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

# DATA ACQUISITION AND PROCESSING REPORT

| | |
|---|---|
| *Type of Survey* | **Hydrographic** |
| *Project* | **S-J977-KR-DEA** |
| *Contract No* | **DG133C-05CQ-1078** |
| *Task Order No* | **T002** |
| *Time Frame* | **November 2006 - April 2007** |

## LOCALITY

| | |
|---|---|
| *State* | **ALABAMA** |
| *General Locality* | **Mobile Bay** |

**2007**

CHIEF OF PARTY

**Jonathan L. Dasler, David Evans and Associates, Inc.**

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U.S. DEPARTMENT OF COMMERCE
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# HYDROGRAPHIC TITLE SHEET

REGISTRY No
H11623
H11624
H11625

**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: Alabama

General Locality: Mobile Bay

Sub-Locality: Fowl River to Bon Secour River

Scale: 1:10,000

Date of Survey: November 9, 2006 to April 28,2007

Instructions dated: October 18, 2006

Project No.: S-J977-KR-DEA

Vessel: R/V Taku

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

Surveyed by: Jonathan Dasler, Jason Creech, John Staly, Shyla Allen, Benjamin Hocker

Soundings by echo sounder, hand lead, pole: RESON 8101, Odom MkIII and CV-100, EdgeTech 4200-FS and 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 detect and map marine debris for the Gulf of Mexico Marine Debris Project and to provide NOAA with modern, accurate hydrographic survey data with which to update the nautical charts of the assigned area.

SUBCONSULTANTS: ZEPHYR MARINE, P.O. Box 1575, Petersberg, AK 99833

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## Acronyms and Abbreviations

| | |
|---|---|
| AML | Applied Microsystems, Ltd. |
| ASV | Autonomous Surface Vehicle |
| BAG | Bathymetric Attributed Grid |
| .BIN | HYPACK Digital Echogram File |
| CO-OPS | Center for Operational Oceanographic Products and Services |
| COTR | Contracting Officer's Technical Representative |
| CUBE | Combined Uncertainty and Bathymetry Estimator |
| DEA | David Evans and Associates, Inc. |
| DXF | Drawing Exchange Format |
| DGPS | Differential Global Positioning System |
| FEMA | Federal Emergency Management Agency |
| GOMMDP | Gulf of Mexico Marine Debris Project |
| GPS | Global Positioning System |
| HDCS | Hydrographic Data Cleaning System |
| HIPS | Hydrographic Information Processing System |
| HPR | Heave, Pitch, Roll |
| HSD | Hydrographic Surveys Division |
| HSX | HYPACK Hysweep File |
| HVF | HIPS Vessel File |
| Hz | Hertz |
| IMU | Inertial Motion Unit |
| ICW | Intracoastal Waterway |
| kHz | kilo Hertz |
| MDB | Microsoft Access Database File |
| MLLW | Mean Lower Low Water |
| NATSUR | Nature of Surface |
| NATQUA | Nature of Surface Qualifying Terms |
| 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 |
| RAW | HYPACK File |
| R/V | Research Vessel |
| RPM | Revolutions per Minute |
| RTK | Real-Time Kinematic |
| SBDARE | Seabed Area |
| SSS | Side Scan Sonar |

| | |
|---|---|
| SV | Sound Velocity |
| SVP | Sound Velocity Profile |
| TIF | Tagged Image Format |
| TPE | Total Propagated Error |
| UTC | Universal Time Coordinated |
| XTF | Extended Triton format file extension |

**S-J977-KR-DEA**
**Data Acquisition and Processing Report**
**Mobile Bay, Alabama**

November 2006 – April 2007
*R/V Taku*
*DEA Autonomous Surface Vehicle (ASV)*
**David Evans and Associates, Inc.**
Lead Hydrographers: Jonathan L. Dasler, Jason C. Creech

## INTRODUCTION

This report applies to surveys H11623, H11624, and H11625 located in Mobile Bay, Alabama which are part of the Gulf of Mexico Marine Debris Project (GOMMDP). These contract surveys were performed under S-J977-KR-DEA as specified in the *Statement of Work* dated October 18, 2006. In general, survey methods meet or exceed requirements as defined in the National Ocean Service (NOS*) Hydrographic Surveys Specifications and Deliverables (June 2006)*. Coverage by side scan sonar for this debris mapping survey was only 100 percent and not the required 200 percent in the NOS specifications. Further, due to the shallow water, side scan sonar altitude requirements were waived for this project.

## A. EQUIPMENT

For this project David Evans and Associates, Inc. (DEA) implemented a state-of-the-art data acquisition system aboard the Research Vessel (*R/V*) *Taku*, in accordance with National Oceanic and Atmospheric Association (NOAA) standards and modern remote sensing techniques. Additionally, survey trials were run with an Autonomous Surface Vehicle (*ASV*) during the project with data collection from the *ASV* platform occurring at the project's end. Data processing took place in the field at a shore side processing station 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 Tables 1 and 2.

### *Table 1. R/V Taku Hardware*

| Instrument | Manufacturer | Model | S/N | Function |
|---|---|---|---|---|
| **Side scan** | | | | |
| | **Edgetech** | **4200 FS** | | 100/400 kHz Digital side scan sonar imagery with towfish heading and depth sensors. |
| Deck Unit | | | 33913 | |
| Towfish | | | 32060 | |
| **Single beam** | | | | |
| | **Odom** | **Echotrac MKIII** | | 200 kHz Single beam sonar with 9° beam angle. |
| Deck Unit | | | 21149 | |
| Transducer | | | n/a | |
| | | **Multibeam** | | |
| | **RESON** | **8101** | | 240 kHz Shallow Water Multibeam sonar with 101 1.5° beams. Firmware 8101-2.09-E34D |
| Deck Unit | SeaBat 8101 | | 16125 | |
| Transducer | | | 3899067 | |
| **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 | | | 447 | |
| Port Antenna | | Compact Zephyr | 60084986 | |
| Starboard Antenna | | Compact Zephyr | 60073510 | |
| | **Trimble** | **ProBeacon** | | Obtain differential corrections United States Coast Guard differential beacons. |
| Unit | | | 220014495 | |
| Antenna | | 24960-00 | 220014366 | |
| | **Trimble** | **DMS 132** | | Secondary positioning system for Quality Assurance/Quality Control (QA/QC) |
| Unit | | | 0 0224093932 | |
| Antenna | | 33580-00 | 0220361419 | |
| **Sound Velocity** | | | | |
| | **AML SV Probe** | **Smart SV&P** | | Primary sound velocity profiler and unused spare. |
| Sensor | | | 5110 | |
| Sensor | | | 5111 | |
| | **Seabird** | **SBE 19*plus*** | | Secondary Conductivity, Temperature, and Depth (CTD) profiler for sound velocity profiles |
| Unit | | | 19P42715-4962 | |
| **Bottom Samples** | | | | |
| | Wildco | Standard Ponar Grab Sampler | | |

***Table 2. ASV Hardware***

| Instrument | Manufacturer | Model | S/N | Function |
|---|---|---|---|---|
| **Side scan** | | | | |
| Deck Unit | **Edgetech** | **4200 HFL** | In towfish | 300/600 kHz Digital side scan sonar imagery with towfish heading and depth sensors. |
| Towfish | | | 33914 | |
| **Single beam** | | | | |
| Deck Unit | **Odom** | **CV-100** | 26003 | 200 kHz Single beam sonar with 9° beam angle. |
| Transducer | | AirMar M194 | | |
| **Attitude and Position** | | | | |
| Deck Unit | **TSS** | **DMS05** | 2220 | Motion Sensor (Heave, Pitch, Roll) |
| Reciever | **Trimble** | **DSM132** | 022409892 | Positioning w/ DGPS corrections (United States Coast Guard differential beacon). |
| Antenna | | 33580-00 | 220360424 | |

## A1. Survey Vessels

### A1.a *R/V Taku*

The *R/V Taku* (Figure 1) which is owned and operated by Zephyr Marine was used as the primary survey vessel for the project. The *R/V Taku*, is a 28-foot trailerable aluminum catamaran with a 10.5-foot beam and a draft of 2.0 feet. The vessel is equipped with twin 225 HP outboard motors, a 12-foot pilot house, a hull-mounted single beam transducer, stern mount A-frame, a side scan sonar bow mount for shallow water operations and a data acquisition station. No unusual sensor setup configurations were required for this survey.


**Figure 1.** *R/V Taku*

### A1.b *ASV*

A SeaRobotics USV-5000 Autonomous Surface Vehicle (Figure 2) was used as a secondary acquisition platform, though the *ASV* was principally deployed on an experimental basis with the ultimate goal of having a stable and reliable survey platform. DEA worked jointly with SeaRobotics (Palm Beach Gardens, Florida) and EdgeTech R&D branch (Boca Raton, Florida) in refinement of this system. The *ASV* was configured with survey instrumentation and data acquisition and vessel guidance computers. A live video feed from a forward looking video camera for collision avoidance was transmitted to a vessel operator to ensure that the *ASV* operated in a safe manner. The *ASV* was successfully used to acquire data towards the end of the project.

**Figure 2.** *ASV*

## A2. Side Scan Sonar Systems

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

### A2.a *R/V Taku*

Side scan sonar imagery was acquired with an EdgeTech 4200-FS dual frequency (100/400 kHz) digital side scan sonar (Figure 3) running in high speed mode at the 400 kilo Hertz (kHz) high frequency setting. The sonar was operated at a 50-meter range scale on all *main scheme* lines and at a 25-meter range during charted item disapprovals. 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, pitch, roll and depth, ship position and computed towfish position from layback calculations. All side scan data was acquired with the towfish deployed from the bow. Fixed layback distance to the bow tow point was manually entered in the Isis software.

**Figure 3.** Edgetech 4200-FS Side Scan Sonar

### A2.b *ASV*

An EdgeTech 4200-HFL dual high frequency (300/600 kHz) digital side scan sonar (Figure 4) was integrated into the *ASV* system. The 4200-HFL is a high frequency lightweight version of the 4200-FS towfish that was used aboard the *R/V Taku*. The lighter towfish was used to reduce the weight of the *ASV* in order to keep it seaworthy and light enough to be deployed from a small boat. Imagery was acquired using Triton Isis with software settings identical to those used on the *R/V Taku*. The *ASV* was only used for *main scheme* acquisition and the sonar was operated at a 50-meter range scale. A manual offset was entered in the layback calculations to account for the offset between the Global Positioning System (GPS) and the *ASV*'s fixed towfish mount.

