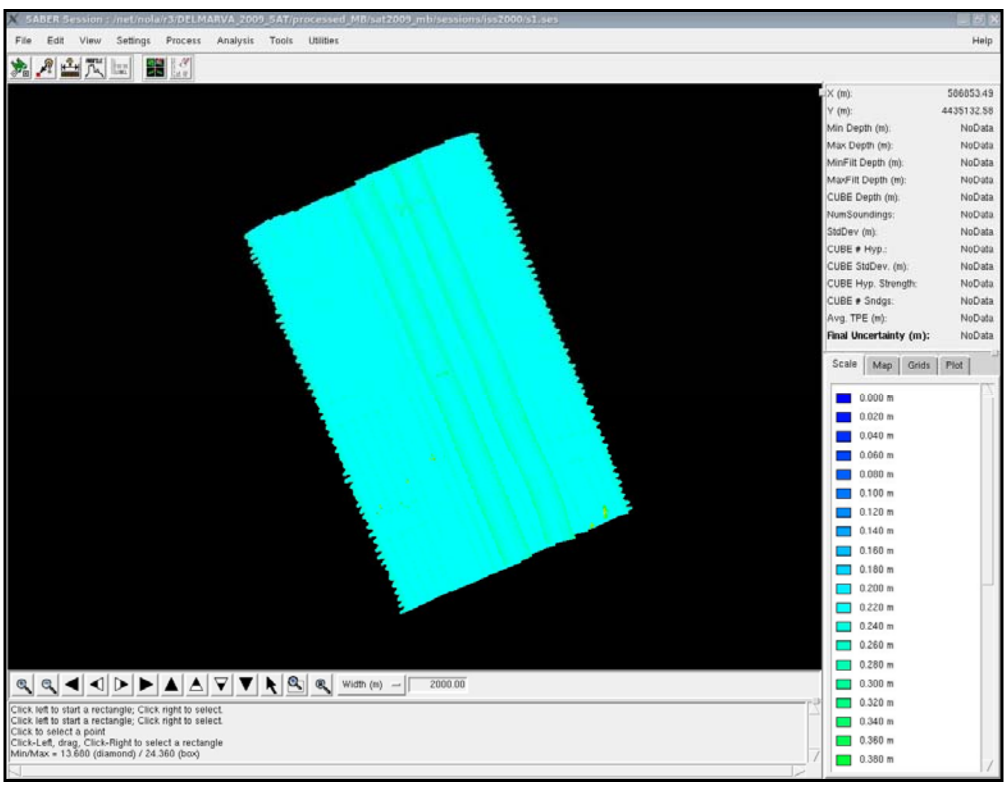

Figure C-40. July 2009 SAT - RESON 7125 PFM Uncertainties

Table C-9. July 2009 SAT - RESON 7125 Junction Analysis of Cross versus Main Scheme

Depth Difference Range (cm)	All		Positive		Negative		Zero	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
0-5cm	2265	28	266	82.87	1813	24.16	186	100.00
5-10cm	3043	66.26	36	94.08	3007	64.23		
10-15cm	2464	97.02	17	99.38	2447	96.84		
15-20cm	234	99.94	1	99.69	233	99.95		
>20cm	5	100.00	1	100.00	4	100.00		
Total	8011	100.00%	321	4.01%	7504	93.67%	186	2.32%

April 2010 SAT

During the April 2010 SAT the same survey described above was re-run to analyze multibeam accuracies after the reinstallation of the RESON 7125. All depths were corrected for predicted tides and zoning using the Atlantic City tide gage, 8534720. Class 1 cutoff angle was set to 5° and class 2 cutoff set to 60°. Standard multibeam data processing procedures were followed to clean the data, apply delayed heave, and calculate errors. One-meter minimum grids of main scheme lines, class one cross lines, and all lines were created. A one-meter PFM of all the data was also generated and the **Gap Checker** and **Check Uncertainty** routines were run on the PFM CUBE depth layer. Multibeam features, sidescan contacts, and selected soundings in feet were generated. The resulting minimum grid with selected soundings (in feet) is shown in Figure C-41. The PFM with CUBE depths and Uncertainties are shown in Figure C-42 and Figure C-43, respectively.

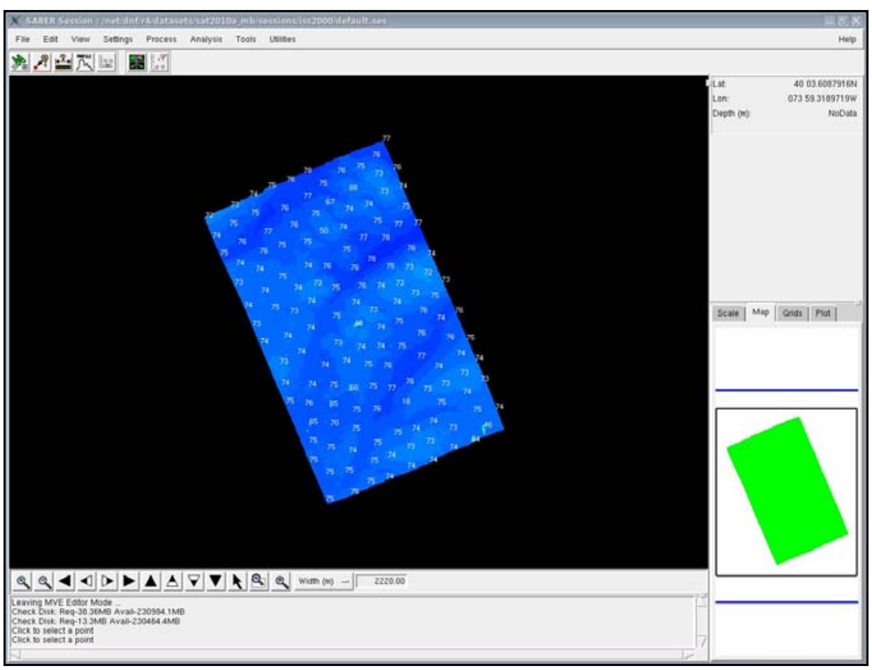

Figure C-41. April 2010 SAT - RESON 7125 Verification Survey Minimum Depth Grid and Selected Soundings

