NOAA FORM 76-35A

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

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey **Hydrographic**

Field No. **David Evans and Associates, Inc.**

Registry No. **H11653**

LOCALITY

State **VIRGINIA**

General Locality **Central Chesapeake Bay**

Sublocality **Stingray Point to Milford Haven**

2007

CHIEF OF PARTY

Jonathan L. Dasler, PE (OR) , PLS (OR,CA)

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DATE

NOAA FORM 77-28 (11-72)	U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY No
HYDROGRAPHIC TITLE SHEET		**H11653, H11654, H11655, H11656, H11657**
INSTRUCTIONS – The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.		FIELD No **David Evans and Associates, Inc.**

State **Virginia**

General Locality **Central Chesapeake Bay**

Sub-Locality **Rappahannock Spit**

Scale **1:10,000** Date of Survey **May 22, 2007 to September 28, 2007**

Instructions dated **February 22, 2007** Project No. **OPR-E349-KR-07**

Vessel **R/V Sealth**

Chief of party **Jonathan L. Dasler, PE (OR) , PLS (OR,CA)**

Surveyed by **Jason Creech, John Staly**

Soundings by echo sounder, hand lead, pole **RESON 7125-B, EdgeTech 4200-FS, EdgeTech 4200-HFL**

Graphic record scaled by **N/A**

Graphic record checked by **N/A** Automated Plot **N/A**

Verification by

Soundings in **Meters at MLLW**

REMARKS: **All times are UTC.**

The purpose of this contract is to provide NOAA with modern, accurate hydrographic survey data with which to update the nautical charts of the assigned area.

SUBCONSULTANTS: **Global Seas, LLC, 2001 Sixth Ave Suite 3420, Seattle, WA 98121**

John Oswald and Associates, 2000 E Dowling Road, Suite 10, Anchorage, AK 99507

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

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Acronyms and Abbreviations

AHB	Atlantic Hydrographic Branch
ATC	Average Time Corrector
BAG	Bathymetric Attributed Grid
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station
CTD	Conductivity, Temperature and Depth
CUBE	Combined Uncertainty and Bathymetry Estimator
DEA	David Evans and Associates, Inc.
DXF	Drawing Exchange Format
DGPS	Differential Global Positioning System
GPS	Global Positioning System
HDCS	Hydrographic Data Cleaning System
HIPS	Hydrographic Information Processing System
HSX	Hypack Hysweep File
HVF	HIPS Vessel File
IHO	International Hydrographic Organization
IMU	Inertial Motion Unit
MVP	Moving Vessel Profiler
NATSUR	Nature of Surface
NATQUA	Nature of Surface Qualifying Terms
NGS	National Geodetic Survey
NMEA	National Marine Electronics Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
POS/MV	Position and Orientation System for Marine Vessels
PPS	Pulse per Second
R/V	Research Vessel
RPM	Revolutions per Minute
RTK	Real-Time Kinematic
SBDARE	Seabed Area
SBET	Smooth Best Estimate and Trajectory
SSS	Side Scan Sonar
SVP	Sound Velocity Profiler
TIF	Tagged Image Format
TPE	Total Propagated Error
UTC	Universal Time Coordinated
XTF	Extended Triton Format
ZDA	Global Positioning System timing message
ZDF	Zone Definition File

OPR-E349-KR-07
Data Acquisition and Processing Report
Central Chesapeake Bay, Virginia
May 2007 - September 2007
R/V Sealth
David Evans and Associates, Inc.
Lead Hydrographer, Jonathan Dasler, P.E., P.L.S.

INTRODUCTION

This report applies to surveys H11653, H11654, H11655, H11656 and H11657 located in Central Chesapeake Bay, Virginia. These contract surveys were performed under OPR-E349-KR-07 as specified in the *Statement of Work* dated February 22, 2007. All survey methods meet or exceed requirements as defined in the National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables April 2007*. Further, due to the shallow water, side scan sonar (SSS) altitude requirements were waived for this project in areas over the Rappahannock Spit for survey H11653.

A. EQUIPMENT

For this project David Evans and Associates, Inc. (DEA) implemented a state-of-the-art data acquisition and preliminary processing system aboard the *Research Vessel (R/V) Sealth*, in accordance with National Oceanic and Atmospheric Association (NOAA) standards and modern remote sensing techniques. Data processing took place onboard the *R/V Sealth* as well as at DEA's corporate headquarters in Portland, Oregon. Instrumentation used to conduct the survey and redundant systems to provide confidence checks consisted of the equipment listed in Table 1.

Table 1. R/V Sealth Hardware

Side scan				
	Edgetech	**4200**		Digital side scan sonar imagery with tow fish heading and depth sensors.
Deck Unit			31913	
Towfish		4200-FS 100/400	32060	
Towfish		4200-FS 300/600	33914	
Cable Counter	**Measurement Technology NW**	**LCI-90**	350	Continuous digital output of deployed side scan tow cable length for layback calculations
Multibeam				
	RESON	**7125**		Dual Frequency Multibeam sonar
Deck Unit	7P		57729	
Transducer			52007	
Sound Speed	SVP 70		3205687	
Attitude and Position				
	Applanix	**POS MV 320 v4**		Integrated Differential Global Positioning System (DGPS) and inertial reference system for position, heading, heave, roll and pitch data
Deck Unit			2204	
IMU			477	
Port Antenna		Compact Zephyr	60080633	
Starboard Antenna		Compact Zephyr	60083810	
	Trimble	**ProBeacon**		Obtain differential corrections United States Coast Guard differential beacons.
Unit			220014495	
Antenna			220014366	
	Trimble	**DSM 132**		Secondary positioning system for Quality Assurance/Quality Control (QA/QC)
Unit			224094182	
Antenna			220360424	
Sound Velocity				
	Brooke Ocean	**MVP 30**		Primary sound velocity profiler (SVP) for sound velocity profiles
Winch			10424	
Sheave			10425	
Controller			10428	
Single Sensor Fish			10426	
Sensor	AML	Smart SV&P	5110	
	Seabird	**SBE 19**		Secondary Conductivity, Temperature, and Depth (CTD) profiler for sound velocity profiles
Unit			1919847-2691	

A1. Side Scan Sonar System

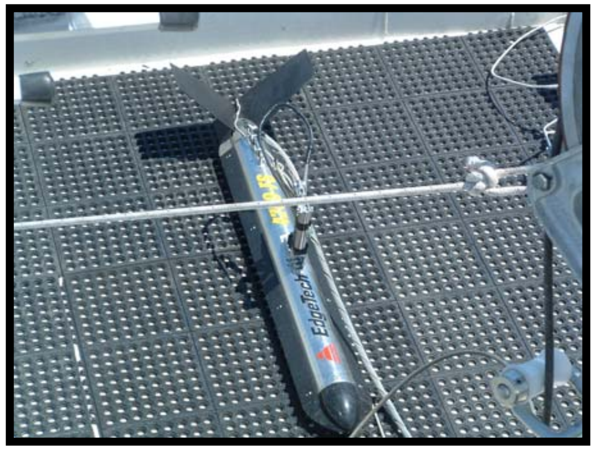

Figure 1. Edgetech 4200-FS 100/400 kHz Side Scan Sonar

Side scan sonar (SSS) imagery was acquired with an EdgeTech 4200-FS dual frequency (100/400 kHz) digital SSS (Figure 1) and an EdgeTech 4200-HFL dual frequency (300/600 kHz) high frequency digital side scan sonar. Both sonars were operated in high speed mode. The 4200-FS operating at 400 kHz was used from the start of the project until June 20, 2007 (DN 171). In order to remove crosstalk between the side scan and multibeam sonars the 4200-FS was replaced with an EdgeTech 4200-HFL operating at 600 kHz and used until project's end. Imagery was logged on DEA's Triton Isis system in extended Triton format (XTF) (16 bit, 1024 pixels/channel) along with ancillary data including; towfish heading, towfish depth, ship position and computed towfish position from layback calculations. Layback was computed in the Isis system by using measured tow point offsets and digital input of cable out and towfish depth. An LCI-90 Cable Payout Meter was used to provide a continuous digital cable length of deployed side scan tow cable to the Isis system.

Daily checks were performed to ensure the SSS was working correctly. Each day prior to deploying the towfish, a rub test was performed to ensure that both the port and starboard transducers were functioning and wired correctly. Confidence checks were conducted on a daily basis during acquisition and noted in the acquisition logs to confirm adequate target resolution at the outer limits of the selected range. Confidence checks were performed more frequently in deteriorating conditions to confirm detection of features at the outer range limits.

A2. Multibeam System

The Reson 7125 multibeam sonar with dual frequency configuration and integrated SVP-70 sound velocity profiler (SVP) ran concurrently with side scan operations. Reson 7125 multibeam data and side scan data from the Edgetech towfish were logged into the same XTF file on the Triton Isis acquisition system. The Reson 7125 operates at either 400 kHz or 200 kHz producing a 128° swath of 256 uniform beams with a beam width of 0.5° x 1.0°. All data were acquired using the high frequency setting of 400 kHz, with range adjustments being made during acquisition as dictated by changes in the local depth.

Weekly leadline or bar checks were performed to ensure that the sonar was functioning properly and static draft was accurately documented. The leadline was constructed by attaching a mushroom anchor to a metric reel fiberglass tape. The bar check was constructed of an 8-inch diameter steel disc which was attached to a metric reel fiberglass tape. Both checks enabled depths to be read to within five millimeters.