**Figure 4.** Edgetech 4200-HFL Side Scan Sonar

## A3. Single Beam Systems

Draft checks were observed twice daily to monitor vessel loading and fuel consumption. Weekly lead line checks were performed to ensure that the sonars were functioning properly and static draft was accurately documented. The lead line was constructed by attaching a mushroom anchor to a metric reel fiberglass tape enabling depths to be read to 5 mm.

Both survey platforms were outfit with Odom single beam echosounders that were operated concurrently with side scan sonar during survey operations. All single beam data were logged in HYPACK file (RAW) and HYPACK Digital Echogram file (.BIN) formats.

### A3.a *R/V Taku*

An Odom Echotrac MKIII with a 9° transducer and 200 kHz operating frequency was deployed on the *R/V Taku*. The transducer was hull mounted amidships on the starboard pontoon.

### A3.b *ASV*

An Odom CV-100 single beam echosounder with a much smaller footprint than the Echotrac MKIII was installed in the *ASV* due to the limited amount of space inside the *ASV*'s monohull. The Odom CV-100 was also integrated with a 9° transducer operating at 200 kHz. The transducer was mounted on the tail of the Edgetech 4200-HFL towfish.

## A4. Multibeam System

Weekly lead line checks were performed when utilizing the multibeam to ensure that the sonar was functioning properly and static draft was accurately documented. The lead line was constructed by attaching a mushroom anchor to a metric reel fiberglass tape enabling depths to be read to 5 mm.

### A4a. *R/V Taku*

A Reson 8101 multibeam sonar was installed on the *R/V Taku* and used during item investigations of side scan sonar contacts. The multibeam echosounder was pole mounted which facilitated easy removal from the water when not in use to prevent damage to the sonar. The multibeam data were logged in XTF format on the Triton Isis acquisition system. The Reson 8101 series operates at 240 kHz producing a 150° swath of 101 uniform beams with a beam width of 1.5° x 1.5°.

### A4b. *ASV*

No multibeam data were acquired from the *ASV*.

## A5. Position, Heading and Motion Reference System

### A5.a *R/V Taku*

An Applanix POS/MV 320 v4 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 GPS antennas, and a data processor. A Trimble ProBeacon receiver, acquiring corrections from the U.S. Coast Guard beacon located at Mobile Point, Alabama (broadcasting at 300 kHz) provided differential corrections for both the primary and secondary positioning systems. Position, heading, and motion data were output to 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 38400 baud and 25 Hertz (Hz); and position and heading at 9600 baud and 1 Hz.

The Position and Orientation System for Marine Vessels (POS/MV) provided time synchronization of sonar instruments and logging computers using a combination of outputs from the POS/MV v4. The Reson processor and HYPACK logging computer were provided both a PPS (pulse per second) and a National Marine Electronics Association (NMEA) global positioning 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 contain time strings and cause the clocks of the computers and sonars to synchronize to the time contained within the message. Time offsets between instruments and computers, relative to times contained in POS/MV network packets, are typically sub-millisecond.

As a quality check a Trimble DSM-132 using differential correctors from the Trimble ProBeacon receiver 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 DSM-132 was observed and documented while the vessel was stationary in port. Logged position data was imported into Excel and a difference computed.

### A5.b *ASV*

Two instruments were used to provide geographic positioning and motion compensation for the data; a Trimble DSM132 DGPS and a TSS DMS05 HPR (heave, pitch and roll) motion compensator.

The Trimble DGPS provided U.S. Coast Guard Beacon corrected differential GPS positions using the Mobile Point, Alabama correctors being broadcast on 300 kHz. The position data was output at 5 Hz (9600 baud) to the Vehicle Control Computer, DMS05 motion compensator and to the onboard data-logging computer running HYPACK and Isis. Proper RS-232 signal levels were maintained using custom DEA circuitry to accommodate the multiple outputs.

The DMS05 HPR data was output, for logging in HYPACK, at 25 Hz and 38400 baud. The instrument was configured in "Fully Aided" mode to minimize heave-settling times. This was accomplished using position and speed inputs from the DGPS data stream and 5 Hz heading inputs from a KVH digital compass. Typical heave settling times were measured as < 20 seconds in the "Fully Aided" mode. Turns between survey lines were programmed to provide sufficient "run-in" time to allow the heave to settle prior to start of data logging.

Time synchronization of all data was accomplished by using Isis to set the data-logging PC clock to UTC via the DGPS data stream. HYPACK was configured to use the data-logging PC clock for data time tags. Since both applications were running on the same PC, all data were time correlated and logged using UTC times.

## A6. Sound Velocity Measurement System

### A6.a *R/V Taku*

An Applied Microsystems, Ltd. (AML) Smart SV&P sound velocity sensor was used to take multiple daily sound speed readings during single beam and multibeam operations. A Seabird SBE 19+ was used to take weekly check casts to verify optimum performance of the AML sensor.

AML sensor 5110 was used from the beginning of survey operations until the cable was damaged on DN110. The SBE 19+ was uses as a temporary substitute on DN111 until the spare AML sensor (5111) could be installed on the *R/V Taku*. AML sensor 5111 was used until the end of survey operations.

The sensors 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 Reports for the survey.

### A6.b *ASV*

Sound velocity (SV) casts for the *ASV* single beam data were performed from the main survey platform and designated as *ASV* casts. Daily pre-survey and post-survey casts were taken in the *ASV* survey area.

## A7. Acquisition Systems

The software and version numbers used throughout the survey are listed in Table 3 below.

***Table 3. Acquisition and Processing Software***

| SOFTWARE | | | | |
|---|---|---|---|---|
| | **Company** | **Program Name** | **Version** | **Date** |
| **Acquisition** | | | | |
| | Triton Imaging, Inc | Isis | 7.0.417.21 | 11/15/2006 |
| | HYPACK, Inc. | HYPACK /HYSWEEP | 6.2.1.1 | 11/15/2006 |
| | EdgeTech | Discover | 5.19 | 11/15/2006 |
| | Applanix | MV-POSView | 3.3.0.0 | 11/15/2006 |
| | Trimble | ProBeacon | 1991 DOS | 11/15/2006 |
| | DEA | Digital LineLog | 1.0.4 | 11/15/2006 |
| **Processing** | | | | |
| | Caris | HIPS | 6.1/SP1/ HF 6 | 11/7/2007 |
| | Caris | Notebook | 3.0/HF 1 | 7/3/2007 |
| | Caris | Bathy DataBASE | 2.1 | 8/30/2007 |
| | Triton Imaging, Inc | Isis Sonar Office Suite | 7.0.417.21 | 11/15/2006 |
| | HYPACK, Inc. | HYPACK Lite | 6.2.1.1 | 11/15/2006 |
| | ESRI | ArcGIS | 9.2.0.1324 | 11/15/2006 |
| | DEA | SVP Convert | 0.0.8 | 11/15/2006 |
| **Other** | | | | |
| | Microsoft | Word | 2003 | |
| | | Excel | 2003 | |
| | | Access | 2003 | |

### A7.a *R/V Taku*

The acquisition station was installed and integrated on the *R/V Taku* by DEA and consisted of a Triton Isis side scan and multibeam sonar data acquisition system and a HYPACK vessel navigation and single beam acquisition system (Table 3). During acquisition, data were logged locally on acquisition PCs and then transferred to the field processing office at the end of each survey day via external USB drives.

### A7.b *ASV*

The acquisition system onboard the autonomous surface vehicle was custom built and integrated into the *ASV*'s three-meter long monohull. The acquisition and logging of data was performed on an embedded computer running Triton Isis for Side Scan Sonar (SSS) data collection and HYPACK for vessel navigation and single beam acquisition. Data were logged onboard the vehicle during acquisition and transferred to the field office via wireless link and USB drives.

Controlling the route of the *ASV* was accomplished by using a combination of HYPACK line files and SeaRobotics' converter software to generate a mission profile plan. Main scheme lines to be run were first identified in HYPACK, modified for smooth turns between lines and converted to geographic waypoints for downloading to the vehicle guidance computer. A mission speed was selected and the vehicle was commanded to commence the mission. HYPACK and Isis were set to start/stop logging when the vehicle was traversing the selected main scheme lines. Monitoring of operation of the vehicle and logging software was accomplished via a radio link and Windows Remote Desktop.

## A8. Survey Methodology

### A8.a Mobilization

Mobilization, sensor installation, and calibration of the *R/V Taku* occurred from November 11 through November 15, 2006 in Gulf Shores, Alabama. Prior to mobilization in Alabama a survey of the the *R/V Taku* was performed while the vessel was at the David Evans and Associates Inc. Corporate office in Portland, Oregon. A total station was used to survey the vessel's sensor mounting points and prominent structural features. Values from the survey were used to calculate sensor offsets and accuracies used in the HIPS vessel file (HVF). The vessel was then trailered to Gulf Shores, Alabama and outfitted with survey hardware and computer systems. Upon completion of equipment installation, the vessel underwent system calibration tests and draft measurements were made under both static and dynamic (settlement and squat) conditions.

The *ASV* was mobilized from SeaRobotics' production facility in Stuart, Florida. This location is near a small lake in which the "in water" tests were performed. Integration of DEA equipment included: power distribution for the various instruments, wiring of all DEA sensors to the embedded form factor acquisition computer, acquisition system software configuration and testing. During testing it was found that electrical noise from the vehicle propulsion system was causing interference with the EdgeTech 4200 SSS. This led to a new propulsion system being installed. Further testing uncovered various software problems with the vehicle control system. These were addressed by SeaRobotics and the vehicle was delivered to DEA on December 31st, 2006. Testing continued in Mobile Bay, Alabama. The vehicle control problems were again addressed and solved during continued testing.

### A8.b Survey Coverage

The Mobile Bay (S-J977-KR-DEA) area was surveyed with line orientations appropriate for each of the three sheet boundaries. The side scan sonars on the *R/V Taku* and the *ASV* were operated at

50-meter range scale with a survey line spacing of 40 meters to attain 100 percent side scan coverage and allow for a 10-meter offline tolerance. Single beam echosounder data was acquired concurrently with side scan sonar operations.