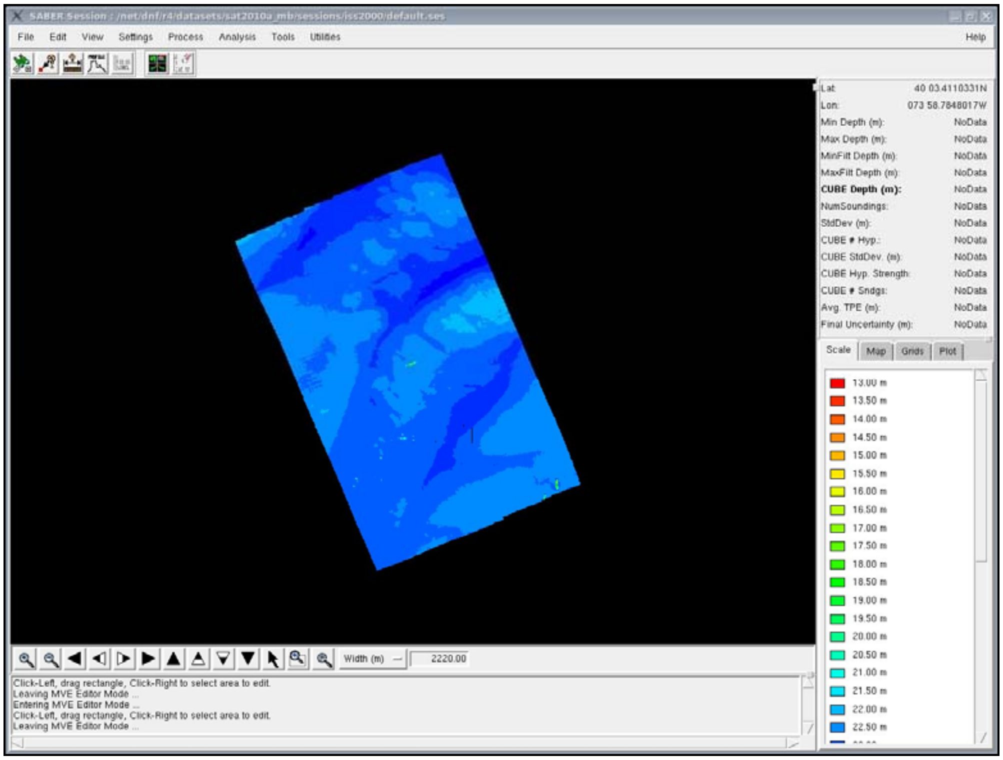

Figure C-42. April 2010 SAT - RESON 7125 Verification Survey PFM CUBE Depths

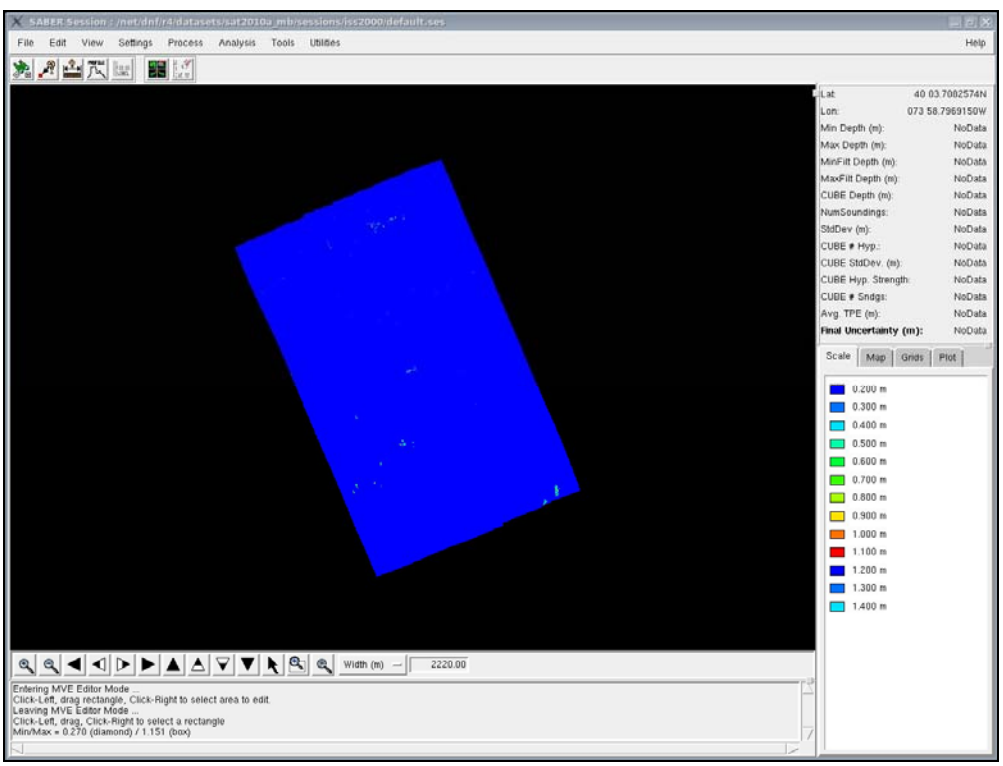

Figure C-43. April 2010 SAT - RESON 7125 Verification Survey PFM Uncertainties

A depth difference grid between one meter the main and cross line grids was created. A statistical analysis of the depth differences using the **Frequency Distribution** tool in **SABER** was performed. The results of the statistical analysis showed that 98% of the depths agree to less than 0.20 meters as shown in Table C-10. A difference grid between the PFM CUBE depth layers from the 2009 and 2010 SAT surveys was also created and analyzed using the **Frequency Distribution** tool. The results for the depth differences between the 2009 and 2010 PFMs show that the 99% of the depths agree to less than 0.10 as shown in Table C-11.

Table C-10. April 2010 SAT - RESON 7125 Frequency Distribution of Depth Differences Between the Class One Cross Line Minimum Grid and the Main Scheme Minimum Grid

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	5815	72.48	4829	60.19	678	8.45	308	3.84
>0.1-0.2	2092	98.55	2092	86.26	0	8.45		
>0.2-0.3	109	99.91	109	87.62	0	8.45		
>0.3-0.4	5	99.98	5	87.69	0	8.45		
>0.5-2.2	1	100.00	1	87.71	0	8.45		
Total	8022	100.00%	7036	87.71%	678	8.45%	308	3.84%

Table C-11. RESON 7125 Frequency Distribution of Depth Differences between the 2010 All PFM CUBE Layer and the 2009 All PFM CUBE Layer