A3. Position, Heading and Motion Reference System

An Applanix Position and Orientation System for Marine Vessels (POS/MV) 320 version 4, integrated differential global positioning system (DGPS) and inertial reference system was used to measure attitude, heading and position for the survey. The system was comprised of an inertial motion unit (IMU), dual global positioning system (GPS) antennas, and a data processor. A Trimble ProBeacon receiver, acquiring corrections from the U.S. Coast Guard beacon located at Driver, Virginia (broadcasting at 289 kHz) or Annapolis, MD (broadcasting at 301 kHz) provided differential corrections for both the primary and secondary positioning systems. Position, heading and motion data were output to the Isis acquisition system using the real-time ethernet option at 25 Hz. Motion and position data were output to the Hypack backup acquisition system over a serial connection with motion data output at 38,400 baud and 25 Hz and position and heading at 9,600 baud and one Hertz.

The POS/MV provided time synchronization of sonar instruments and logging computers using a combination of outputs. The Reson 7-P processor and Hypack logging computer were provided both a pulse per second (PPS) and a National Marine Electronics Association (NMEA) GPS timing message (ZDA) to achieve synchronization with the POS/MV. The EdgeTech 4200 side scan sonar deck unit was provided a NMEA ZDA message for time synchronization. The Isis logging computer synchronized its time using the proprietary Trimble universal time coordinated (UTC) message provided by the POS/MV. All messages contained time strings and caused the clocks of the computers and sonars to synchronize to the time contained within the message. Time offsets between the instruments and computers, relative to the times contained in POS/MV network packets, were typically sub-millisecond.

As a quality check, a Trimble DSM132 was used as a secondary positioning system. Positions from both the primary and secondary systems were displayed in real-time using Hypack and compared while online. The POS/MV system position and heading were displayed as a vessel shape and the Trimble position was displayed with a circle and cross hair overlaid on the vessel shape in a different color. Position data from both systems were displayed and tracks from both systems were drawn in different colors such that a history of derived positions could be observed for quality control.

A weekly comparison between positions from the POS/MV and the DSM132 was observed and documented while the vessel was stationary in port. Logged position data was imported into Excel and a difference computed.

TrueHeave™ was logged from the POS/MV during data acquisition with a single .000 file created per day under the typical operating scenario. In addition, all of the POSPac logging groups were recorded to the daily .000 files. These files were later applied to the survey data in Caris Hydrographic Information Processing System (HIPS) v6.1 during data processing. The POS/MV QC plot was displayed and monitored onscreen during data acquisition.

A4. Sound Velocity Measurement System

A SVP-70 mounted on the Reson 7125 sonar head was input into the Reson 7-P processor and velocities from the sensor were used in real-time during acquisition for beam forming on the 7125's flat array. In addition, a Brooke Ocean Technology Moving Vessel Profiler (MVP) 30 was mounted on the port stern of the *R/V Sealth* and was used as the primary sound speed sensor used to correct multibeam data during processing.

Each sensor had been calibrated prior to the start and at the end of the survey. Factory calibration results are included in the Separates Section II of the Descriptive Report for the survey.

A5. Survey Vessel

The *R/V Sealth*, which is owned and operated by Global Seas, LLC (Figure 2) was used as the survey vessel for the project. The *R/V Sealth*, hull registration number SFU399054D99 (official number 1080270), is a 55-foot, 45 gross ton, aluminum catamaran with a 20-foot beam and a draft of three feet. The vessel is equipped with a moon pool, custom multibeam mount, stern mount A-frame, a SSS bow mount for shallow water operations, server room, and acquisition station. This configuration allowed for the multibeam sonar to be mounted near the vessel's center of gravity and to be easily deployed and retracted minimizing the risk of striking the head on debris or overstressing the mount when underway at high speeds. No unusual sensor setup configurations were required for this survey.

Figure 2. *R/V Sealth*

A6. Acquisition and Processing System

The acquisition and processing station was custom installed and integrated on the *R/V Sealth* by DEA and consisted of a Triton Isis data acquisition system, Hypack navigation software and Caris HIPS software (Figure 3). During acquisition, data were logged locally on acquisition PCs and then transferred to a high capacity onboard RAID server while offline in order to minimize network activity. Initial processing was performed aboard the *R/V Sealth*, while final processing and review was performed at DEA's office in Portland, Oregon. The software and version numbers used throughout the survey are listed in Table 2.

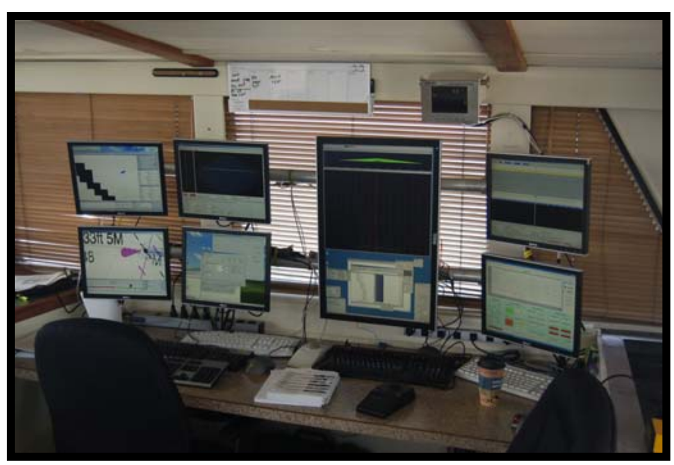

Figure 3. Acquisition station used on *R/V Sealth*

Table 2. Acquisition and Processing Software

SURVEY SOFTWARE				
	Company	**Program Name**	**Version**	**Date**
Acquisition				
	Triton Imaging, Inc	Isis and TargetPro	7.1.428.53	5/20/2007
	HYPACK, Inc.	Hypack Max /Hysweep	6.2.2.2	5/20/2007
	EdgeTech	Discover 4200	5.19	5/20/2007
	Reson	7K SeaBat	3.3.0.0	5/20/2007
	Reson	7K Center	3.0.0.0	5/20/2007
	Applanix	MV-POSView	3.4.0.0	5/20/2007
	Brooke Ocean Technology Ltd.	MVP Controller	MVP 2.27	5/20/2007
	Trimble	ProBeacon	1991 DOS	5/20/2007
	DEA	Digital LineLog	1.0.5	5/20/2007
Processing				
	Caris	HIPS	6.1/ SP1/ HF 7	12/19/2007
	Caris	Notebook	3.0/HF1	7/3/2007
	Caris	Bathy DataBASE	2.1	8/30/2007
	Triton Imaging, Inc	Isis and TargetPro	7.0.414.0	5/20/2007
	HYPACK, Inc.	Hypack Lite	6.2.2.2	5/20/2007
	ESRI	ArcGIS	9.2.0.1324	5/20/2007
	Applanix	POSPac	4.4	4/16/2007
	NOAA	Velocwin	8.8	5/20/2007
Other				
	Microsoft	Word	2003	
		Excel	2003	
		Access	2003	

A7. Survey Methodology

A7.a Mobilization

Mobilization, sensor installation, and calibration occurred from May 4, 2007 through May 14, 2007 in Deltaville, Virginia. All sensors were surveyed in using a terrestrial land survey total station on May 4th, 2006. Values from this survey were used to calculate sensor offsets and accuracies used in the HIPS vessel file (HVF) for project OPR-E349-KR-07. Once installation was complete and the survey manager was confident that all sensors were operational, the vessel underwent system calibration tests, including settlement and squat, alignment and static vessel measurement. During mobilization the SSS tow cable was marked at 10-meter intervals which were color coded for use as a comparison check against the digital cable counter during survey operations.

A7.b Survey Coverage

The Central Chesapeake Bay (OPR-E349-KR-07) area was surveyed with a line orientation appropriate for each of the five sheet boundaries. For deep water areas the side scan sonar was operated at 75-meter range scale and line spacing was run at 130-meter spacing for each 100%

side scan coverage. The 200% coverage line spacing was offset 65 meters for a total coverage of the area at 65-meter line spacing. Shallow water required portions of the project to be surveyed at 50-meter side scan range scale with line spacing adjusted to 40-meter spacing for 200% coverage.

A7.c Side Scan Sonar Operations

Side scan imagery was collected using the sonar's high frequency settings (400 kHz or 600 kHz, towfish 32060 and 33914, respectively) in the multi-pulse high-speed mode at a range of 75 meters for the majority of the project. Shallow portions of sheets H11656 (H), H11657 (I), H11654 (D) and H11653 (A) were collected with the same configuration with an adjustment to the range of 50 meters (Figure 4). The EdgeTech 4200 series sonar has a ping rate of 20 Hz at 75-meter range and a ping rate of 30 Hz at 50-meter range, while operating in the high speed mode which places additional pings in the water. In accordance with the NOS *Hydrographic Surveys Specifications and Deliverables* (April, 2007), vessel speed was monitored to ensure three pings per meter to ensure detection of a 1m x 1m x 1m object on the seafloor. The survey vessel maintained a speed under 8.5 knots throughout the side scan survey which allowed for a minimum of 4.6 pings per meter. The side scan was towed from the stern of the vessel during acquisition within deeper waters of the survey area.