The vast majority of the survey was performed with the *R/V Taku.* The *ASV* was used in a limited basis for near shore acquisition on H11623 (Sheet A) and H11624 (Sheet C), as shown in Figure 5.

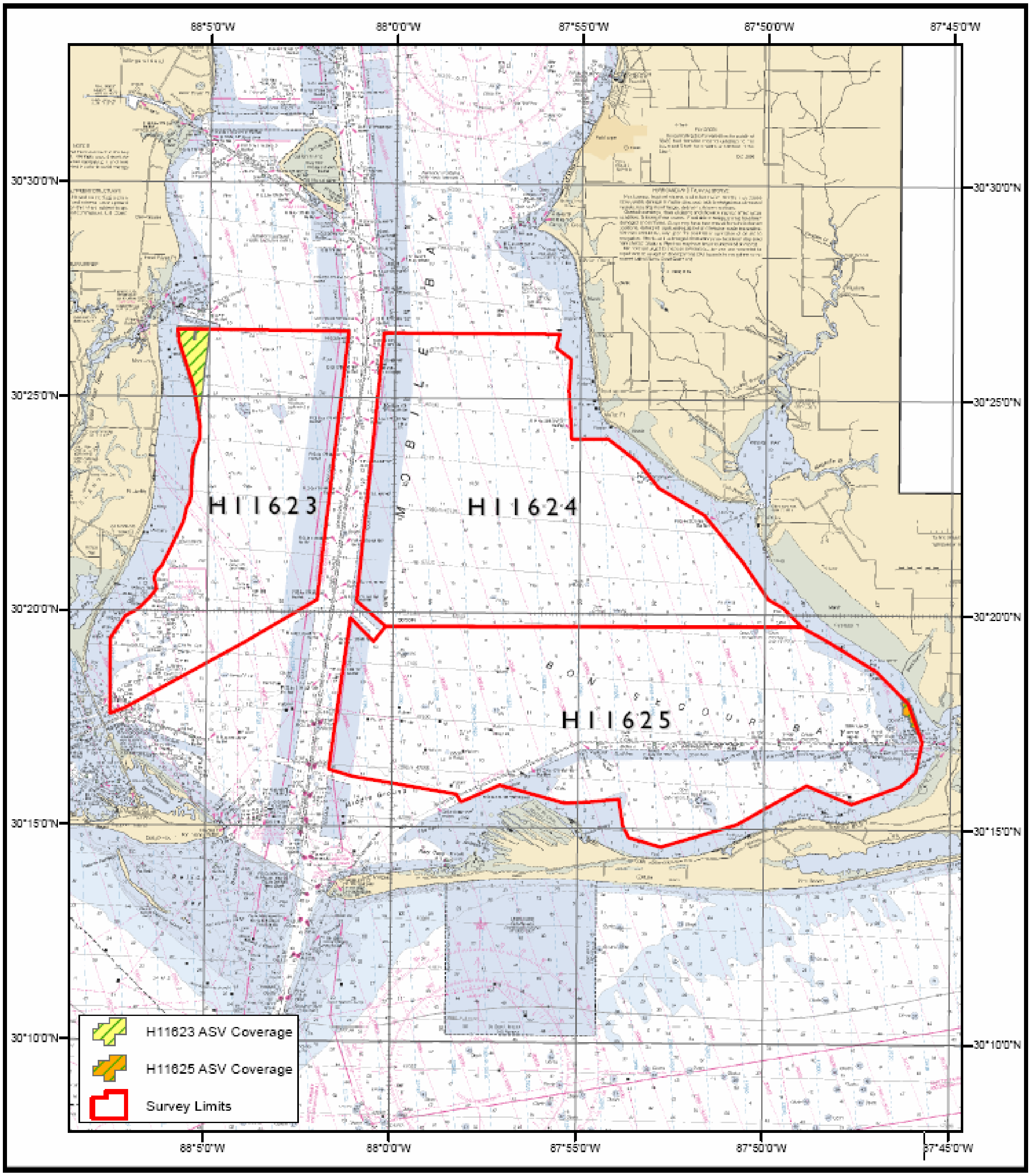


**Figure 5.** Areas of *ASV* Data Acquisition

Multibeam echosounder contact investigations were run with the *R/V Taku*, in a manner that allowed efficient sonar coverage with additional considerations for crew and vessel safety.

### A8.c Side Scan Sonar Operations

The primary purpose of this survey was to detect and map marine debris for the GOMMDP. The *Statement of Work* (October 18, 2007) waived the standard 200 percent side scan coverage requirement and only required 100 percent side scan coverage over the survey area, with 200 percent coverage limited to charted item disapprovals.

Side scan and single beam data were acquired concurrently from both the *R/V Taku* and the *ASV*. Preplanned HYPACK line files were created for each survey sheet at 40-meter spacing. This setup allowed for 100 percent main scheme line coverage with an offline tolerance of 10 meters.

The *R/V Taku* was staffed with a vessel operator and a hydrographer. The hydrographer's tasks included: analyzing the digital sonogram, maintaining a digital acquisition log which was used to track contacts, daily confidence checks, and other survey activities. All acquisition occurred during daylight hours with the vessel leaving port in the morning and returning in the evening.

Side scan imagery was collected using the sonar's high frequency (400 kHz) setting in the multi-pulse high speed mode at a range of 50 meters for all main scheme data acquisition. At a 50-meter range scale using the high speed mode, which allows multiple pings in the water at one time, the EdgeTech 4200-FS has a ping rate of 20 Hz. In accordance with the NOS *Hydrographic Surveys Specifications and Deliverables* (June 2006), vessel speed was monitored to ensure 3 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.

In addition, the operator monitored coverage displays and towfish height, attempting to maintain within 8 to 20 percent of the range when not limited to the extremely shallow waters within the survey area. When weather or sea conditions degraded side scan sonar imagery, operations were suspended.

The *ASV* was still under development during much of the survey and used sparingly towards the end of the project for side scan and single beam data acquisition. Operationally, side scan sonar acquisition followed the same protocols that were used onboard the *R/V Taku* with the exception that the hydrographer monitored the acquisition systems remotely.

Side scan imagery was acquired from the *ASV* using the high frequency (400 kHz) in the multi-pulse high speed mode at a range of 50 meters for all data acquisition. The survey vessel maintained a speed well under 8.5 knots throughout the survey which allowed for a minimum of 4.6 pings per meter.

During operations the *ASV* was deployed from either the *R/V Taku* or from a rigid inflatable boat. When deployed from the *R/V Taku* the *ASV* was launched from a custom deployment/recovery ramp at the stern of the vessel. This allowed the vehicle to be moved to the survey area at high speeds. Control of the vehicle was maintained between the *ASV* and operator onboard the *R/V Taku* via radio link while both platforms were operating in the same general area. Under the other deployment scenario a 12-foot rigid inflatable boat was used to tow the *ASV* to the survey area. The boat carried a laptop, radio and power system for maintaining communications and control of the *ASV*. This method allowed the main survey vessel to operate independently of the *ASV*.

Data was transferred to DEA's Portland office and side scan sonar mosaics were created to illustrate completeness of coverage and any detected data holidays were filled by running additional survey lines. After review of data a 200 percent pass was run over all charted items that were not found in the side scan imagery for disproval of the item. Discussion of disproved charted items can be found in the Descriptive Report for each survey.

### A8.d Single Beam Sonar Operations

Single beam sonar operations occurred concurrently with side scan sonar acquisition. The sonar operator monitored the single beam echosounder digital echogram which was displayed and logged on the Hypack acquisition computer. A traditional paper trace was not recorded during this survey as the full water column return was digitally recorded.

### A8.e Multibeam Operations

Multibeam investigations occurred after 100 percent side scan coverage was achieved and a list of the 50 most significant contacts requiring investigations was compiled. The *Statement of Work* required investigation and least depth determination of the top 50 contacts located within each survey sheet using single beam and two additional side scan passes at 25-meter range scale. After discussions with the Contracting Officer's Technical Representative (COTR), the requirement for two additional side scan passes over each contact was waived and replaced with a 100 percent multibeam investigation.

The list of top 50 contacts was compiled after examining parameters such as contact height, level of significance, depth of the contact and navigational significance. In actuality, more than 50 contacts were identified and investigated per sheet due to the numerous contacts that were observed within uncharted or mischarted fish havens and oyster beds. Further discussion of contacts and multibeam development can be found in the Descriptive Report for each survey.

For all investigations the sonar head was mounted at a 15° starboard roll offset to facilitate investigations in shallow water where the survey vessel could not safely navigate directly over the contacts. Under normal conditions contacts were ensonified with interior beams no more than 60° from nadir.

The multibeam sonar system was operated at a recorded ping rate of 18 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 18 Hz and an average vessel speed of seven knots, the bottom coverage averaged 5.0 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 investigation areas ranged from -2.0 to 24 feet (-0.6 to 7.5 meters). Table 4 lists the typical sonar settings for the multibeam investigations.

***Table 4. Reson 8101 Sonar Settings***

| 8101 Parameter | Value |
|---|---|
| Range: | Variable, depth dependent |
| Gain: | Variable, depth and bottom type dependent |
| Power: | Variable, depth and bottom type dependent |
| Spreading | 28 dB |
| Absorption: | 50 dB/km |
| Ping Rate | 18 p/s |
| Pulse Width: | 113 µs |

### A8.f Bottom Sampling

A total of 110 bottom sediment grab samples were obtained within all 3 survey sheets. Four of the samples were located within a charted anchorage (H11623) and were collected at a 1200-meter grid spacing. The remaining samples were collected across a 2000-meter grid. Samples were obtained with a Ponar grab sampler, which collects a sample size up to 8.2 liters with a typical 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 IHO S-57 requirements for Seabed Area (SBDARE) features with attribution of COLOUR, Nature of Surface Qualifying terms (NATQUA), and Nature of Surface (NATSUR).

## A9. Quality Assurance

A field processing office was stationed in Gulf Shores, Alabama in order to facilitate rapid review of survey data and meet the weekly reporting requirements of the debris mapping program. The field office was outfitted with a high capacity server, multiple processing workstations with a full suite of hydrographic processing and GIS software including Triton Isis and DelphMap, Caris Hydrographic Information Processing System (HIPS), HYPACK, and ESRI Arcmap. The day following acquisition a DEA hydrographer performed a second review of the SSS imagery, logging additional contacts if any were detected. A completed list of both online and post-survey review contacts was then compiled. The re-evaluation of imagery for contacts by the data processor resulted in two reviews of the side scan imagery before contacts were submitted via the weekly contact lists.