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	616432	99.89	171762	27.83	165278	26.78	279392	45.27
>0.1-0.2	318	99.94	164	27.86	154	26.81		
>0.2-0.3	86	99.95	46	27.87	40	26.81		
>0.3-0.4	48	99.96	21	27.87	27	26.82		
>0.4-0.5	24	99.96	17	27.87	7	26.82		
>0.5-1.0	53	99.97	30	27.88	23	26.82		
>1.0-2.0	83	99.99	44	27.88	39	26.83		
>2.0-3.0	49	99.99	22	27.89	27	26.83		
>3.0-4.0	16	100.00	9	27.89	7	26.83		
>4.0-5.0	10	100.00	3	27.89	7	26.84		
>5.0-9.1	10	100.00	6	27.89	4	26.84		
Total	617129	100.00%	172124	27.89%	165613	26.94%	279392	45.27%

July 2010 SAT

On 20 July 2010 the same survey described above was re-run to analyze multibeam accuracies after the installation of the RESON 8101. All depths were corrected for predicted tides and zoning using the Atlantic City tide gage, 8534720. Class 1 cutoff angle was set to 5° and class 2 cutoff set to 60°. Standard multibeam data processing procedures were followed to clean the data, apply delayed heave, and calculate errors. One meter minimum grids of main scheme lines, class one cross lines, and all lines were created. A one-meter PFM of all the data was also generated and the **Gap Checker** and **Check Uncertainty** routines were run on the PFM CUBE depth layer. The resulting minimum grid with selected soundings (in feet) is shown in Figure C-44. The PFM with CUBE depths and Uncertainties are shown in Figure C-45 and Figure C-46, respectively.

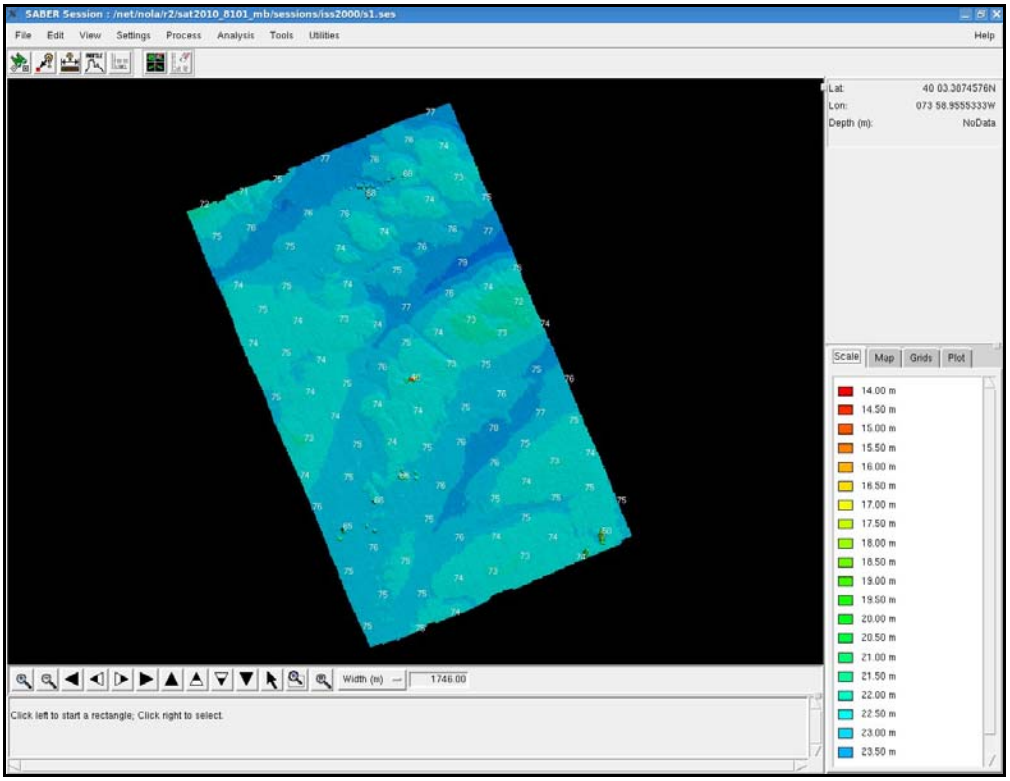

Figure C-44. July 2010 SAT - RESON 8101 Verification Survey Minimum Depth Grid and Selected Soundings