To prevent crosstalk between the multibeam and side scan sonars which operated at similar frequencies, the EdgeTech 4200-FS was replaced with an EdgeTech 4200-HFL dual high frequency (300/600 kHz) digital SSS. The EdgeTech 4200-HFL was added on June 20, 2007 (DN171) and used until the end of the project. The new sonar was operated on the 600 kHz transmit frequency and in the high speed mode.

The shallow waters within the project area required several operational modifications in order to meet specifications and to prevent crosstalk between the side scan and multibeam sonars. In order to meet the 8% to 20 % altitude requirement in the shallow water areas of the project, the range scale was reduced to 50-meter and line spacing was adjusted accordingly. The altitude requirement was waived by the COTR for areas over the Rappahannock Spit for H11653 (A) where depths were too shallow to meet this requirement. In addition, when running in the shallowest areas of the project the tow point was moved to the bow of the vessel to move the towfish out of the vessel's jet wash. Isis tow point offsets were modified when running in this shallow water configuration so that towfish layback was calculated correctly.

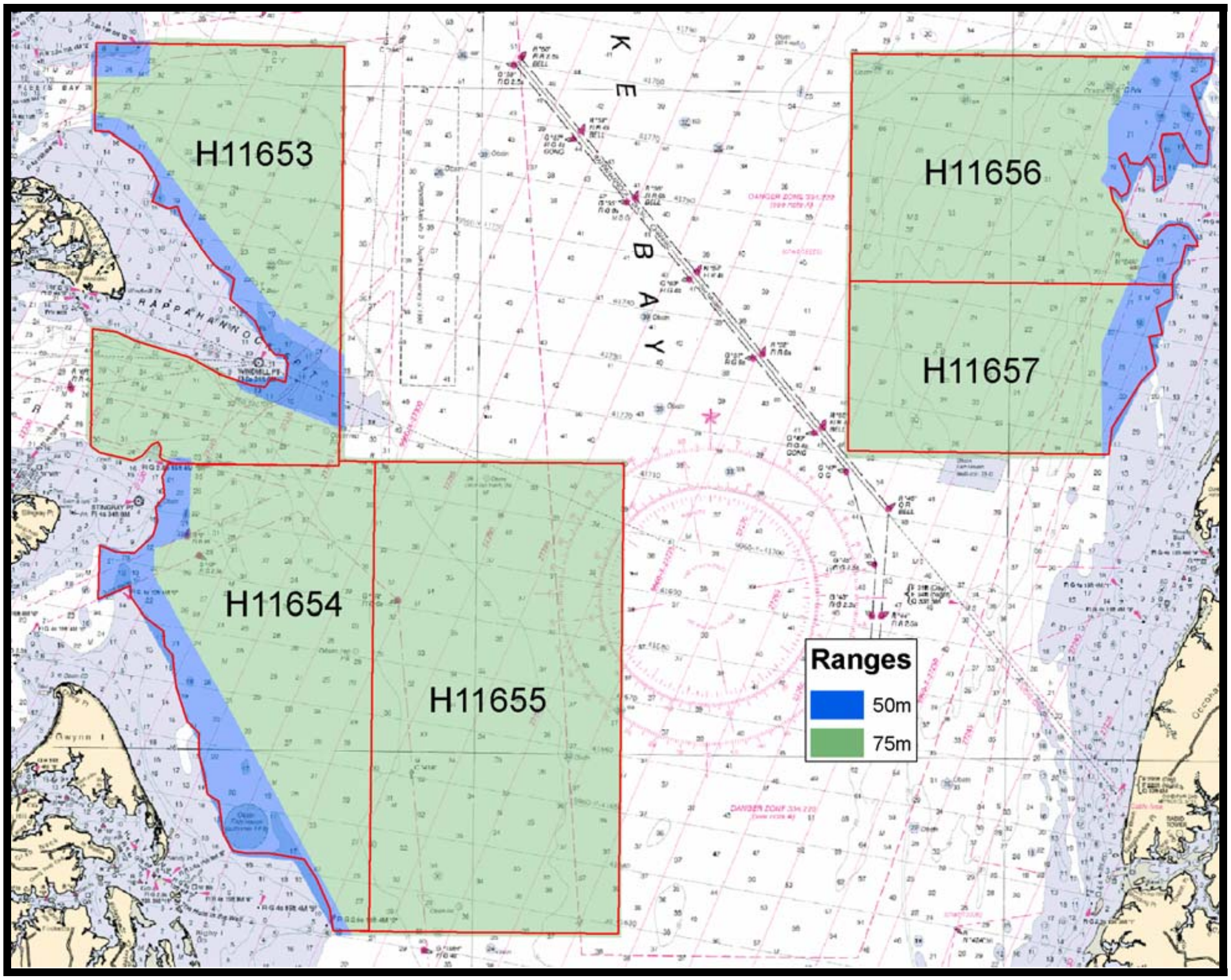

Figure 4. Side Scan Sonar Range Scale Use by Survey Area

The SSS operator was assigned the task of analyzing the digital sonogram and keeping towfish height within specification by adjusting cable out. The operator also called out contacts and daily confidence checks, which were entered in the digital acquisition log by the multibeam operator/log keeper. When weather or sea conditions degraded SSS imagery, operations were suspended. All acquisition occurred during daylight hours with the vessel leaving port in the morning and returning in the evening.

Side scan sonar coverage was obtained by using Technique 2 under 6.1 of the NOS *Hydrographic Surveys Specifications and Deliverables* (April 2007). This technique allows for two separate 100% coverages by running splits between the first coverage to obtain the second coverage. The sonar acquisition operator monitored the vessel speed; ensuring speed over ground did not exceed 8.5 knots thus allowing a minimum of three pings per meter. In addition, the SSS operator monitored towfish height, ensuring a height of 8% to 20% of the range above the bottom and coverage displays to ensure 100% coverage was obtained.

A7.d Multibeam Operations

Multibeam operations occurred concurrently with SSS acquisition using the Set Line Spacing coverage technique as stated in the OPR-E349-KR-07 *Statement of Work* (February 22, 2007) and defined by the NOS *Hydrographic Surveys Specifications and Deliverables* (April 2007). Full multibeam coverage was not a requirement for this survey. The multibeam sonar system was operated at a recorded ping rate of 20 Hz during all data acquisition. The multibeam sonar was able to detect shoals that measure two meters by two meters horizontally and one meter vertically in depths of 40 meters or less. Based on a sonar update rate of 20 Hz and an average vessel speed of seven knots, the bottom coverage averaged 5.6 beam footprints per meter. The multibeam sonar was operated at different range scales throughout the survey by adjusting the depth range to obtain the best coverage in varying depths of water. The depth of the survey area ranged from 2.6 feet to 130 feet (0.8 meters to 39.7 meters). The majority of the survey was run at the 40-meter range scale. Table 3 lists the typical sonar settings for the survey.

Table 3. Reson 7125 Sonar Settings

7125 Parameter	Value
Range:	Variable, depth dependent
Gain:	15 dB
Power:	220 dB
Spreading	30 dB
Absorption:	60 dB/km
Ping Rate	20 p/s
Pulse Width:	60 µs

A7.e Bottom Sampling

A total of 77 bottom sediment grab samples were obtained on a 2,000-meter grid across all 5 survey sheets. Samples were obtained with a Ponar grab sampler which collects a sample size of 8.2 liters with a penetration depth of 3.5 inches. Position, depth, date, time, unique identifier, description and photograph were recorded for each sample. Each sample was described in accordance with International Hydrographic Organization (IHO) S-57 requirements for Seabed Area (SBDARE) features with attribution of COLOUR, Nature of Surface Qualifying terms (NATQUA), and Nature of Surface (NATSUR).

A8. Quality Assurance

A processing workstation containing Triton Isis, DelphMap and Caris HIPS was installed aboard the *R/V Sealth* for preliminary processing, SSS contact creation, and quality assurance. Data was transferred from the acquisition computers to the vessel's data server, during turns at the end of each line, and reviewed near real-time to ensure that the acquisition system was functioning properly, and that environmental conditions were not degrading the data.

Under typical conditions a line of side scan data was transferred to the vessel server and processed as soon as the acquisition of the line ended. Side scan contacts noted while online were created in Triton Isis. Additional contacts not identified while online were also identified and created during this phase of processing. The re-evaluation of imagery for contacts by the data processor resulted in two reviews of the side scan imagery while data was still onboard the *R/V Sealth*. SSS imagery was also corrected for layback, slant range, and speed in Isis on the processing station.

Multibeam data were converted in Caris HIPS v6.1 during preliminary processing of multibeam data. Attitude and navigation sensor data were evaluated for timing problems, data gaps, or erroneous data before sound speed corrections were applied.

Side scan contacts were reviewed during multibeam processing to ensure that contacts were fully developed and no further investigation was required (Figure 5). Additional investigations were run when necessary.