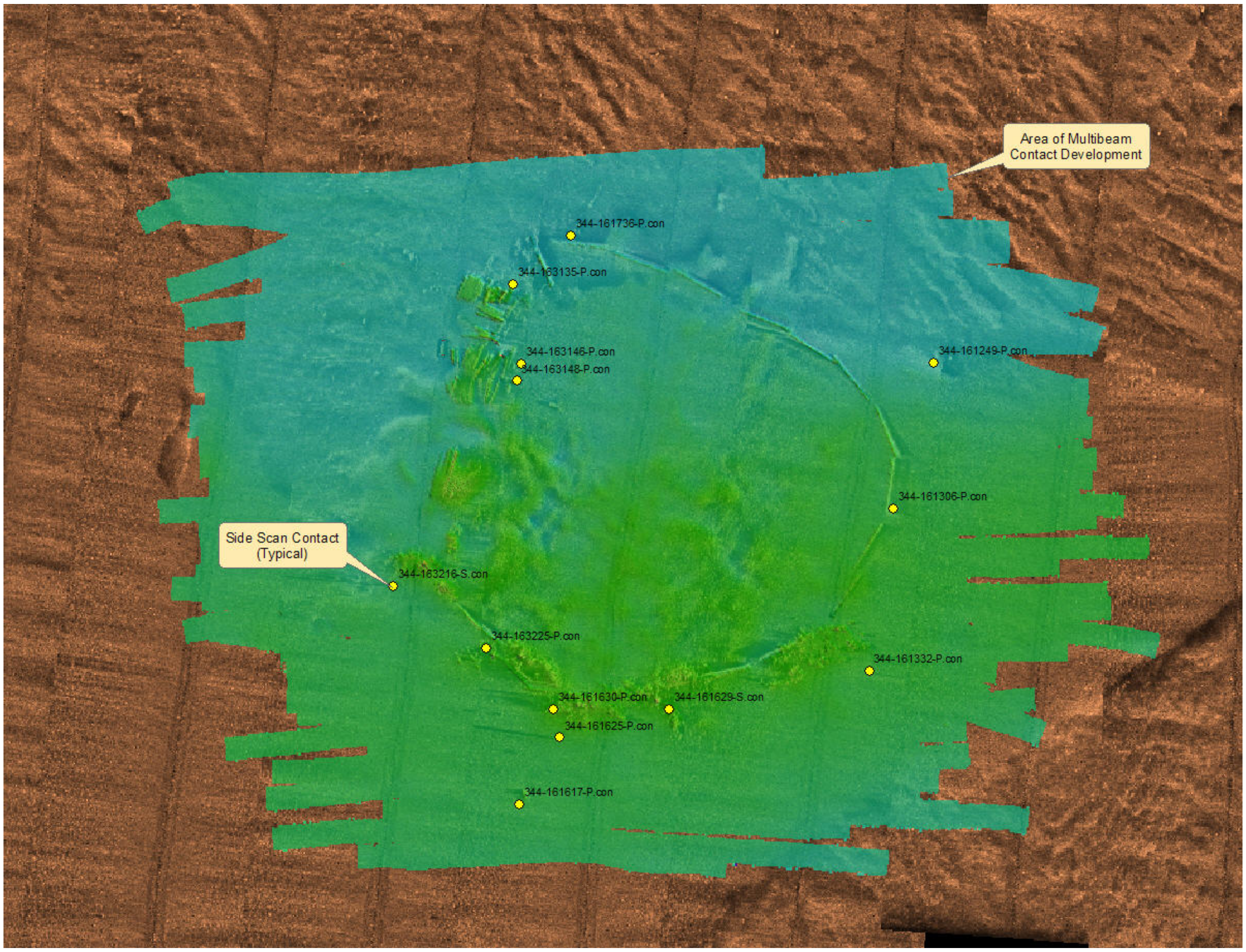


**Figure 6.** Graphic of side scan mosaic overlaid with contacts and multibeam swath coverage

During item investigations the multibeam data were reviewed in the field processing office after acquisition in order to ensure optimal system performance and that a valid least depth was found for each item.

## 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 format. Adjustments to towfish 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. Typical windows for monitoring raw sensor information included a waterfall display for the sonar imagery, graphs of vessel motions, and a sonar signal voltage display. Data were displayed on a 30-inch LCD flat panel monitor mounted vertically at the acquisition station.

The large format display allowed for increased time to analyze contacts prior to the display scrolling from view. Contacts were selected in real time and during post processing.

### B1.b Single Beam

Odom MKIII Single beam echosounder data were acquired throughout side scan sonar operations. All single beam data were recorded in HYPACK in "RAW" format. A digital echogram and sonar signal voltage were displayed in HYPACK and recorded in the HYPACK .BIN format. Due to a software design flaw in HYPACK's recording of the .BIN file (file associated with the sonar echogram) the range of the sonar was not changed while on line because the resultant change would not be recorded in the echogram. This did not adversely affect operations as the water depths across the survey area were fairly uniform and could be confined within a depth threshold. In addition, while ODOM outputs at 1600 samples over a given range and HYPACK Survey logs data at full resolution; the data are down-sampled by about one-third of the resolution over a given range in HYPACK's single beam data processing software SB MAX. To capture the highest resolution echogram possible during survey acquisition the chart width was set to the minimum value of five meters.

A draft correction of 0.5 meters was entered into the ODOM MKIII echosounder and applied to the data during acquisition.

### B1.c *ASV*

Survey operations were monitored via radio link by a hydrographer responsible for tending the *ASV*. The Hydrographer monitored the incoming data and also observed the oncoming path of the *ASV* by means of a forward looking video camera. Under normal operation the *ASV* autonomously followed pre-planned HYPACK line files, but the hydrographer was able to take manual control of the *ASV* at any time in order to avoid hazards or to break operations.

*ASV* single beam acquisition mirrored that of the *R/V Taku* with ODOM CV-100 data displayed and logged in HYPACK. Sonar, navigation, and attitude data were logged in HYPACK RAW format and the digital echogram was logged in .BIN format.

### B1.d Multibeam

Multibeam echosounder data were only collected in order to develop side scan contacts deemed navigationally significant. Multibeam coverage was limited to the fifty most significant contacts per survey sheet. 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 (June 2006)* 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. Position confidence checks, leadline to single beam comparisons, single beam bar checks, and leadline to multibeam comparisons were conducted weekly to confirm required accuracy was being maintained. Weekly checks of the sound speed instrumentation were conducted by deploying both profilers in tandem. Sound speed profiles were computed for each sensor and compared to confirm instrumentation was functioning within survey tolerances.

Contacts were classified as significant if their height was greater than one meter in deeper areas, greater than 0.5 meters in shallow navigationally significant areas, or were observer to be baring features. When possible towfish altitude was maintained at 8 to 20 percent of the range, but in many cases this standard could not be met due to the extremely shallow waters within the survey area. To aid the hydrographer a table listing slant range and towfish altitude for one meter contacts at 50 meter range scale was posted at the acquisition station.

In order to manage the high volume of side scan sonar contacts DEA created a custom database that would meet the debris project's weekly reporting requirements as well as meet the contract tracking requirements of the NOS *Hydrographic Surveys Specifications and Deliverables (2006)*. The database was maintained and stored in Microsoft Access using the Microsoft Access Database File (.MDB) format. Contacts were added into the database on a daily basis with the import of contacts occurring 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. The database had an export feature which created weekly reports in the Federal Emergency Management Agency (FEMA) format which were uploaded to the GOMMDP SharePoint each Monday.

Flow diagrams of the single beam, shallow water multibeam, and side scan sonar data acquisition and processing pipelines are presented in Figures 7, 8 and 9 respectively. These diagrams graphically illustrate the data pipeline and processing workflow from acquisition to deliverable production.