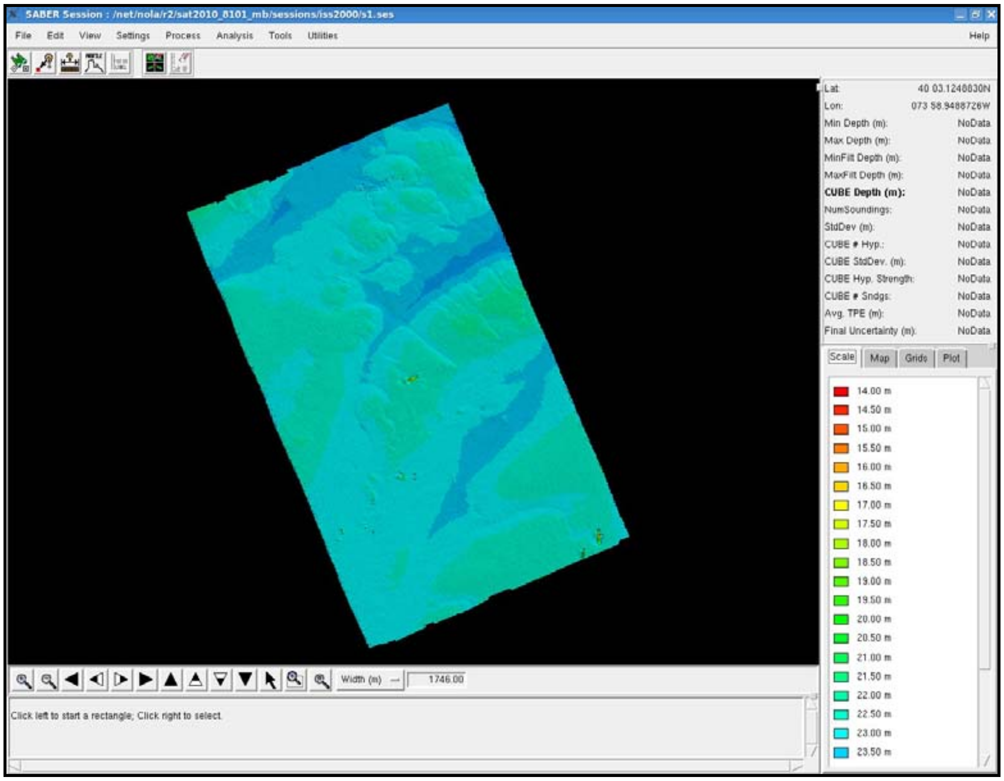

Figure C-45. July 2010 SAT - RESON 8101 Verification Survey PFM CUBE Depths

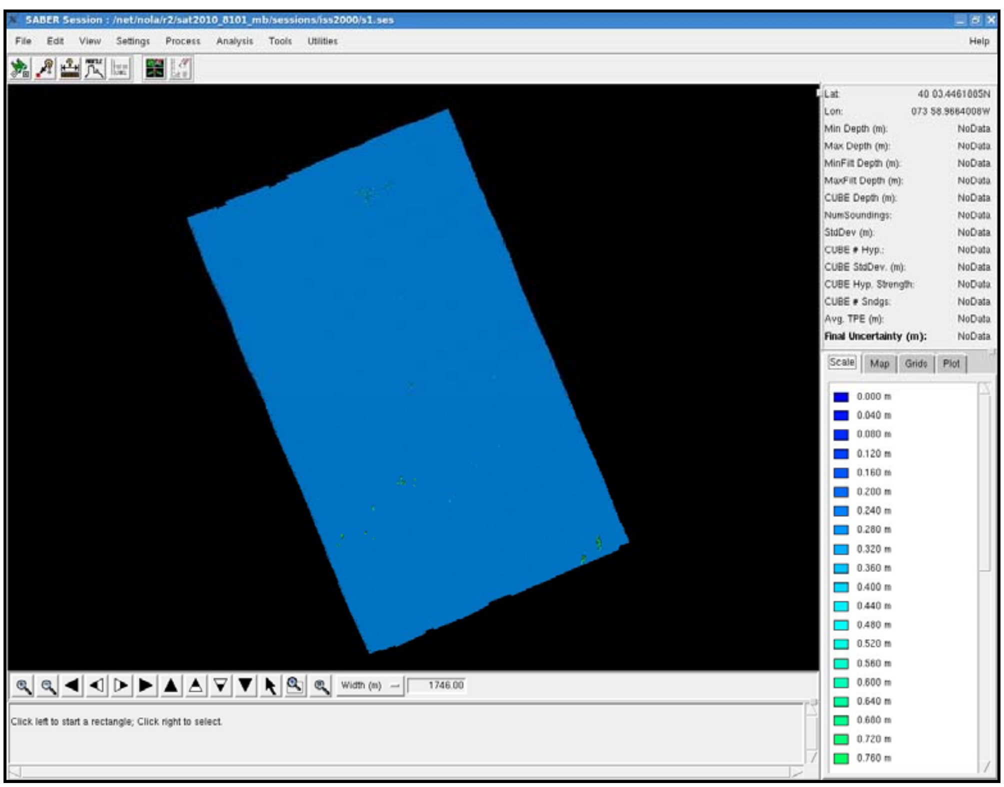

Figure C-46. July 2010 SAT - RESON 8101 Verification Survey PFM Uncertainties

The junction analysis results for the depth differences between the main and cross lines are shown in Table C-12 showing agreement between values. A depth difference grid between one-meter the main and cross line grids was created. A statistical analysis of the depth differences using the **Frequency Distribution** tool in **SABER** was performed. The results of the statistical analysis showed that 99% of the depths agree to less than 0.15 meters (Table C-12).