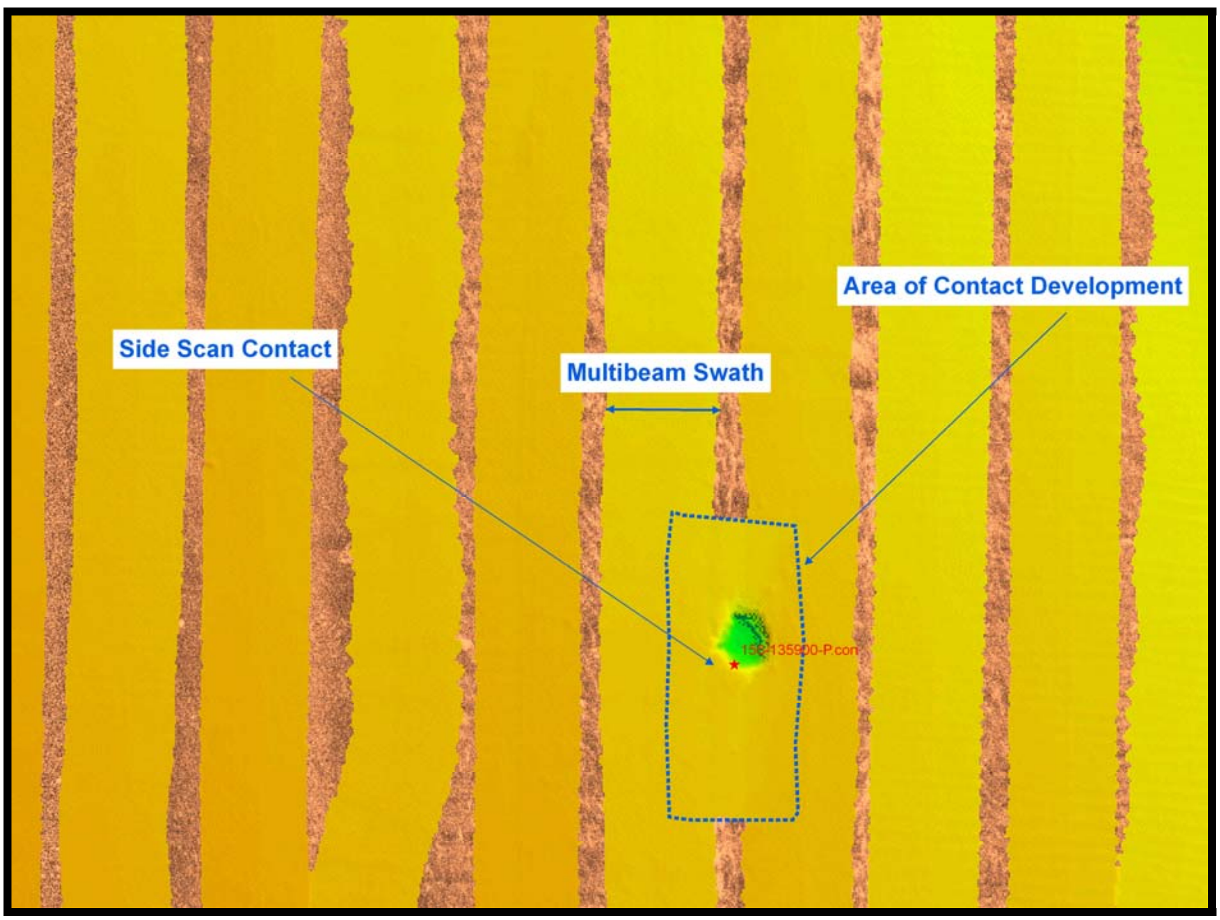

Figure 5. Graphic of side scan mosaic overlaid with contacts and multibeam swath coverage

B. QUALITY CONTROL

B1. Data Acquisition

B1.a Side Scan Sonar

Triton Elics ISIS acquisition software was used to record side scan sonar data in XTF. Adjustments to tow fish height were made as necessary during data acquisition and logged in ISIS to ensure the best image quality. Layback values and changes were recorded in the daily acquisition log.

Side scan sonar imagery from the high frequency channel was displayed in real-time on the Isis data display, a 30-inch LCD flat panel monitor mounted vertically at the acquisition station. The large format display allowed the SSS operator to review digital side scan imagery and have time to manage and react to multiple contacts or to ask other crew members to provide additional review of imagery before the waterfall imagery scrolled off screen. The side scan operator was tasked with identifying contacts and reading out time, ping and range values for input into the digital log by the multibeam operator.

To aid in the consistency of contact identification, a table was posted listing slant range and towfish altitude to determine minimum shadow heights for one meter contacts at 75-meter and 50-meter ranges. Contacts were classified as significant if their estimated height was one meter or more. Maintaining towfish altitude at 8% to 20% of the range (6 meters to 15 meters altitude above the bottom at 75-meter range) was tasked to the side scan operator who also controlled the winch operation. The operator could view the towfish altitude above the seafloor on the Isis display and adjust cable out accordingly to fly the towfish at the required height. Digital cable out values were confirmed by stopping pay out of the tow cable when 10-meter marks on the cable were at a predetermined mark on the block. Using this method, the cable out meter was calibrated each day prior to deploying the towfish. Using the MVP-30 sound velocity profile data, the operator was often able to adjust towfish height and fly below haloclines.

B1.b Multibeam

Positioned beside the side scan acquisition station was the multibeam operator who controlled the Hypack station, monitored the multibeam sonar, and entered information into the digital line log. The multibeam operator could also view the side scan monitor from their station and provided additional review when necessary.

During acquisition data were monitored in real-time using the 2-D and 3-D data display windows in ISIS and Reson SeaBat 8101 display. Typical windows for monitoring raw sensor information included a waterfall display for the sonar imagery, graphs of vessel motions, and a signal voltage display. Vessel navigation was monitored with HYPACK. Raw soundings, attitude, heading and position data were recorded in ISIS XTF format and also in HYPACK Hysweep file (HSX) format, as a supplementary backup. Adjustments to the sonar, including changes in range and gain were made, as necessary, during acquisition to ensure the best bathymetric data quality. Additionally, vessel speed was adjusted in accordance with the NOS *Hydrographic Surveys Specifications and Deliverables (April 2007)* to ensure the required along track coverage.

B2. Methodology Used to Maintain Data Integrity

The acquisition system and survey protocols were designed with some redundancy to demonstrate that the required accuracy was being achieved during the survey and provide a backup to primary systems. Data integrity was monitored throughout the survey through system comparisons. Two positioning systems were used to provide real-time monitoring of position data. A position confidence check and leadline to multibeam comparison were conducted weekly to confirm required accuracy was being maintained. Weekly checks of the sound speed profiler integrated into the MVP-30 were conducted by deploying a SeaBird Conductivity, Temperature and Depth (CTD) profiler in tandem with the MVP-30. Sound velocity profiles were computed for each of the sensors and compared to confirm instrumentation was functioning within survey tolerances.

Contacts were classified as significant if their estimated height was greater than one meter in deeper areas or greater than 0.5 meters in shallow navigationally significant areas. Towfish altitude was maintained at 8% to 20% of the range except during the survey of the Rappahannock Spit.

In order to manage the high volume of side scan sonar contacts DEA created a custom database that would meet the contact tracking requirements of the *Specifications and Deliverables*. The database was maintained and stored in Microsoft Access using the .MDB file format. Contacts were added into the database on a daily basis upon completion of the side scan review and contact identification. The use of the .MDB format allowed direct geographic display of contacts and spatial queries within ESRI ArcGIS where contacts were correlated and compared to the chart and other survey data.

A flow diagram of the shallow water multibeam and SSS data acquisition and processing pipeline is presented in Figures 6 and 7 respectively. These diagrams graphically illustrate the data pipeline and processing workflow from acquisition to deliverable production.