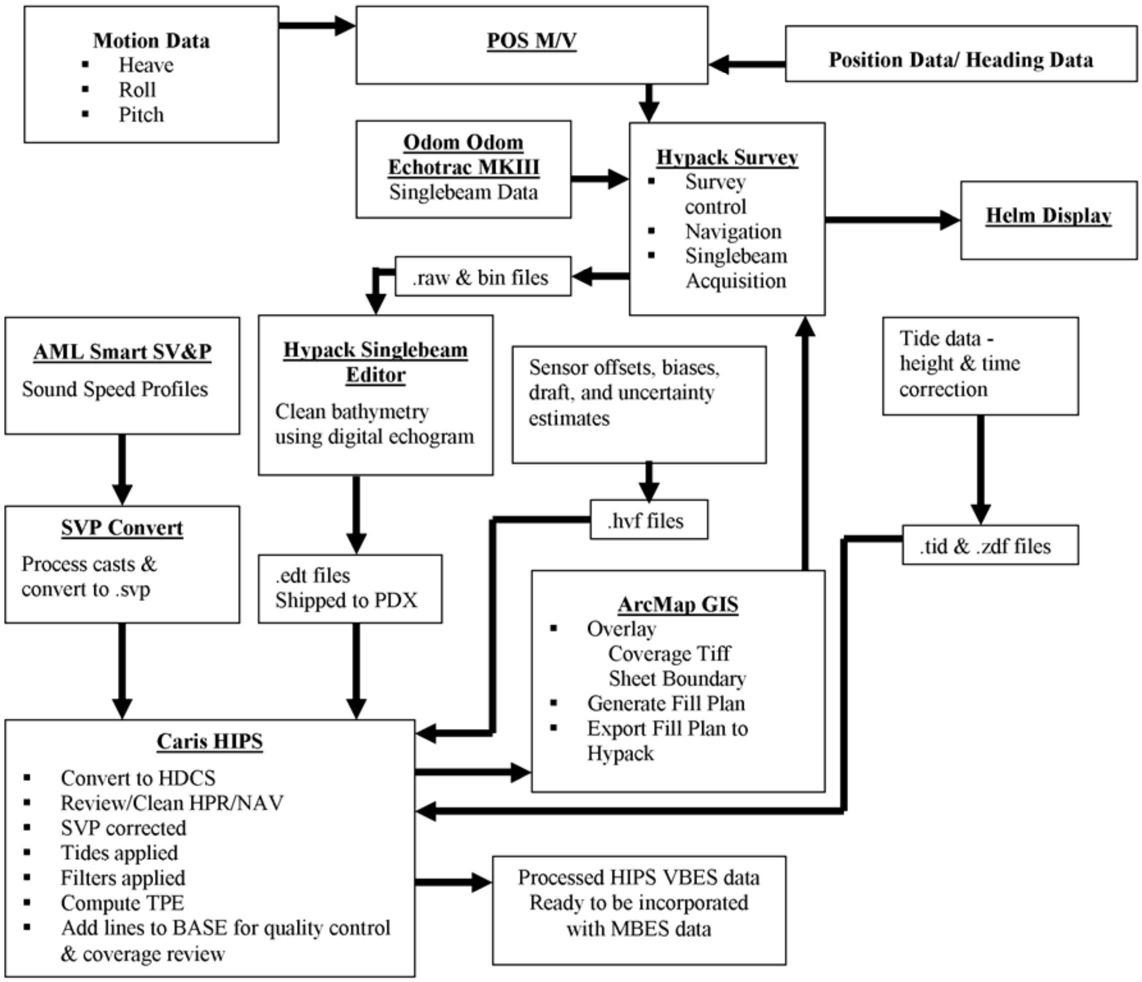


**Figure 7.** Flowchart of single beam data acquisition and processing pipeline

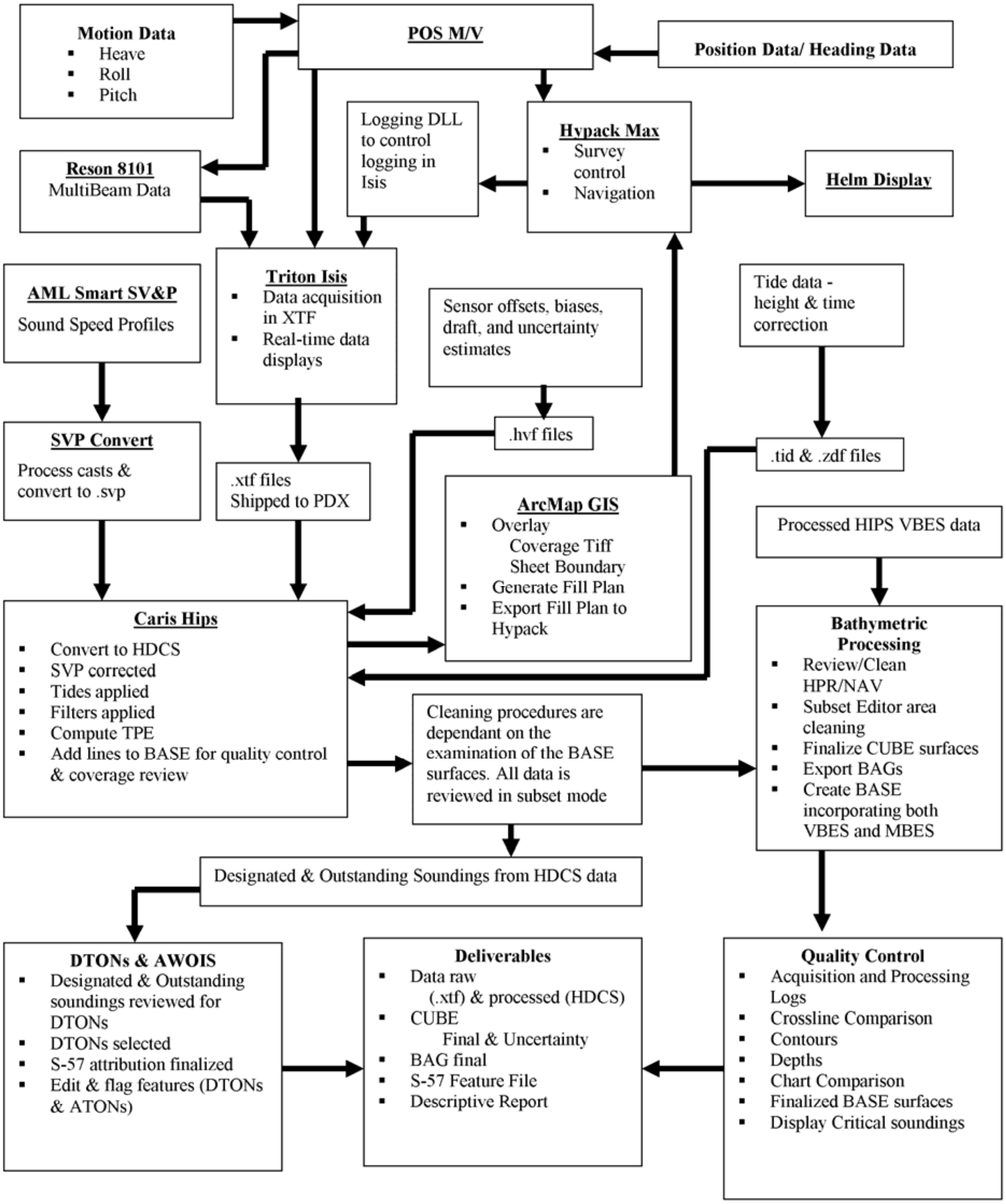


**Figure 8.** Flowchart of multibeam data acquisition and processing pipeline

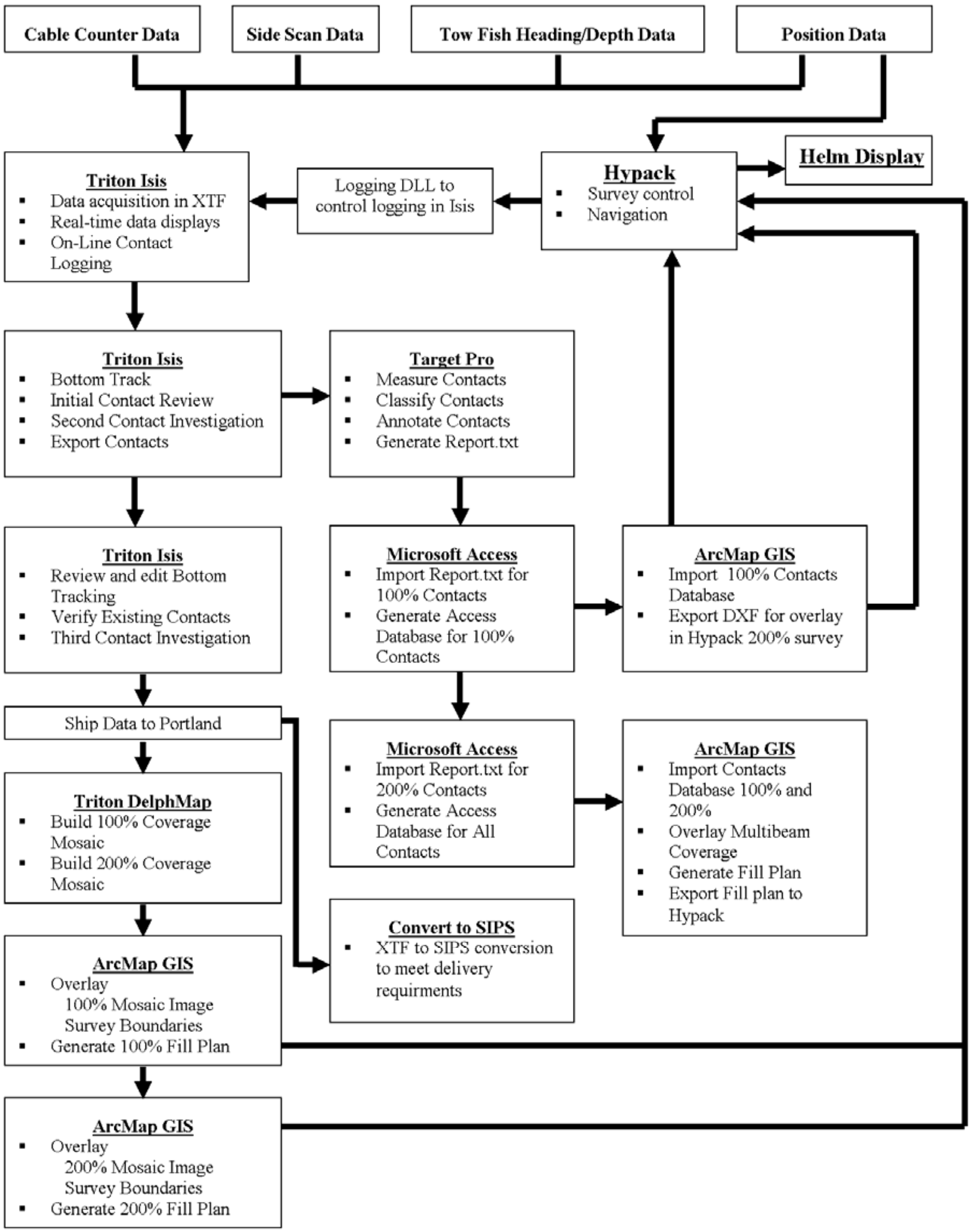


**Figure 9.** Flowchart of side scan sonar data acquisition and processing pipeline

At the end of each survey day that day's worth of data was copied from the boat to an external hard-drive. The hard drive was removed from the boat and taken to the field processing office where the data was copied to the server and prepared for processing. Approximately every four days a high capacity hard drive containing raw and processed data was sent to David Evans and Associates, Inc. office in Portland, Oregon. As a safeguard DEA maintained at least three complete copies of the dataset during field operations.

### B2.a HIPS Conversion

Multibeam data were converted from XTF format to CARIS Hydrographic Data Cleaning System (HDCS) format using HIPS conversion wizard (XTF converter 6.1.0.0) with the sensor navigation and ship gyro datagrams selected at conversion. 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 meeting delivery requirements. 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.

Single beam data from the *R/V Taku* and *ASV* were processed in HYPACK single beam editor and saved in .EDT format. The processed .EDT files were converted (Hypack converter 6.1.0.0) into HIPS format for secondary processing.

### B2.b Vessel Files

Three HVF's were created for each vessel configuration used during the survey, as listed in Table 5. 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 5. HIPS Vessel Files***

| HIPS Vessel File | Survey Vessel | Echosounder Used |
|---|---|---|
| NOAA0007_VBES_Taku.hvf | *R/V Taku* | ODOM Echotrak MKIII |
| NOAA0007_VBES_*ASV*.hvf | *ASV* | ODOM CV-100 |
| NOAA0007_MBES_Taku.hvf | *R/V Taku* | Reson 8101 |

Sensor offset values were calculated from the vessel surveys.