Table C-12. July 2010 SAT - RESON 8101 Frequency Distribution of Depth Differences Between the Class One Cross Line Minimum Grid and the Main Scheme Minimum Grid

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.00-0.05	4625	72.67	1833	28.80	2317	36.41	475	7.46
>0.05-0.1	1514	96.46	516	36.91	998	52.09		
>0.1-0.15	209	99.75	56	37.79	153	54.49		
>0.15-0.2	13	99.95	9	37.93	4	54.56		
>0.2-0.25	3	100.00	3	37.98	0	54.56		
Total	6364	100.00%	2417	37.98%	3472	54.56%	475	7.46%

A difference grid between the PFM CUBE depth layers from the 2009 and July 2010 8101 surveys was also created and analyzed using the **Frequency Distribution** tool. The results for the depth differences between the 2009 and 2010 8101 PFMs show that the 99% of the depths agree to less than 0.20 as shown in Table C-13.

Table C-13. RESON 8101 Frequency Distribution of Depth Differences between the 2010 All PFM CUBE Layer and the RESON 7125 2009 All PFM CUBE Layer

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	547706	90.41	453685	74.89	66060	10.9	27961	4.62
>0.1-0.2	54570	99.42	51863	83.45	2707	11.35		
>0.2-0.3	3045	99.92	2744	83.91	301	11.4		
>0.3-0.4	188	99.95	161	83.93	27	11.41		
>0.4-0.5	46	99.96	29	83.94	17	11.41		
>0.5-1.0	90	99.98	58	83.95	32	11.41		
>1.0-2.0	55	99.99	33	83.95	22	11.42		
>2.0-3.0	41	99.99	23	83.96	18	11.42		
>3.0-4.0	30	100.00	20	83.96	10	11.42		
>4.0-5.0	12	100.00	3	83.96	9	11.52		
>5.0-6.0	6	100.00	2	83.96	4	11.52		
Total	605789	100.00%	508621	83.96%	69207	11.42%	27961	4.62%

A difference grid between the PFM CUBE depth layers from the April 2010 7125 and July 2010 8101 surveys was also created and analyzed using the **Frequency Distribution** tool. The results for the depth differences between PFMs show that the 99 % of the depths agree to less than 0.20 as shown in Table C-14.

Table C-14. July 2010 RESON 8101 Frequency Distribution of Depth Differences between the 2010 All PFM CUBE Layer and the RESON 7125 2010 All PFM CUBE Layer

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	584116	96.17	256173	42.18	267266	44	60677	9.99
>0.1-0.2	19819	99.43	1406	42.41	18413	47.03		
>0.2-0.3	2832	99.9	115	42.43	2717	47.48		
>0.3-0.4	287	99.95	67	42.44	220	47.52		
>0.4-0.5	44	99.95	25	42.44	19	47.52		
>0.5-1.0	92	99.97	47	42.45	45	47.53		
>1.0-2.0	84	99.98	36	42.46	48	47.54		
>2.0-3.0	71	99.99	50	42.46	21	47.54		
>3.0-4.0	23	100.00	19	42.47	4	47.54		
>4.0-5.0	12	100.00	2	42.47	10	47.54		
>5.0-6.6	5	100.00	4	42.47	1	47.54		
Total	607385	100.00%	257944	42.47%	288764	47.54%	60677	9.99%

August 2010 SAT

On 15 August 2010 the same survey described above was re-run to analyze multibeam accuracies after the re-installation of the RESON 7125. All depths were corrected for observed tides and zoning using the Atlantic City tide gage, 8534720. Class 1 cutoff angle was set to 5° and class 2 cutoff set to 60°. Standard multibeam data processing procedures were followed to clean the data, apply delayed heave and calculate errors. One meter minimum grids of main scheme lines, class one cross lines, and all lines were created. A one-meter PFM of all the data was also generated and the **Gap Checker** and **Check Uncertainty** routines were run on the PFM CUBE depth layer. The resulting minimum grid with selected soundings (in feet) is shown in Figure C-47. The PFM with CUBE depths and Uncertainties are shown in Figure C-48 and Figure C-49, respectively.