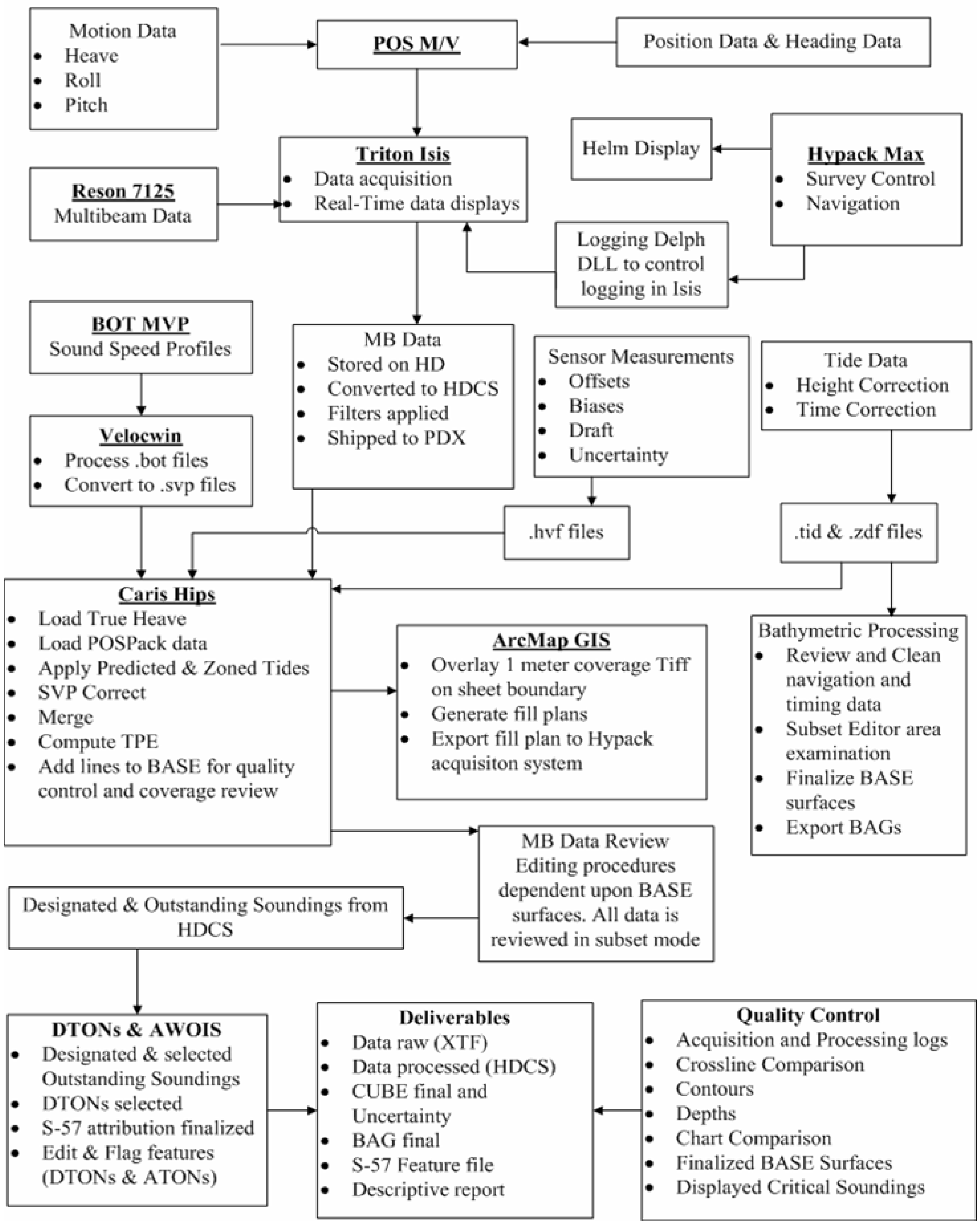

Figure 6. Flowchart of multibeam data acquisition and processing pipeline

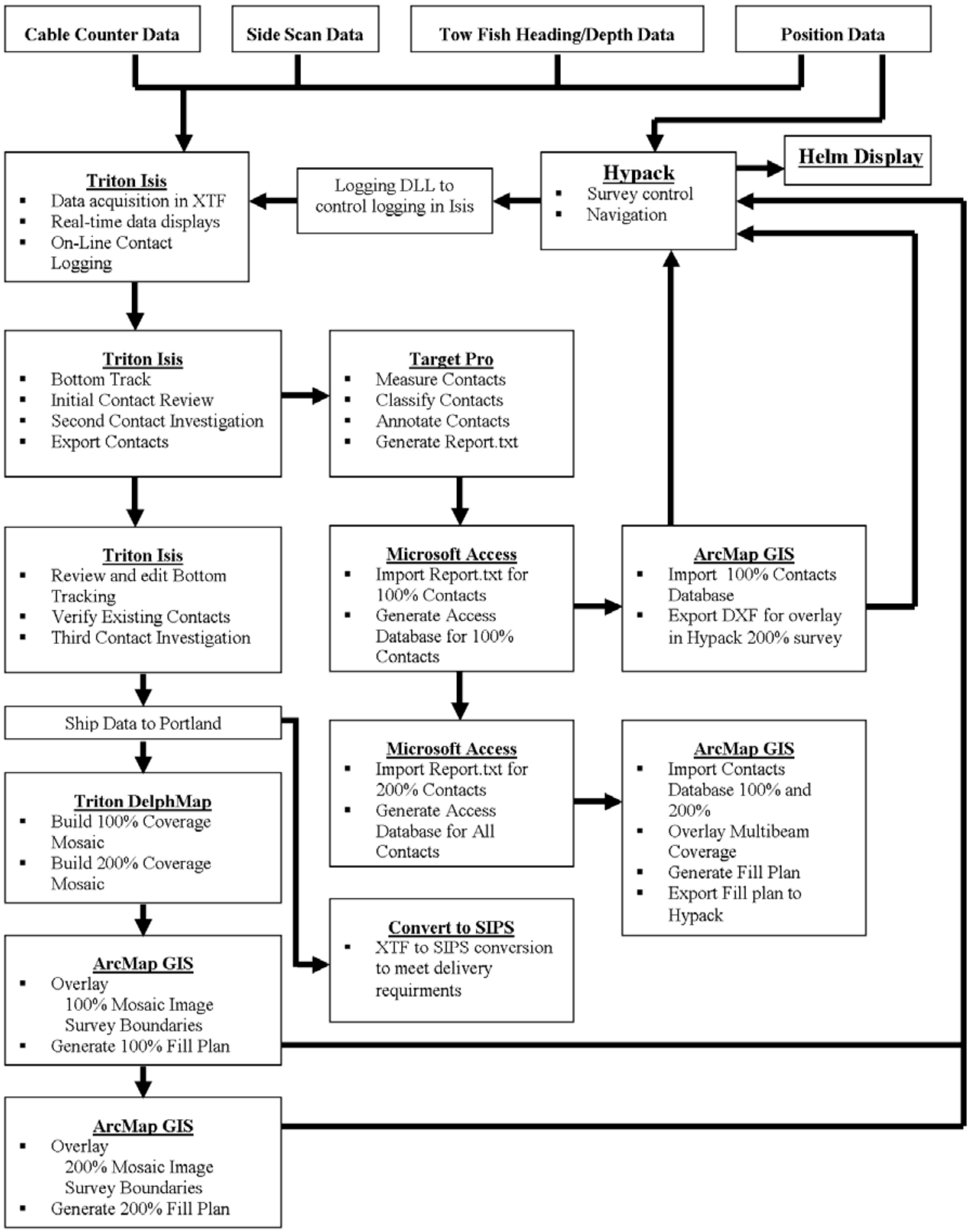

Figure 7. Flowchart of side scan sonar data acquisition and processing pipeline

Multibeam data processing onboard the survey vessel was kept to a minimum in order to focus on side scan processing and contact identification. Data were transferred to the vessel server during turns at the end of a line and converted into Hydrographic Data Cleaning System (HDCS) format. After each survey line was converted, position and sensor data were reviewed for anomalies and edited if necessary. Sounding data from the first survey line of the day were reviewed to ensure that the acquisition system was operating correctly.

A daily HIPS sound speed file of concatenated cast data was compiled at the end of the day and then applied to that day's survey lines. At this point multibeam processing was complete until the survey data were shipped to DEA's Portland office where processing continued.

At the end of each day, data were backed up to an external hard drive and removed from the vessel. Approximately every four days, all data that had been collected within that time period, was shipped to DEA's Portland office where additional processing occurred.

B2.a HIPS Conversion

Multibeam data were converted from XTF format to CARIS HDCS format using the HIPS conversion wizard (XTF converter 6.1.1.0 or higher) with ship navigation, attitude, and gyro from the raw navigation datagrams with a few exceptions. The 6.1.1.0 XTF converter was implemented with Service Pack 1 Hotfix 3 to address a bug in the conversion process.

During data acquisition Triton Isis software would sporadically go offline line resulting in data gaps within the mainscheme mulitbeam data. To fill these gaps data was used from the data logged in the Hypack data acquisition system. A separate vessel configuration file was created to convert the HSX formatted data (HSX converter 6.1.0.0 or higher).

No data were rejected based on quality flags during conversion. The CARIS output window was reviewed for failures during conversion.

Side scan imagery was converted (XTF converter 6.1.1.2) from the bottom tracked XTF file into a separate HIPS file during post processing for the sole purpose of providing the processing branch with SIPS compatible data. The XTF 6.1.1.2 converter implemented in Service Pack 1 Hotfix 6 is required in order to support the weighting factor used by the Edgetech model 4200 sonars. Side scan navigation was converted from the ship datagram and course made good was used for towfish heading. All SSS processing was performed using Triton Isis.

B2.b Vessel Files

Four HVFs (Table 4) were created to correspond to each vessel configuration used during the survey. The vessel file contains all offsets and system biases for the survey vessels and its systems, as well as, error estimates for latency, sensor offset measurements, attitude and navigation measurements, and draft measurements.

Table 4. HIPS Vessel Files

HIPS Vessel File	HIPS Converter	Sonar Type	Comment
E349-KR-07_MBES.hvf	XTF 6.1.1.0	Multibeam	Primary MBES hvf
E349-KR-07_MBES_HSX.hvf	HSX 6.1.1.0	Multibeam	Hypack data to fill gaps in XTF
E349-KR-07_SSS.hvf	XTF 6.1.1.2	Side scan	Stern tow SSS
E349-KR-07_SSS_Bow.hvf	XTF 6.1.1.2	Side scan	Bow tow SSS

Sensor offsets values were calculated from the vessel survey (5/4/06). Draft (water line) was measured and entered daily from draft marks on the port and starboard side of the vessel's hull directly abeam of the multibeam moon pool. Port and starboard draft readings were averaged to obtain the multibeam draft in the center of the vessel. Draft changes relative to the vessel reference point were entered into the multibeam vessel files.

Dynamic draft (settlement and squat) values were calculated through the use of Real-time Kinematic (RTK) GPS observations.