Draft (water line) was measured twice daily, averaged and entered into the HVF as a correction for the applied waterline value.

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. Manufacturers' published values were entered into the sensor accuracy fields. Other values were either calculated or estimated. All other error estimates are read from the HVF and Device Model file. Table 6 represents HVF TPE values for each vessel.

## *Table 6. Hydrographic Vessel File TPE Values*

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

**All values given as 1 sigma**

| VESSEL | TAKU | VESSEL | ASV |
|---|---|---|---|
| Motion Sensor | POS/MV | Motion Sensor | TSS DMS05 |
| POSITION SYSTEM | POS/MV Model 320 V4 | POSITION SYSTEM | Trimble DSM132 |
| **Gyro/Heading** | | **Gyro/Heading** | |
| Gyro (deg) | 0.02 | Gyro (deg) | 1 |
| **Heave** | | **Heave** | |
| Heave% Amp | 5 | Heave% Amp | 5 |
| Heave (m) | 0.05 | Heave (m) | 0.05 |
| **Roll and Pitch** | | **Roll and Pitch** | |
| Roll (deg) | 0.02 | Roll (deg) | 0.04 |
| Pitch (deg) | 0.02 | Pitch (deg) | 0.04 |
| **GPS Sensor** | | **GPS Sensor** | |
| Pos. Navigation (m) | 0.7 | Pos. Navigation (m) | 0.7 |
| **Latency** | | **Latency** | |
| Timing Trans (s) | 0.01 | Timing Trans (s) | 0.01 |
| Nav Timing (s) | 0.01 | Nav Timing (s) | 0.01 |
| Gyro Timing (s) | 0.01 | Gyro Timing (s) | 0.01 |
| Heave Timing (s) | 0.01 | Heave Timing (s) | 0.01 |
| Pitch Timing (s) | 0.01 | Pitch Timing (s) | 0.01 |
| Roll Timing (s) | 0.01 | Roll Timing (s) | 0.01 |
| **Measurement** | | **Measurement** | |
| Offset X (m) | 0.003 | Offset X (m) | 0.05 |
| Offset Y (m) | 0.003 | Offset Y (m) | 0.05 |
| Offset Z (m) | 0.003 | Offset Z (m) | 0.05 |
| **Speed** | | **Speed** | |
| Vessel Speed (m/s) | 0.03 | Vessel Speed (m/s) | 0.03 |
| **Draft and Loading** | | **Draft and Loading** | |
| Loading | 0.03 | Loading | 0 |
| Draft (m) | 0.05 | Draft (m) | 0.05 |
| DeltaDraft (m) | 0.01 | DeltaDraft (m) | 0.01 |

### Physical Alignment / Physical Alignment Errors

**All values given as 1 sigma**

| VESSEL | TAKU | VESSEL | TAKU |
|---|---|---|---|
| POSITION SYSTEM | POS/MV Model 320 V3 | POSITION SYSTEM | POS/MV Model 320 V3 |
| **Alignment** | | **Alignment** | |
| MRU alignStdev gyro | 0 | MRU alignStdev gyro | 0 |
| MRU align roll/pitch | 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 | 0.01 |
| Tided Value Zoning | 0.1 |
| **Sound Speed Values** | |
| Sound Speed Measur | 0.5 |
| Surface Sound Speed | 0.25 |

### B2.c Static Draft

The static draft marks were surveyed as part of the vessel's frame of reference on the starboard side of the vessel directly abeam of the single beam and multibeam transducers. Draft readings were observed twice per day and the average draft was used for the day.

### B2.d Sound Velocity

The individual sound velocity profiles were concatenated into CARIS format files, each representing one day of data collection. They were analyzed for errors or issues caused by sensor aeration then applied to the data set using the "nearest in distance within two hours" option. In addition, each sound speed profile was graphed in Excel and compared to all the casts taken that day. This was done to determine the amount of variation in sound speed in the water column at one area and across the survey area to aid in survey planning.

## B3. Preliminary Side Scan Processing

Side scan imagery was corrected for layback, slant range and speed as well as re-bottom tracked in ISIS. 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 MDB 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.

Once imported into the contact database least depths of the significant contacts were estimated using the tide corrected single beam depth collected at the time of contact acquisition and the contact height. Preliminary tides were used to reduce single beam depths and compute estimated clearance by subtracting contact height based on side scan image shadow analysis. The estimated clearance values were input into the "Estimated Clearance" field of the contract database and reported in the weekly GOMMDP submissions.

## B4. Preliminary Bathymetric Processing

Single beam data were reviewed in HYPACK and erroneous depths were rejected. During HYPACK editing the bottom trace was overlaid on the digital echogram and used to evaluate data, pick new depths and reject fliers. Single beam data were saved in HYPACK EDT format then converted to CARIS format, where sound velocity profiles and tides were applied.

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 total propagated error 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. Merge vessel offsets
5. Compute TPE
   - Tide Value Measured 0.01
   - Tided Value Zoning 0.1
   - Sound Speed Measured 0.25
   - Surface Sound Speed 0.5
6. Filters applied based on the following criteria:
   - Reject soundings with poor quality flags (0 for Reson)
   - Reject TPE greater than the horizontal and vertical error limits specified in the NOS *Hydrographic Surveys Specifications and Deliverables (June 2006)*.
   - Reject based on depth threshold (if needed)
7. Add data to field sheet
   - Two-meter "Uncertainty" weighted surface for single beam
   - 50-centimeter "CUBE" weighted surface for multibeam developments

Verified zoned tides were applied to the data prior to depth editing or surface creation. NOAA provided water level reducers and zoning for tide gauge Dauphin Island (873-5180). The final water level and zoning files are included with the HIPS deliverables on the "Processing" external data drive. Water levels were graphed in Excel or CARIS and reviewed for outliers or data gaps. Any observed problems with the tide file were reported to NOAA and resolved prior to final processing.

All bathymetric data were reviewed in HIPS subset mode. Subset tiles were used to track the progress of processing activities. In addition, data processors reviewed data sounding data and CUBE surfaces for 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.

In areas of multibeam and single beam overlap, data were reviewed together in HIPS subset mode to ensure that data visually fit together and no systematic biases or artifacts were induced into the data.

### B5. Final Side Scan Processing

Final review and editing of the side scan data were 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 percent and 200 percent side scan mosaics at 50 cm resolution. During mosaic creation in Delphmap each 100 percent coverage was broken into several sections to facilitate reprocessing a mosaic if necessary 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 percent coverage was created for submittal.

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

### B6. Final Bathymetric Processing

Upon the completion of editing multibeam data in HIPS a finalized CUBE grid of the item investigations was generated using the “greater of the two” option for the final uncertainty value. An uncertainty weighted grid was generated for the single beam data due to the sparse nature of single beam data. Depths and contours were generated from the surfaces and used for chart comparison purposes, but are not included with the deliverables. Bathymetric Attributed Grids (BAGs) for each CUBE surface were exported from HIPS for submittal.

Designated soundings and detached positions 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. In addition, S-57 objects were created for all uncharted baring features such as piles and oyster stakes. Many, if not all, items included in the S-57 feature file have already been submitted as Dangers to Navigation. In some cases an obstruction that is depicted in the S-57 feature files was not reported as a Danger to Navigation 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

### C1.a *R/V Taku*

With the vessel out of the water, markings were surveyed and painted on the hull of the *R/V Taku* providing a means to monitor vessel draft (Figure 8). At the start of the project the approximate draft of the Single beam transducer was 0.50 meters. This value was entered in to Odom Echotrak III echosounder and used throughout the survey enabling the output of a depth relative to the approximate vessel waterline therefore enabling quick review of depths at time of acquisition and to remove a tedious processing step in HYPACK. Static draft readings 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 vessel's fuel and ballast levels were maintained to control the vessel draft and an average of the start and end of day draft values was calculated daily and entered into a draft tracking sheet. 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 the daily draft relative the 0.50 meter value that was used during acquisition. These differences relative to the assumed 0.50 meter Single beam draft were entered into the waterline field in the Caris HVF *(NOAA0007_VBES_Taku.hvf)*.

### C1.b *ASV*

A direct measurement of the Single beam transducer draft relative to the waterline mark was taken with the *ASV* out of the water and entered in to the Odom CV-100. This value did not change during survey operations.

## C2. Dynamic Draft

### C2.a *R/V Taku*

A settlement and squat test using Real-time Kinematic (RTK) GPS observations for the *R/V Taku* was performed in the vicinity of the survey area on November 12 and 13, 2006 (Day Numbers 316 and 317). Data from these measurements are displayed graphically in Figure 10 and are included in Appendix V of the Descriptive Report for each survey.

The settlement and squat values were obtained by computing three-minute GPS height averages at different ship speeds, measured in knots and revolutions per minute (RPM) during transects. Each transect was run twice at each RMP interval with the second transect run at a heading, opposite of the first.

After a series of 700 RPM transects were run, ship speeds at increments of 200 RPMs were observed from 1000 to 2200 RPM with GPS height recorded at 1 Hz. With the vessel at rest, static RTK 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 minutes resulting in one average GPS height measurement per transect. Dynamic draft correctors were then calculated from 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. The average speed for each RPM interval and the average dynamic draft corrector were entered into the HIPS vessel file. A slight decrease in squat was noticed at approximately 5.5 knots during both the full and half-tank tests. The cause of this change is not known. TPE values for dynamic draft were calculated by taking the average of the standard deviation for all dynamic draft calculations per transect.