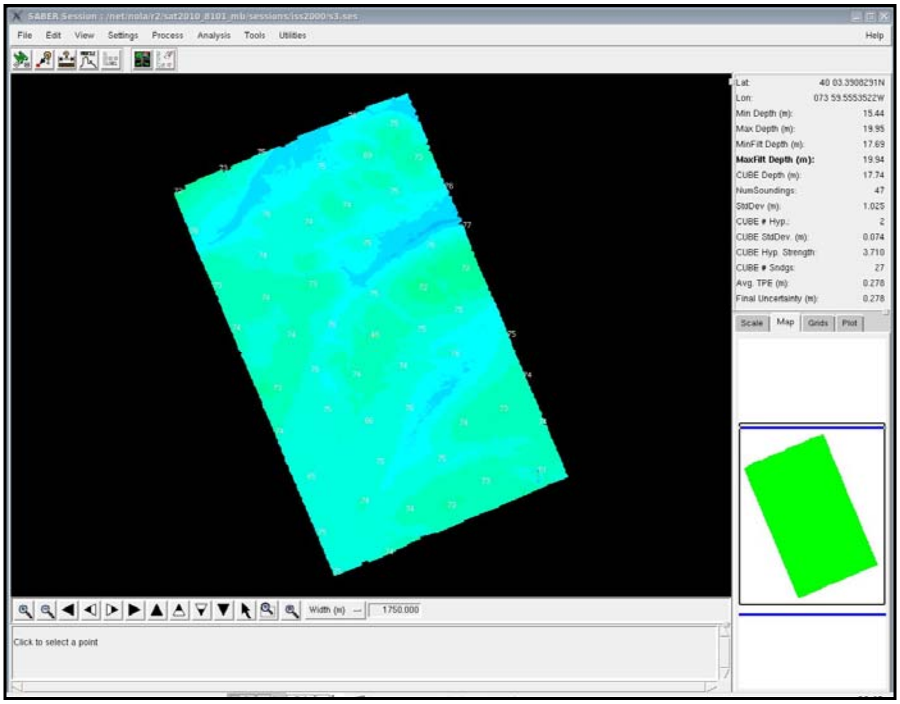

Figure C-47. August 2010 SAT - RESON 7125 Verification Survey Minimum Depth Grid and Selected Soundings