Best estimates for total propagated error (TPE) values were entered into the vessel file based on current knowledge of the TPE Combined Uncertainty and Bathymetry Estimator (TPE/CUBE) processing model. Manufactures' published values were entered into the sensor accuracy fields. Other values were either calculated or estimated. Table 5 represents HVF TPE values for each vessel.

Table 5. Hydrographic Vessel File TPE Values

Manufacture Accuracy Values for Total Propagation Error Computation
HIPS Vessel File (HVF)

All values given as 1 sigma

VESSEL	*SEALTH*
Motion Sensor	*POS/MV*
POSITION SYSTEM	*POS/MV Model 320 V3*
Gyro/Heading	
Gyro (deg)	0.02
Heave	
Heave% Amp	5
Heave (m)	0.05
Roll and Pitch	
Roll (deg)	0.02
Pitch (deg)	0.02
GPS Sensor	
Pos. Navigation (m)	0.5
Latency	
Timing Trans (s)	0.01
Nav Timing (s)	0.01
Gyro Timing (s)	0.01
Heave Timing (s)	0.01
Pitch Timing (s)	0.01
Roll Timing (s)	0.01
Measurement	
Offset X (m)	0.007
Offset Y (m)	0.007
Offset Z (m)	0.007
Speed	
Vessel Speed (m/s)	0.03
Draft and Loading	
Loading	0.00
Draft (m)	0.01
DeltaDraft (m)	0.01

Physical Alignment Errors

All values given as 1 sigma

VESSEL	*SEALTH*
POSITION SYSTEM	*POS/MV Model 320 V3*
Alignment	
MRU alignStdev gyro	0
MRU align roll/pitch	0

Manufacture Accuracy Values for Total Propagation Error Computation in CARIS HIPS
Survey Specific Parameters (These values from Specifications and Deliverables)

All values given as 1 sigma

Tide Value	
Tide Value Measured	0.05
Tided Value Zoning	0.1
Sound Speed Values	
Sound Speed Measured	0.25
Surface Sound Speed	0.25

B2.c Static Draft

Static draft marks were surveyed and painted on the port and starboard side of the *R/V Sealth's* hull directly abeam of the multibeam moon pool. Port and starboard draft readings were averaged to obtain the multibeam draft in the center of the vessel.

During survey operations, draft was observed at the beginning and end of daily survey operations to compute average draft for the day. This provided an accurate draft reading during survey operations with the majority of the fuel load change during the day being burned during transit out and back from the survey area. The average of the start and end of day draft values was calculated daily and entered into the waterline field in the HVF.

B2.d Sound Velocity

Sound speed profiles were applied to each line using the nearest in distance within time (two hours) option in the Caris SVP correct routine. Velocity casts were taken at frequent intervals (typically every 15 minutes) through the use of the MVP-30. A real-time comparison of sound velocity measurements was made during survey operations between the SVP-70 mounted on the sonar head and the MVP-30 when being towed near the surface.

B3. Preliminary Side Scan Processing

Side scan imagery underwent preliminary processing aboard the survey vessel using the Isis processing station. The side scan imagery was corrected for: layback, slant range and speed. In addition, the recorded altitude picks were examined and re-tracked, if necessary. The data processor reviewed acquisition logs for contacts and performed a second review of side scan data. Using Triton Target Pro utility, the processor generated Isis targets for each contact. Contacts were designated as significant or insignificant based on shadow length. All contacts and processing comments were imported in the Microsoft Access database which was used to track and manage contacts for each survey. Any line that did not meet the quality criteria was rejected and re-acquired.

B4. Caris Data Processing

Multibeam data processing followed the standard HIPS workflow for CUBE editing except that the hypothesis surface was not edited. Instead, fliers influencing the CUBE surface were rejected and critical soundings not incorporated in the CUBE surface were designated.

Below is the list of correctors and filters applied to the bathymetric data in CARIS. Several of the steps are interim processes (such as the water levels) and were re-applied as needed. The TPE was re-computed for the multibeam data as needed to reflect changes in the correctors.

1. Apply zoned water levels
2. Apply concatenated sound speed profiles for each day
    - "Nearest in time, with in two hours"
3. True heave
4. Load post-processed attitude, navigation, and heading

5. Load post-processed error estimates
6. Merge vessel offsets
7. Compute TPE
    - Tide Value Measured 0.05 m
    - Tided Value Zoning 0.10 m
    - Sound Speed Measured 0.25 m/s
    - Surface Sound Speed 0.25 m/s
8. Filters applied based on the following criteria:
    - Reject soundings with poor quality flags (0 and 1 for Reson)
    - Reject TPE greater than the horizontal and vertical error limits specified in the NOS *Hydrographic Surveys Specifications and Deliverables (April 2007)*.
    - Reject based on depth threshold (if needed)

7. Add data to field sheet
    - One meter "CUBE" weighted surface
        - IHO S-44 Order 1
        - Density & Local Disambiguation method
        - Deep Advanced settings

After filtering, each survey sheet was subdivided by creating multiple Caris field sheets to reduce processing time and the computer power required to generate the CUBE surfaces. The field sheets were created to keep the number of nodes under the recommended limit of 25 million for each CUBE surface. All CUBE surfaces were created at a one meter resolution, which more than adequately represented the sea floor. CUBE surfaces of varying resolutions were not required since one meter resolution exceeded the two-meter minimum resolution for *Complete Multibeam Coverage*. Separate grids for coverage demonstration and seafloor depiction were not required for these surveys. CUBE surface resolution was discussed and agreed upon with OCS staff from the Atlantic Hydrographic Branch (AHB) prior to CUBE creation.

Navigation, attitude, and heading and their corresponding error estimates were reapplied during post processing in HIPS. Data were post processed using POSPac software. Navigation and inertial sensor information logged to the POSPac .000 file was blended with stationary GPS data which was logged at a base station that was run continually throughout the project. The blended solutions were much more accurate than the DGPS navigation and inertial measurements that were logged during acquisition. The base station, DVL-Marina, was installed at the Deltaville Boatyard located on Jackson Creek on May 20, 2007 (DN 140) and operated until its removal on October 4, 2007 (DN 277). Data from the DVL-Marina station was used during post-processing of all OPR-E349-KR-07 surveys. In addition, the National Geodetic Survey (NGS) continuously operating reference station (CORS) station VIMS was used along with the DVL-Marina station during post-processing of H11656 (H) and H11657 (I) due to the long baseline distance between the survey areas and the DVL-Marina station. The CORS station VIMS is located in the town of Wachapreague, Virginia on the Eastern Shore of Virginia. Using the multi base station option during post-processing increased the performance of the data reprocessing by keeping the maximum baseline distance under the recommended value of 35 km. POSPac Smooth Best Estimate and Trajectory (SBET) and POSProc RMS File (SMRMSG) files were applied in HIPS with the Load Attitude/Navigation data and Load Error data tools.

Verified zoned tides were applied to the data prior to depth editing or CUBE creation. Tide data were compiled and applied to the survey data through the use of a HIPS zone definition file (ZDF) which was built for each survey. These file are included with the HIPS deliverables.

All data were reviewed in HIPS 2D subset with the 1m CUBE reference surface visible. Fliers making the CUBE surface shoaler than expected by more than the allowable IHO Order 1 error were rejected. Any legitimate sounding that was not incorporated into the CUBE surface and shoaler than the surface by more than half the allowable IHO Order 1 error was flagged as a critical sounding. Data processors had a table of allowable IHO Order 1 error relative to depth at their station while processing. Subset tiles were used to track the progress of processing activities. In addition, data processors reviewed data sounding data and CUBE surfaces for excessive motion artifacts or systematic biases. All crosslines were manually reviewed to ensure high internal consistency between the datasets.

Side scan mosaics and contacts were displayed in the background in HIPS as a Drawing Exchange Format (DXF) file and reviewed for multibeam coverage. In addition, contact least depths were queried in subset editor and entered into the contact database with additional multibeam information such as ping, beam, and time. Designated soundings were also created for each contact least depths. Contacts over the same feature were correlated in the database by entering contact identification numbers of matching contacts into the “Correlate” field of the database.

B5. Final Side Scan Processing

Final review and editing of the side scan data was performed in the DEA Portland office using Triton Isis and Delphmap software. The data processor performed an additional review of all imagery for contacts (third review), created Tagged Image Format (TIF) images of all contacts and generated 100% and 200% side scan mosaics at 50 cm resolution. During mosaic creation in Delphmap each 100 percent coverage was broken into four sections to facilitate reprocessing a mosaic, if needed, without having to generate a new mosaic for the entire sheet. Each of the TIF images were merged using Lizardtech GeoExpress 6.1. A single TIF image per 100% coverage was created for submittal.

Side scan images were imported into ESRI ArcView and reviewed for data gaps or holidays and for problematic data that would warrant reprocessing the data or resurvey of an area. After review of the mosaics SSS fill plans were generated and sent to the survey vessel.

Side scan sonar data was converted from the bottom tracked XTF file to separate HIPS files during post processing for the sole purpose of meeting delivery requirements.

B6. Final Bathymetric Processing

Upon the completion of editing multibeam data in HIPS, finalized CUBE grids were generated using the “greater of the two” option for the final uncertainty value. Depths and contours were generated from the surfaces and used for chart comparison purposes, but are not included with the deliverables. Finalized surfaces were reviewed in the HIPS 3D graphics window with an extreme vertical exaggeration to verify that all fliers have been removed from the surfaces. Bathymetric Attributed Grids (BAGs) for each CUBE surface were exported from HIPS for submittal.