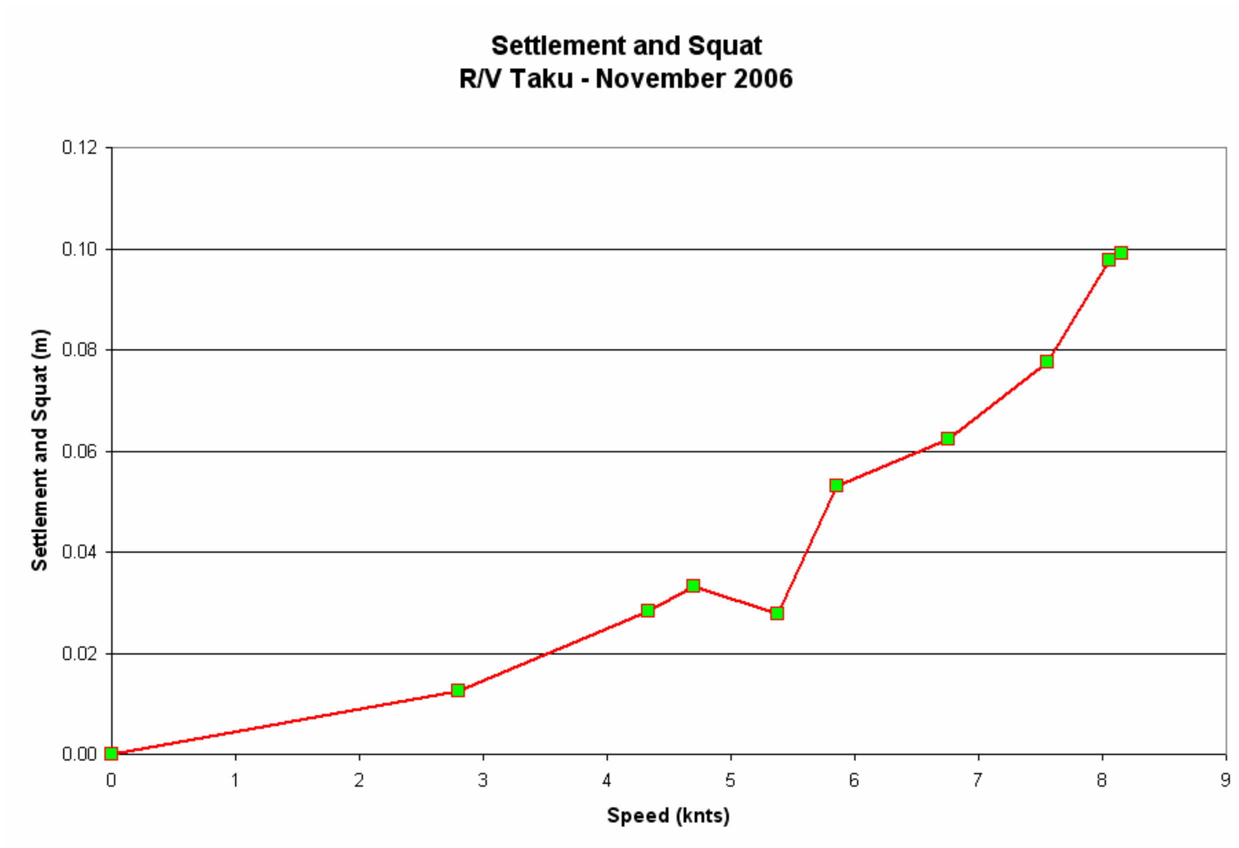


**Figure 10.** Settlement and squat of *R/V Taku*

## C2.b *ASV*

A squat test was performed for the *ASV* on January 1, 2007. Squat measurements were made by driving the *ASV* at varying speeds through a laser beam which illuminated a measuring scale attached to the *ASV*. Data from these measurements are displayed graphically in Figure 11. The measurements were taken visually and recorded at the time of the reading. Measurements were observed for speeds ranging from 0.0 to 5.2 knots. Static measurements were recorded at the beginning, end, and at 15-minute intervals during the tests.

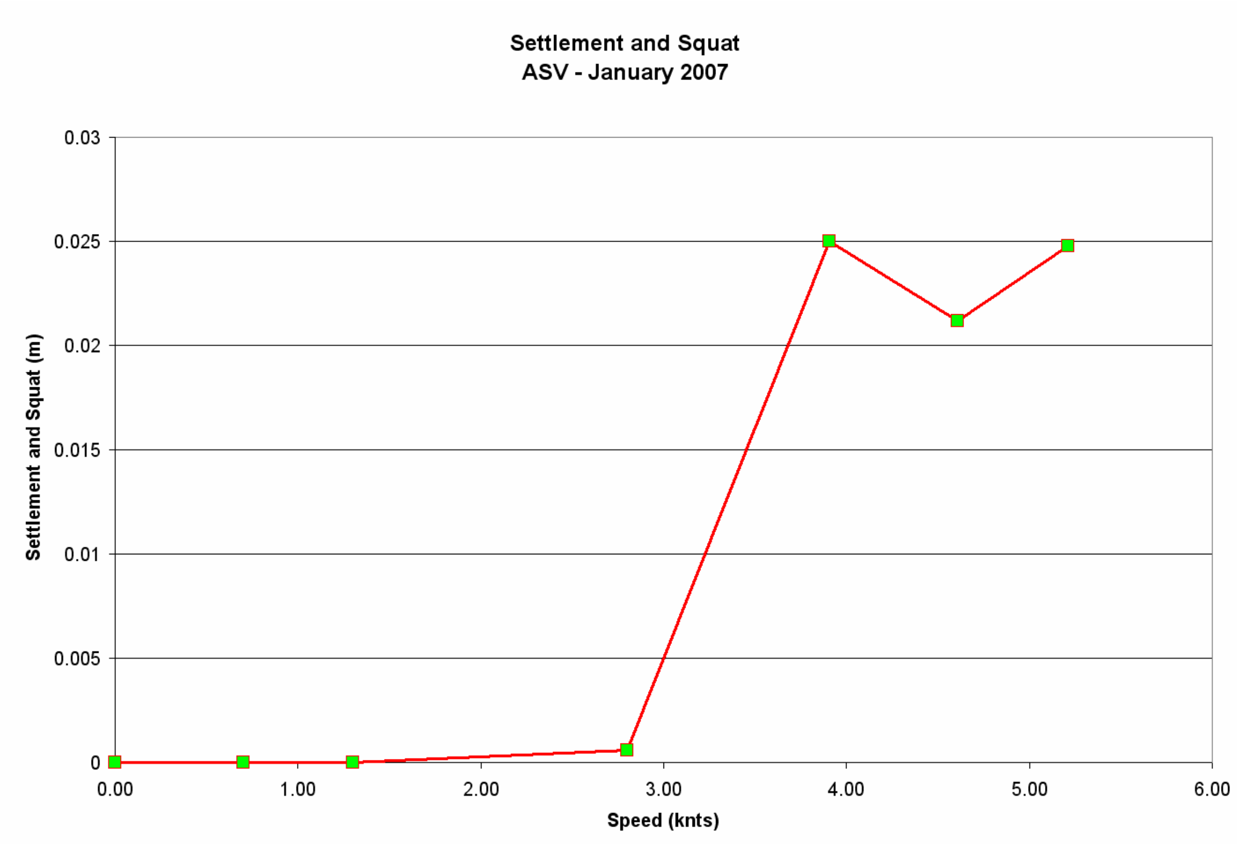


**Figure 11.** Settlement and squat of the *ASV*

## C3. Lead Line Comparisons and Bar Checks

Weekly lead line checks or bar checks were performed for each sonar if they were used to acquire data anytime within a particular week. Tabulated lead line comparisons may be found in the Lead Line Comparison log included in Appendix V of the Descriptive Reports.

A lead line check was used to validate the *R/V Taku's* single beam echosounder performance. While the vessel was alongside its berth in the marina, a lead line reading was taken and compared to the depth output by the echosounder after adjusting it for the draft offset. Lead line observations were recorded in a lead line comparison log. The standard deviation between the lead line and single beam measurements was 0.021 meters with a maximum weekly difference of 0.045 meters.

In addition, lead line checks were performed during the two weeks of multibeam investigations. An XTF file was logged as the lead line depth was read. The file was then loaded into HIPS and a depth was picked from the nadir beams. Lead line observations were recorded in the lead line comparison log. The average difference between lead line and multibeam was -0.010 meters.

A bar check was used to verify optimal performance of the *ASV*'s single beam system including validating the draft offset. During the check a weighted aluminum bar was suspended under the sonar with a chain at a known distance. Echosounder depths were compared to the fixed distance between the bar and the water surface and logged in a tracking sheet.

### C4. Heave, Roll and Pitch Corrections

An Applanix POS/MV 320 v4 integrated DGPS and inertial reference system was used for the motion sensor aboard the *R/V Taku*. The POS/MV 320 is a six-degree of freedom motion unit, with a stated accuracy of 0.05-meter or 5 percent for heave, 0.02 degrees 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 degrees, 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 HIPS HVF and used for TPE computations. A schematic of the vessel and sensor set-up is shown in Figures 12 and 13.