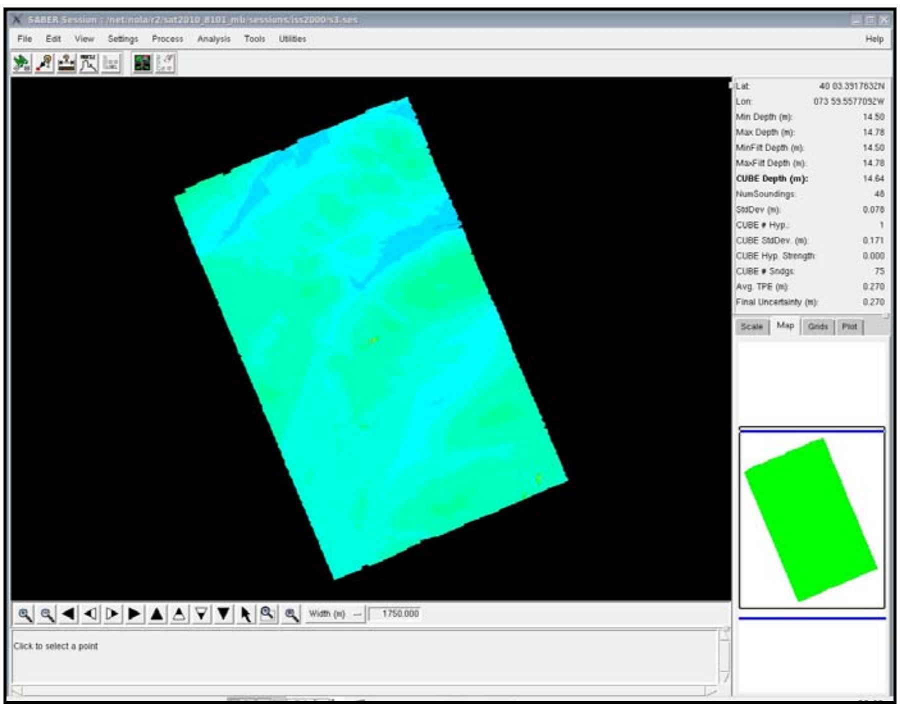

Figure C-48. August 2010 SAT - RESON 7125 PFM CUBE Depth Layer

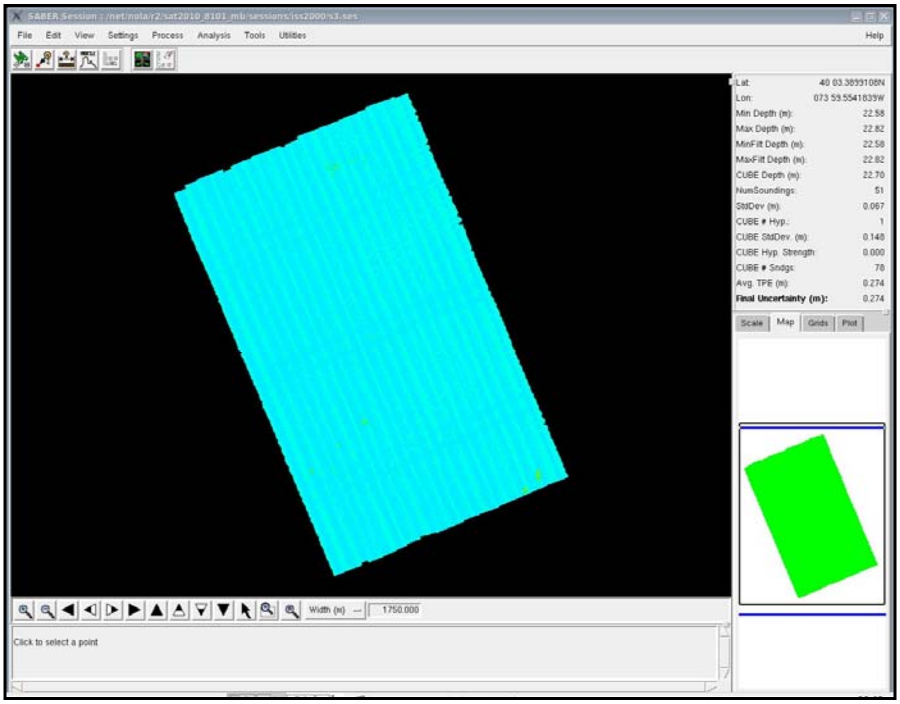

Figure C-49. August 2010 SAT - RESON 7125 PFM Uncertainties

The junction analysis results for the depth differences between the main and cross lines are shown in Table C-15 showing agreement between values. A depth difference grid between one-meter the main and cross line grids was created. A statistical analysis of the depth differences using the **Frequency Distribution** tool in **SABER** was performed. The results of the statistical analysis showed that 99% of the depths agree to less than 0.15 meters (Table C-15).

Table C-15. August 2010 SAT - RESON 7125 Frequency Distribution of Depth Differences Between the Class One Cross Line Minimum Grid and the Main Scheme Minimum Grid

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.05	6875	87.49	3252	41.38	2782	35.40	841	10.70
>0.05-0.1	894	98.87	691	50.18	203	37.99		
>0.1-0.15	66	99.71	63	50.98	3	38.02		
>0.15-0.2	5	99.77	4	51.03	1	38.04		
>0.2-0.5	4	99.82	1	51.08	0	38.04		
>0.5-1.0	1	99.83	1	51.09	0	38.04		
>1.0-2.0	5	99.90	1	51.11	4	38.09		
>2.0-3.2	7	100.00	5	51.17	2	28.13		
Total	7858	100.00%	4021	51.17%	2996	38.13%	841	10.70%

A difference grid between the PFM CUBE depth layers from the 2009 and August 2010 7125 surveys was also created and analyzed using the **Frequency Distribution** tool. The results for the depth differences between the 2009 and August 2010 7125 PFMs show that the 99% of the depths agree to less than 0.40 as shown in Table C-16. The higher differences can be attributed to the fact that the 2009 data was corrected for predicted tides and this survey was corrected for observed tides.

Table C-16. August 2010 RESON 7125 Frequency Distribution of Depth Differences between the all PFM CUBE Layer and the RESON 7125 2009 all PFM CUBE Layer

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	14178	2.32	13362	2.18	606	0.10	210	0.03
>0.1-0.2	228444	39.63	228363	39.48	81	0.11		
>0.2-0.3	340924	95.31	340899	95.16	25	0.12		
>0.3-0.4	27486	99.80	27469	99.65	17	0.12		
>0.4-0.5	913	99.95	907	99.80	6	0.12		
>0.5-1.0	78	99.97	50	99.81	28	0.12		
>1.0-2.0	111	99.98	61	99.82	50	0.13		
>2.0-3.0	68	99.99	31	99.82	27	0.14		
>3.0-4.0	25	100.00	12	99.82	13	0.14		
>4.0-5.0	6	100.00	3	99.82	3	0.14		
>5.0-6.9	4	100.00	1	99.83	3	0.14		
Total	612237	100.00%	611158	99.83%	869	0.14%	210	0.03%

A difference grid between the PFM CUBE depth layers from the April 2010 7125 and August 2010 7125 surveys was also created and analyzed using the **Frequency Distribution** tool. The results for the depth differences between PFMs show that the 99% of the depths agree to less than 0.30 as shown in Table C-17.

Table C-17. August 2010 RESON 7125 Frequency Distribution of Depth Differences between the all PFM CUBE Layer and the April 2010 RESON 7125 all PFM CUBE Layer

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	46912	7.63	43834	7.13	2413	0.39	665	0.11
>0.1-0.2	489447	87.25	489305	86.72	142	0.42		
>0.2-0.3	77695	99.89	77665	99.36	30	0.42		
>0.3-0.4	288	99.93	275	99.4	13	0.42		
>0.4-0.5	93	99.95	88	99.42	5	0.42		
>0.5-1.0	102	99.96	76	99.43	26	0.43		
>1.0-2.0	117	99.98	62	99.44	55	0.44		
>2.0-3.0	62	99.99	37	99.44	25	0.44		
>3.0-4.0	32	100.00	20	99.45	12	0.44		
>4.0-5.0	6	100.00	1	99.45	5	0.44		
>5.0-6.9	5	100.00	4	99.45	1	0.44		
Total	614759	100.00%	611367	99.45%	2727	0.44%	655	0.11%

A difference grid between the PFM CUBE depth layers from the April 2010 7125 and July 2010 8101 surveys was also created and analyzed using the **Frequency Distribution** tool. The results for the depth differences between PFMs show that the 99% of the depths agree to less than 0.30 as shown in Table C-18.

