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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

Data Acquisition and Processing Report

Type of Survey *Shallow Water Multibeam Hydrographic and Side Scan Sonar Survey*
Field No. *OPR-H328-OS-08*

Locality

State *Florida*
General Locality *Atlantic Ocean*

2009

CHIEF OF PARTY

George G. Reynolds

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Date……………………………………………….

HYDROGRAPHIC TITLE SHEET

HYDROGRAPHIC TITLE SHEET	REGISTRY NOS. <u>*H11896*</u> <u>*H11897*</u> <u>*H11898*</u>
	FIELD NO. <u>*OPR-H328-OS-08*</u>

State *Florida*

General Locality *Atlantic Ocean*

Locality *East of Port Everglades, East of Miami Beach, East of Key Biscayne*

Scale *N/A* Date of Survey *February 12, 2009 - July 6, 2009*

Instructions Dated *May 7, 2008* Project No. *OPR-H328-OS-08*

Vessel *R.V. Able II - Registration Number CT4788BB*

Chief of Party *George G. Reynolds*

Surveyed By *John G. Wetmur, Robert M. Wallace, John L. Bean*

Soundings taken by (*Echo Sounder*) *Reson Seabat 8101*

Graphic Record Scaled by *N/A*

Graphic Record Checked by *N/A*

Protracted by *N/A* Automated Plot by *Angela M. Rizzo*

Verification by *Michael J. Engels*

Soundings in *Meters (MLLW)*

REMARKS: *All Times Recorded in UTC*

Data Recorded and Presented relative to UTM Zone 17 North

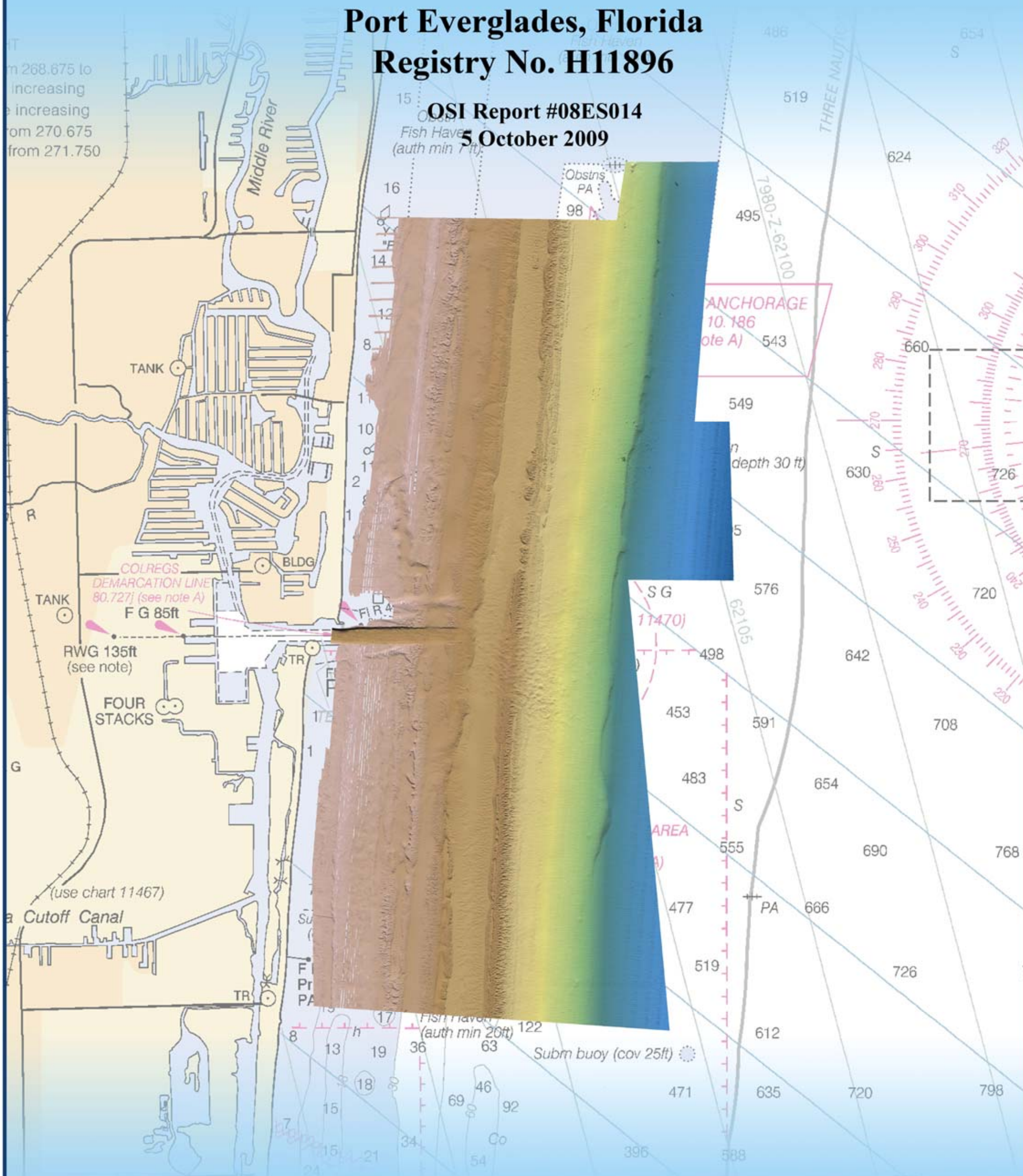
Original SOW modified by Oct 28, 2008 e-mail from COTR Mark Lathrop. (Refer to Appendix IV of the Descriptive Report.)