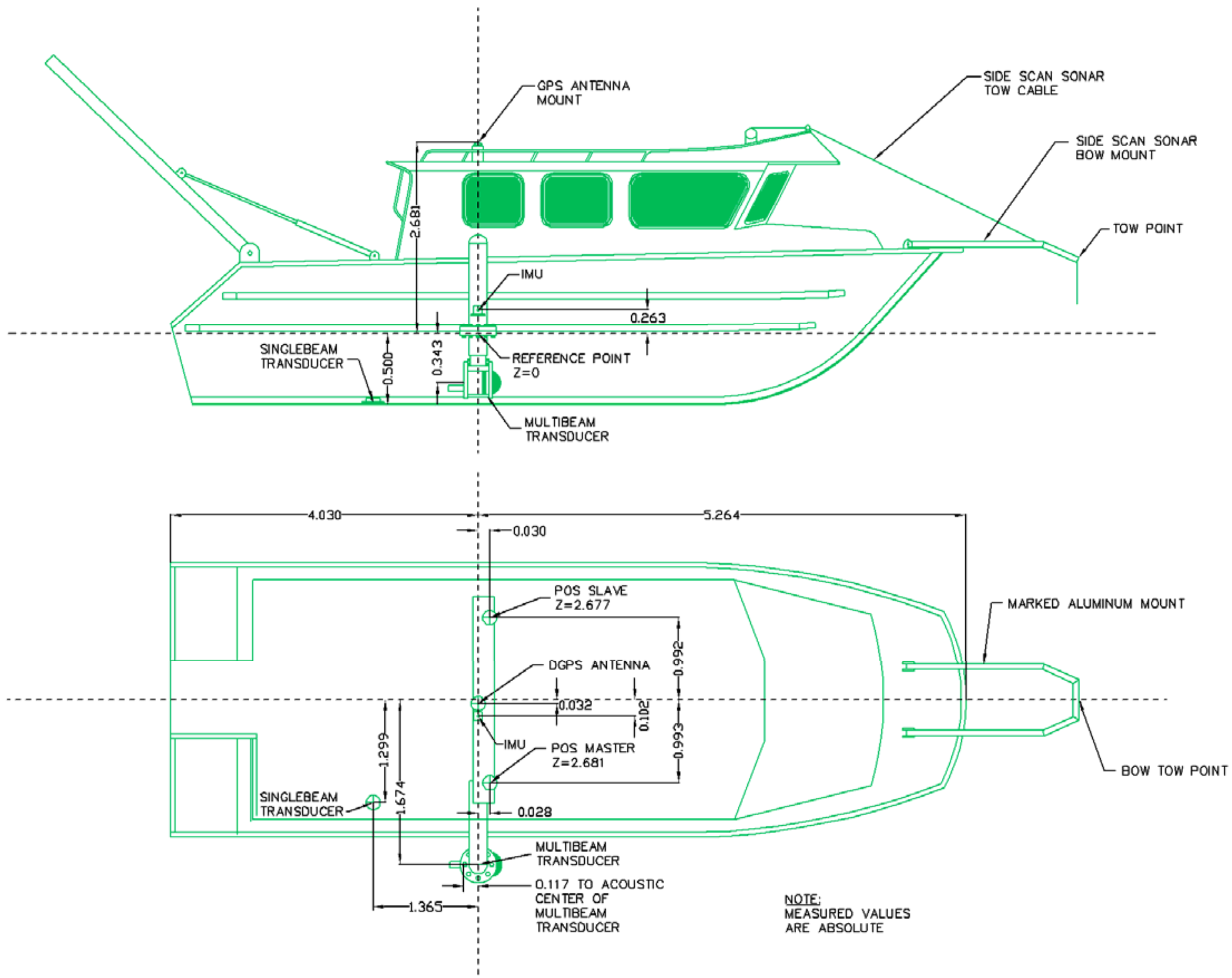


**Figure 12.** Schematic of *R/V Taku* and sensor setup

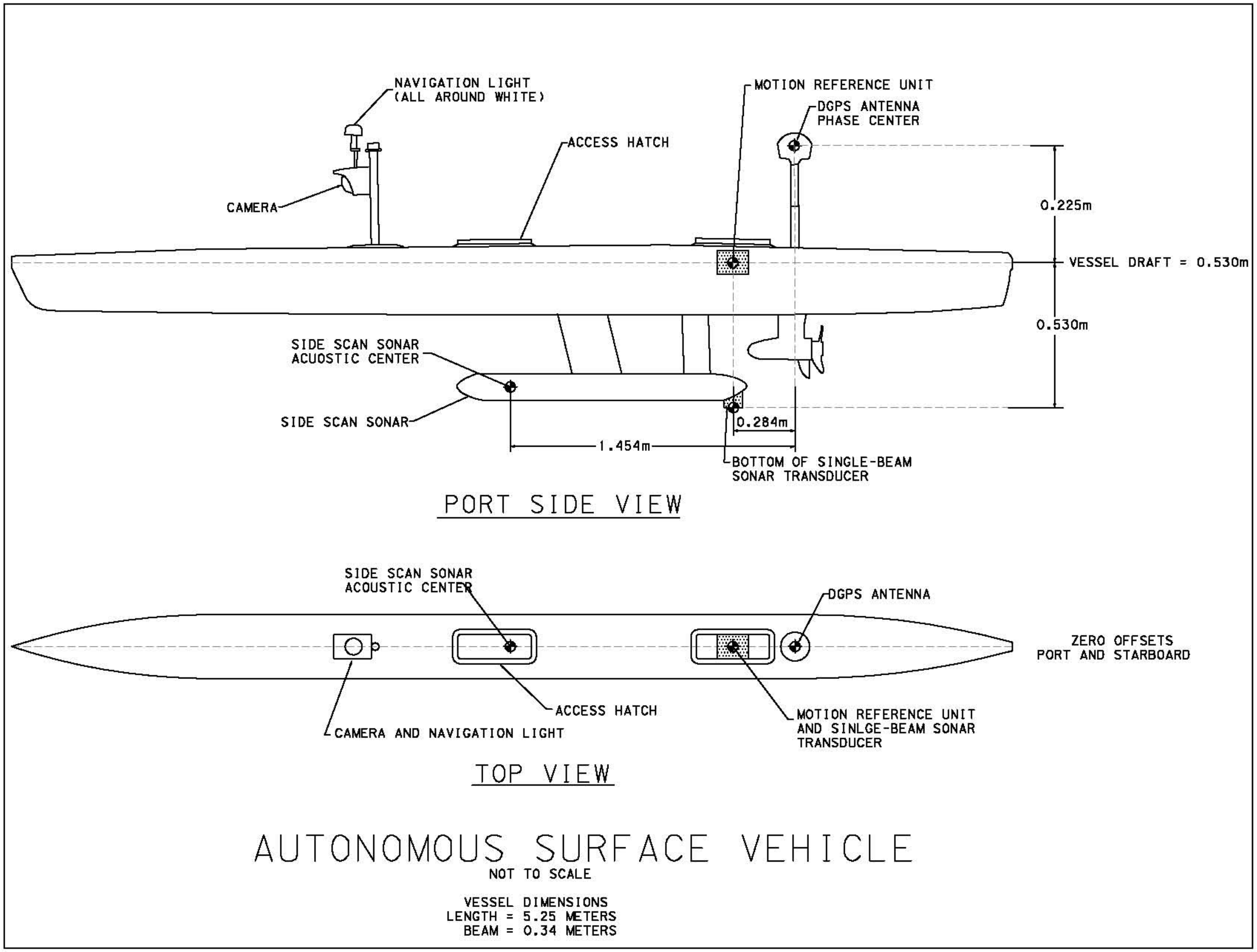


**Figure 13.** Schematic of the *ASV* and sensor setup

Installation bias was applied to all the data and stored in a Caris HIPS vessel file specific to bathymetry type. System offsets and biases for relative to single beam acquisition were stored in the Caris "NOAA0007_VBES_Taku.hvf" vessel file. Offsets and biases for the multibeam acquisition system, including the results obtained from the patch test at the start of the survey, were stored in the Caris "NOAA0007_MBES_Taku.hvf" vessel configuration file.

The Caris vessel configuration file "NOAA0007_VBES_*ASV*.hvf" stored sensor offset and bias information relative to the *ASV* and was used during HIPS processing of *ASV* data.

## C5. Patch Tests

A patch test was conducted prior to performing multibeam item investigations to measure alignment offsets between the *R/V Taku's* IMU sensor and multibeam transducer, and to verify delay times applied to the time-tagged sensor data. 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. The patch test was conducted over a stretch of the Intracoastal Waterway (ICW) within Bon Secour Bay in accordance with NOAA standards on April 13 and 15, 2007 (Day Numbers 103 and 105).

A precise timing latency test was performed by running reciprocal lines 700 meters long over a flat bottom, in a water depth of 17 meters. Sea conditions were slightly rough during the test in order to amplify the effects of latency and make the error conspicuous during data review. The lines were then opened in the HIPS calibration editor (after applying tide and Sound Velocity Profile (SVP) corrections) and a slice of along track 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 750 meters in length over the slope crated by the ICW channel. Yaw was determined by running parallel lines over the same area. All lines were run at approximately 6 knots.

Selected pairs of lines were then analyzed in the 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. The second set was used to confirm the results of the data. Bias correction values are displayed in Table 7.

***Table 7. Biases applied when using the POS/MV for pitch and roll.***

| Alignment | Bias |
|---|---|
| Roll | -0.30° |
| Pitch | 0.70° |
| Yaw | 0.50° |
| Latency | 0.00s |

## C6. Tide and Water Level Corrections

Verified zoned tides from Dauphin Island, AL (873-5180) were applied to all survey data. Water levels relative to the Mean Lower Low Water (MLLW) datum and UTC time system were downloaded from the Center for Operational Oceanographic Products and Services (CO-OPS) website. Tides zones used were created by CO-OPS and evaluated by DEA to ensure that the time and range correctors agreed with the survey data.

Dauphin Island Hydro, AL (873-5181) was originally assigned as the primary tide gauge for this project. During review of this data, DEA staff found a datum shift error that impacted the quality and usability of water levels from the gauge. CO-OPS and Hydrographics Survey Division (HSD) were made aware of the issue and CO-OPS determined that data from 873-5181 were not suitable for the project and transferred project control to Dauphin Island, AL (873-5180).

Zoned water levels were applied to the bathymetric data in Caris HIPS. The HIPS tide file (8735180.tid) and zone definition file (J977KR2007DEA_CORP.zdf) are included on the data drive with the other Caris deliverables.

The Dauphin Island Hydro, AL (873-5181) experienced no down time during periods of hydrographic survey.

## C7. Sound Velocity Correction

Manual sound velocity casts were taken periodically throughout each survey day. A cast was typically taken onsite prior to starting acquisition and then approximately every two hours during the survey.

A sound velocity cast was taken by lowering the AML SV&P sensor to the bottom while the vessel was holding station. A HYPACK target was taken to record the time and position of the cast which would later be entered into the HIPS sound velocity file. The sampling period was increased if large changes in sound speed were observed between casts. During concurrent single beam and side scan acquisition casts were taken more frequently if refraction artifacts were visible in the side scan sonar record. During multibeam item investigations, casts were taken in the vicinity of each investigation. At least one deep cast (extending to 95 *percent* of depth) was taken per day.

After each cast the sound speed data was reviewed for outliers or anomalies such as a sharp thermocline or halocline which could impact data quality. In addition to these periodic comparisons, weekly check casts were taken to verify proper performance of the AML sensor. For this check a SeaCat SBE 19+ was simultaneously deployed with the AML sensor. 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 Reports for this project.

The sound speed correction was applied to each line using the nearest in distance within time (2 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

**LETTER OF APPROVAL**

S-J977-KR-DEA
Data Acquisition and Processing Report

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of S-J977-KR-DEA 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 Statement of Work.

Digitally signed by Jon Dasler
DN: CN = Jon Dasler, C = US, O = David Evans and Associates, Inc.
Date: 2007.12.28 13:49:48 -08'00'

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

Digitally signed by Jason Creech
DN: CN = Jason Creech, C = US, O = David Evans and Associates, Inc.
Date: 2007.12.28 13:51:29 -08'00'

Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
April 2007

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