Designated soundings were used as a starting point for S-57 feature creation. Designated soundings that were determined to be obstructions or wrecks were imported into the S-57 feature files and attributed. Many, if not all, items included in the S-57 feature file have already been submitted as DtoN. In some cases an obstruction that is depicted in the S-57 feature files was not reported as a DtoN because it was found to be deeper than currently charted soundings.

The feature file also includes bottom samples (SBDARE) and required meta-objects (M_COVR and M_QUAL).

C. CORRECTIONS TO ECHO SOUNDINGS

C1. Static Draft

With the vessel out of the water, markings were surveyed and painted on the port and starboard sides of the hull directly abeam with the multibeam sonar providing a means to monitor vessel draft. Static draft readings from the port and starboard side were recorded at the start and end of each survey day, while the ship was alongside the pier and where an accurate draft reading could be obtained. The start and end of day draft values for the sonar were calculated from the average of the port and starboard draft readings. The draft marks were directly abeam of the multibeam head mounted in the center of the vessel. The vessel's fuel and ballast levels were maintained to control the vessel draft. An average of the start and end of day draft values was calculated daily and entered into the waterline field in the Caris HVF. The average draft value best approximates the true draft value during acquisition due to loading changes from fuel consumption during transit to and from the survey area at the start and end of each day. Ultimately, the daily draft values were used to calculate daily draft relative the HIPS reference point which was entered into the waterline field in the Caris multibeam HVF files.

C2. Dynamic Draft

A settlement and squat test for the *R/V Sealth* using post processed GPS height observations was performed in the vicinity of the mouth of the Rappahannock River on June 2, 2007 (Day Number 153). Data from these measurements are displayed graphically in Figure 8 and are included in Appendix V *Supplemental Survey Records and Correspondence* of the Descriptive Report.

The settlement and squat values were obtained by computing a three minute GPS height average at different ship speeds, measured in knots and revolutions per minute (RPM) during transects near the mouth of the Rappahannock River. Transects were run twice at each RMP interval; once at a westerly heading and once at an easterly heading.

Ship speeds in increments of 100 RPMs were observed from 700 to 1600 RPM with GPS height recorded at 25 HZ. With the vessel at rest static GPS height observations were recorded between each RPM interval in order to have a baseline GPS height value not affected by tide changes during the test. Three minute running averages of GPS height were calculated to remove any heave bias from the calculations. Each transect was run for approximately three minute resulting in one average GPS height measurements per transect. The difference between the GPS height and an interpolated static GPS height (to account for changing tide) at the time of the average height value were used to calculate the dynamic draft for each transect. An average dynamic draft corrector was then calculated from the average of the two values for each RPM interval. The average speed for each RPM interval and the average dynamic draft corrector were entered into the HIPS vessel file. TPE values for dynamic draft were calculated by taking the average of the standard deviation for all dynamic draft calculations per transect.

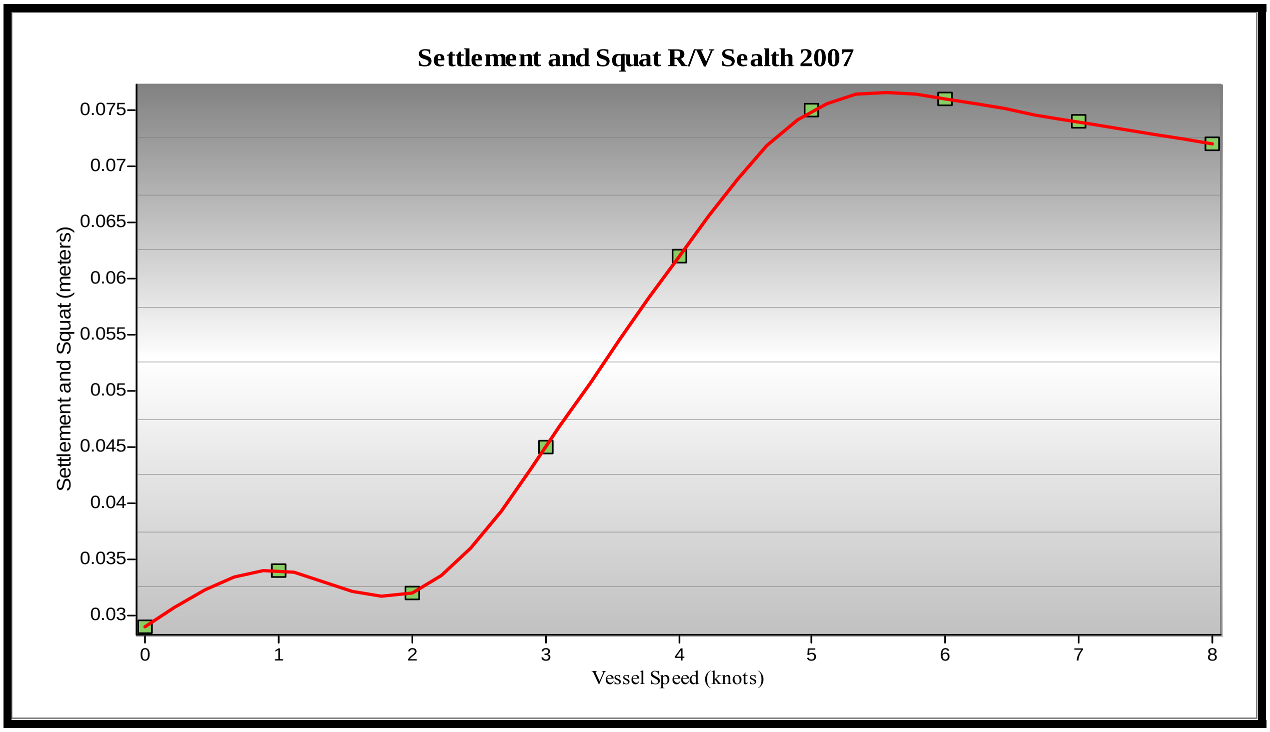

Figure 8. Settlement and squat of *R/V Sealth*

C3. Leadline Comparisons

Leadline or bar checks were performed against the multibeam echosounder at the start of each week to confirm that the system was working properly. Leadline checks were performed every week except for the check on July 5, 2007 (DN 186) which used a bar check.

The leadline was used to directly measure the distance from the water surface to the bottom. The leadline depth was compared to the multibeam depth of the bottom at the same location. During the first few weeks the multibeam depths were processed through Caris HIPS and compared to the leadline value in order to verify the offsets in the HVF were being applied correctly. During subsequent checks leadline depth was compared to the multibeam depth recorded in the Triton Isis beam confidence check dialog window by using beam number to display depth. The beam number was selected dependent on the placement of the leadline, either 3.0 meters offset to port and starboard for leadlines taken over the side, or at nadir for leadlines taken directly at the sonar head from underneath the survey vessel. A floating platform was used to gain access to the sonar when leadlines were taken at nadir.

The bar check performed on July 5, 2007 (DN 186) was constructed of an 8-inch diameter steel disc which was attached to a metric reel fiberglass tape and lowered to a point above the bottom where it could be clearly ensonified. The depth of the bar reported on the tape was compared to the depth of the plate reported by the multibeam sonar.

Observations were recorded in a leadline comparison log. The average difference between the leadline and multibeam measurements was 0.013 meters, the standard deviation was 0.008 meters, and the maximum deviation was 0.093 meters. The maximum deviations were attributed to the soft and irregular bottom while using a leadline.

Tabulated leadline comparisons may be found in the Leadline Comparison log included in Appendix V *Supplemental Survey Records and Correspondence* of the Descriptive Report.

C4. Heave, Roll and Pitch Corrections

An Applanix POS/MV 320 version 4 integrated DGPS and inertial reference system was used for the motion sensor for this survey. The POS/MV 320 is a six-degree of freedom motion unit, with a stated accuracy of 0.05-meter or five percent for heave, 0.02° for roll and pitch and heading. Real-time displays of the vessel motion accuracy were monitored throughout the survey with the POS/MV controller program. If any of the vessel motion accuracy degraded to greater than 0.05°, survey operations would be suspended until the inertial unit was able to regain the higher degree of accuracy. Manufacturer reported accuracies as published on the Caris HIPS TPE website (http://www.caris.com/tpe/) were entered into the HVF and used for TPE computations. A schematic of the vessel and sensor set-up is shown in Figure 9.