Table C-18. August 2010 RESON 7125 Frequency Distribution of Depth Differences between the All PFM CUBE Layer and the July 2010 RESON 8101 All PFM CUBE Layer

Depth Difference (Meters)	Bins	Cumulative Percent	Positive Bins	Positive Cumulative Percent	Negative Bins	Negative Cumulative Percent	Zero Bins	Zero Cumulative Percent
0.0-0.1	17835	2.93	17687	2.91	119	0.02	29	0.00
>0.1-0.2	498249	84.92	498187	84.89	62	0.03		
>0.2-0.3	87873	99.38	87844	99.34	29	0.03		
>0.3-0.4	3246	99.92	3231	99.88	15	0.04		
>0.4-0.5	153	99.94	136	99.9	17	0.04		
>0.5-1.0	125	99.96	82	99.91	43	0.05		
>1.0-2.0	128	99.98	73	99.92	55	0.06		
>2.0-3.0	45	99.99	15	99.93	30	0.06		
>3.0-4.0	31	100.00	11	99.93	20	0.06		
>4.0-5.0	9	100.00	8	99.93	1	0.06		
>5.0-6.1	8	100.00	4	99.93	4	0.06		
Total	607702	100.00%	607278	99.93%	395	0.06%	29	0.00%

TIDES AND WATER LEVELS

NOAA tide station 8651370 Duck, NC was the source of final verified water level heights for the Mid-Atlantic Corridor, Coast of Virginia surveys (see supplemental correspondence email string with final date of 10 July 2009, located in Appendix V, and revised tide section for Project Instructions). Preliminary and verified water level data for this station were downloaded from the NOAA Center for Operational Oceanographic Products and Services Tides & Currents web site (http://www.tidesandcurrents.noaa.gov/). All water level data in meters were annotated with Coordinated Universal Time (UTC).

Final water level files for each tide zone were created from downloaded verified tide data using the **SABER Create Water Level Files** tool. Water level files contained water level heights that were algebraically subtracted from depths to correct the sounding for tides and water levels. These water level files were applied to the multibeam data using the **SABER Apply Tides** program within the **SABER** software.

When it was necessary to apply updated water level correctors such as verified tides to the GSF files, the program removed the previous water level corrector and applied the new corrector. Each time a routine was run on the GSF multibeam data file, a history record was appended to the end of the GSF file documenting the date and water level files applied. For quality assurance, the **SABER Check Tides** program was run on all GSF files to confirm that the appropriate water level corrector had been applied to the GSF file.

After confirmation that verified water levels were applied to all multibeam data, grids were created and analyzed using various color change intervals. The color intervals provided a means to check for significant, unnatural changes in depth across zone boundaries due to water level correction errors, unusual currents, storm surges, etc.

The primary means for analyzing the adequacy of zoning was observing zone boundary crossings in **MVE**. In addition, cross line analysis using the **SABER Analyze Crossings** software was used to identify possible depth discrepancies resulting from the applied water level corrector. Discrepancies were further analyzed to determine if they were the result of incorrect zoning parameters or weather (wind) conditions between the tide station and the survey area. The NOAA provided preliminary zone boundaries and zoning parameters are presented in Table C-19.

Table C-19. Preliminary Tide Zone Parameters

Zone	Time Corrector (minutes)	Range Ratio	Reference Station
SA45	0	1.05	8651370
SA46A	0	1.08	8651370
SA55A	0	1.11	8651370

Final Tide Note

H12091, H12092, H12093, and H12094 surveys were entirely within preliminary water level zones for Duck, NC, 8651370 (SA45, SA46A, and SA55A). Correctors were computed at six minute intervals for each zone. Analysis of the multibeam data in **MVE** and in depth grids revealed minimal depth jumps across the junction of the zones. A spreadsheet analysis of the water level correctors for each zone and the differences observed at the boundaries of adjacent zones also confirmed the adequacy of zoning correctors based on Duck, NC (8651370). For the analysis, observed verified water levels from 19 September through 25 October 2009 and from 10 April through 31 August 2010 were entered separately into the spreadsheet. Differences were computed zone-to-zone and summarized in Table C-20 for the period 19 September 2009 through 25 October 2009 and Table C-21 for the period 10 April 2010 through 31 August 2010. As a result, the NOAA preliminary zone boundaries and zoning parameters for Duck, NC (8651370) were accepted as final and applied to all multibeam data for H12091, H12092, H12093, and H12094. The final analysis of the zone to zone comparisons for sheets yet to be delivered (H12092, H12093, and H12094) will be submitted with the Horizontal and Vertical Control Report and each sheets Descriptive Report.

Table C-20. 2009 Differences in Water Level Correctors between Adjacent Zones Using Zoning Parameters for Station 8651370

Zone Boundary	SA46A – SA45	SA46A – SA55A
Minimum Difference	-0.001	-0.001
Maximum Difference	0.058	0.058
Average Difference	0.023	0.023
Standard Deviation	0.012	0.012

Table C-21. 2010 Differences in Water Level Correctors between Adjacent Zones Using Zoning Parameters for Station 8651370

Zone Boundary	SA46A – SA45	SA46A – SA55A
Minimum Difference	-0.008	-0.007
Maximum Difference	0.050	0.050
Average Difference	0.019	0.019
Standard Deviation	0.011	0.011

D. APPROVAL SHEET

01 October 2010

LETTER OF APPROVAL

REGISTRY NUMBER: H12091, H12092, H12093, H12094

This Data Acquisition and Processing Report for project OPR-D302-SA-09, Mid-Atlantic Corridor, Coast of Virginia Project is respectfully submitted.

Field operations and data processing contributing to the accomplishment of these surveys, H12091, H12092, H12093, and H12094 were conducted under supervision of myself and lead hydrographers Paul L. Donaldson, Jason M. Infantino, Chuck Holloway, Evan L. Robertson, and Deborah M. Smith with frequent personal checks of progress and adequacy. This report has been closely reviewed and is considered complete and adequate as per the Statement of Work.

Reports concurrently submitted to NOAA for this project include:

Report	**Submission Date**
H12091 Descriptive Report 10-TR-004	01 October 2010

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Gary R. Davis

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Gary R. Davis
Chief Hydrographer
Science Applications International Corporation
01 October 2010