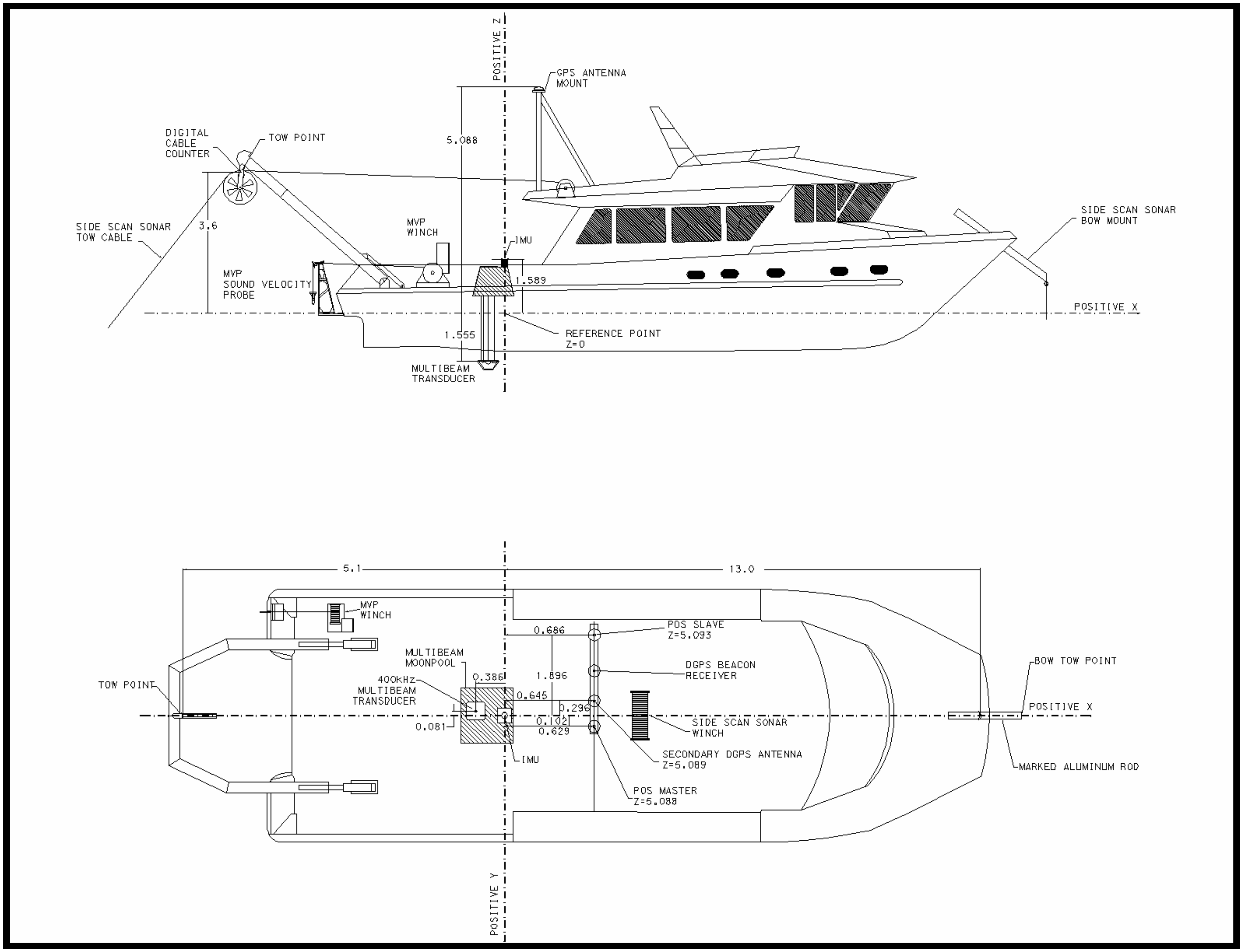

Figure 9. Schematic of *R/V Sealth* and sensor setup

Attitude and heading were reapplied after post-processing navigation and inertial sensor data in POSPac Smooth Best Estimate and Trajectory (SBET) and POSProc RMS File (SMRMSG) files were applied in HIPS with the Load Attitude/Navigation data and Load Error data tools.

Installation bias was applied to all the data, along with results obtained from the patch test at the start of the survey. These values were stored in the Caris HVF files.

C5. Patch Tests

Patch tests were conducted to measure alignment offsets between the IMU sensor with the multibeam transducer, and to verify delay times applied to the time-tagged sensor data. Tests were performed at the beginning and end of the project to determine if any movement of the pole mounted sonar occurred during the project. The patch test consisted of a series of lines run in a specific pattern, which were then used in pairs to analyze roll, pitch and heading alignment bias angles, as well as, latency in the time tagging of the sensor data. Patch tests were conducted in accordance with NOAA standards and occurred on May 22, 2007 (Day Number 144) and September 28, 2007 (Day Number 271). The patch test data were evaluated in HIPS after loading post-processed navigation, attitude, and heading.

A precise timing latency test was performed by running reciprocal lines over a flat bottom. The lines were then opened in the HIPS calibration editor (after applying tide and SVP corrections) and a small along track slice of data was evaluated in the outer swath of the line. Incremental changes to the roll time offset were made to evaluate the performance of the precise timing setup and to determine if a latency correction was needed. No latency was found in the system. These lines were also used to evaluate the roll bias.

Roll alignment was determined by evaluating the reciprocal lines run over a flat bottom used for the latency test. The pitch test consisted of set of reciprocal lines over a large wreck located in the entrance channel of the Piankatank River east of Stingray Point Light. The heading error was determined by running parallel lines over the same area. All lines were run at approximately 5 knots.

Selected pairs of lines were then analyzed in HIPS Calibration editor to measure the angular sensor bias values. Visual inspection of the data confirmed each adjustment. Two sets of lines were run and analyzed for each of the mounting biases with the second set was used to confirm the results of the data.

Comparison of the open and closing patch tests reveals a slight change in the roll value occurred during the project. The opening roll value was measured as -0.12° and the closing value was measured as -0.02°. It is impossible to know whether this change was gradual and occurred during the course of the project or occurred at a single point in time. Due to the small change that occurred the average of the opening and closing roll values were entered in the HIPS vessel file and used for the entire project. No changes were seen between the opening and closing values of the other alignment parameters. Project wide correction values used in the HIPS Vessel File are displayed in Table 6.

Table 6. Biases applied when using the POS/MV for pitch and roll.

Alignment	Bias
Roll	-0.07°
Pitch	0.10°
Yaw	0.90°
Latency	0.00s

C6. Tide and Water Level Corrections

The primary water level station for this project was Windmill Point, Virginia (863-6580). Subordinate gauges were installed at the Rappahannock Front Range, Virginia (863-2837) and Gaskins Point, Virginia (863-2869). NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) preliminary zoning files tied to Windmill Point, Virginia (863-6580) were adjusted using the DEA installed subordinate gauges as the reference stations. Zone boundaries were not modified, but new time and range correctors were calculated for each zone relative to each subordinate gauge. This resulted in three zoning files, the original file relative to 863-6580 created by CO-OPS, and two new files relative to 863-2837 and 863-6580.

Time correctors were calculated by adjusting the average time corrector (ATC) for zones which surrounded the two subordinate gauges to zero minutes. Similarly, the range corrector was adjusted to 1.00. From this ATCs were calculated for each remaining zone relative to each subordinate gauge by calculating the difference between the ATC relative to 863-6580 for the zone in question. Range correctors were calculated by dividing the range corrector for the zone in question by the range corrector of the zones which surround the two subordinate gauges

A HIPS ZDF was used to apply zoned tides to the multibeam data. See the Descriptive Report for each survey for discussion of the water level data and zoning scheme that was used.

The primary and subordinate stations experienced no down time during periods of hydrographic survey.

C7. Sound Velocity Correction

While underway during data acquisition the MVP-30 was deployed as needed to obtain an adequate number of sound velocity profiles to properly correct the multibeam data during data processing. At the start of each survey day a cast was taken right before coming online with additional casts being taken on a periodic basis, usually every 15 minutes to 20 minutes, unless there was a chance of entangling the SSS towfish with the MPV; typically when in strong currents or when surveying in deeper areas where extra SSS cable was payed out. Casts were taken more frequently if refraction artifacts were visible in the SSS record or if large changes in sound speed were observed between casts. One deep cast (extending to 95% of depth) was taken per day.

After each cast the sound speed data was reviewed for outliers or anomalies such as a sharp thermocline which could impact data quality. The sound speed measured by the MVP at 1.5 meters depth was also compared to the Reson head velocity for agreement to ensure that both systems were working properly. In addition to these periodic comparisons, weekly check casts were taken to verify proper performance of the MVP 30. For this check a SeaBird Instruments SBE 19 – CTD profiler was attached to the MVP fish and the two probes were simultaneously deployed at the deepest end of the survey area for that day's operations. Corrections for the speed of sound through the water column were computed for each sensor and imported into an Excel file where sound speed profiles were created and overlaid for comparison. Each sensor had been calibrated prior to the start and at the end of the survey. Factory calibration results are included in the Separates Section II of the Descriptive Report for the survey.

The sound speed correction was applied to each line using the nearest in distance within time (two hours) option in the HIPS SVP correct routine. All casts were concatenated into a daily HIPS SVP file for each survey day. Time, position, and sound speed for each profile were included in the HIPS file.

D. LETTER OF APPROVAL

DAVID EVANS AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-E349-KR-07
DATA ACQUISITION AND PROCESSING REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-E349-KR-07 were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the OPR-E349-KR-07 *Statement of Work* (February 22, 2007).

Digitally signed by Jon Dasler
DN: cn=Jon Dasler, email=jld@deainc.com, o=David Evans and Associates, Inc., c=US
Date: 2008.03.19 15:57:16 -07'00'

Jonathan L. Dasler, PE (OR), PLS (OR,CA)
Chief of Party

Digitally signed by Jason Creech
DN: cn=Jason Creech, email=jasc@deainc.com, o=David Evans and Associates, Inc., c=US
Date: 2008.03.19 15:57:50 -07'00'

Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
September 2007