Contractor: *Ocean Surveys, Inc.*
91 Sheffield St.
Old Saybrook, CT. 06475

OPR-H328-OS-08

Port Everglades, Florida
Registry No. H11896

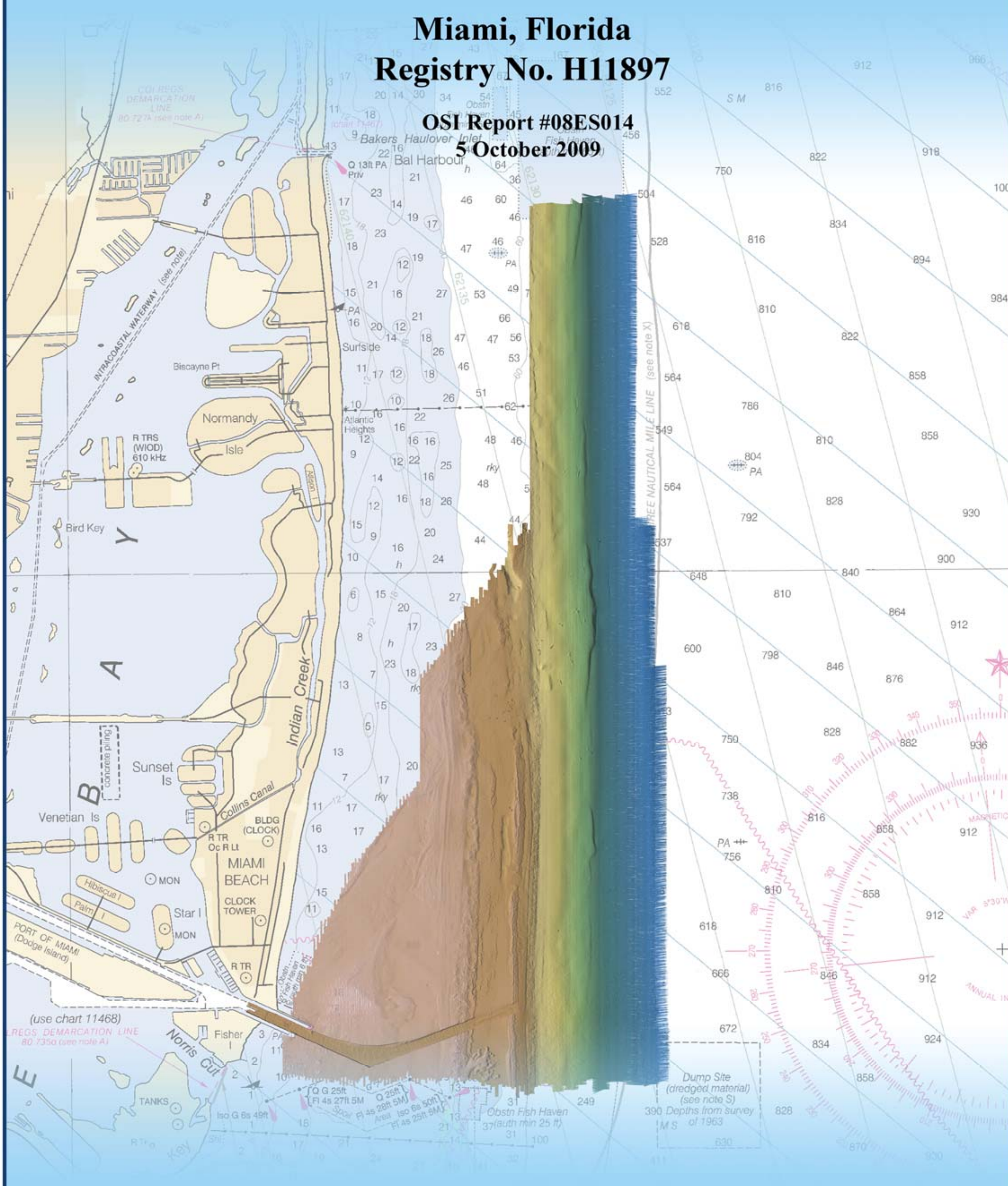
OSI Report #08ES014
5 October 2009



OPR-H328-OS-08

Miami, Florida
Registry No. H11897

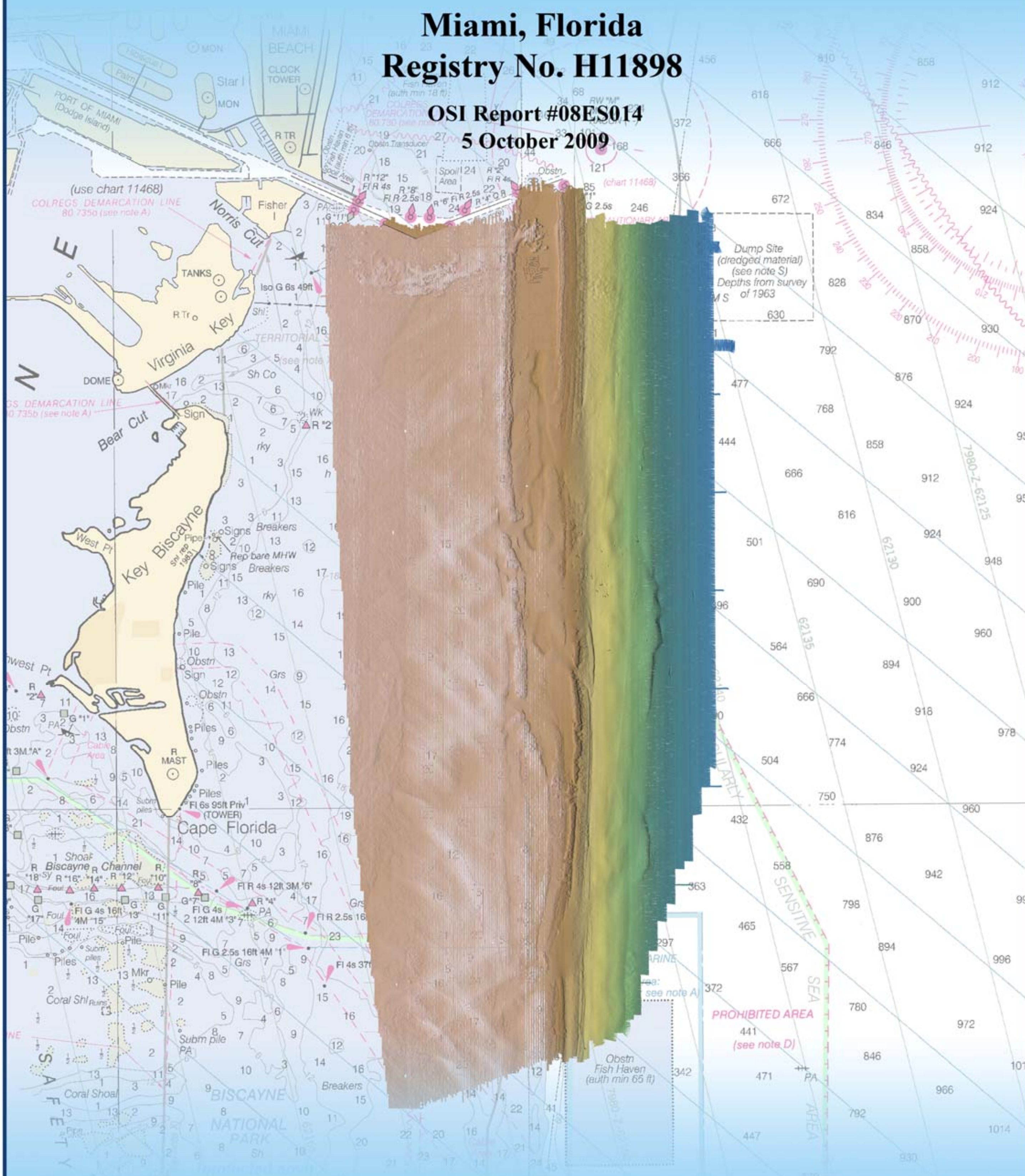
OSI Report #08ES014
5 October 2009



OPR-H328-OS-08

Miami, Florida
Registry No. H11898

OSI Report #08ES014
5 October 2009



THE INFORMATION PRESENTED IN THIS REPORT AND THE ACCOMPANYING BASE SURFACE REPRESENTS THE RESULTS OF SURVEYS PERFORMED BY OCEAN SURVEYS, INC. DURING THE PERIOD OF 12 FEBRUARY 2009 TO 6 JULY 2009 AND CAN ONLY BE CONSIDERED AS INDICATING THE CONDITIONS EXISTING AT THAT TIME. REUSE OF THIS INFORMATION BY CLIENT OR OTHERS BEYOND THE SPECIFIC SCOPE OF WORK FOR WHICH IT WAS ACQUIRED SHALL BE AT THE SOLE RISK OF THE USER AND WITHOUT LIABILITY TO OSI.

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A. EQUIPMENT

A.1 Survey Vessel

All survey operations were conducted from OSI's R/V "Able II" (Figure 1). R/V Able II, Connecticut Registration Number CT 4788 BB, is a 7.6-meter fiberglass vessel, with a 2.9-meter beam and 0.8-meter draft. The vessel is powered by twin 150 HP outboard engines.

Figure 1. R/V Able II in multibeam/SSS configuration.

The R/V Able II was modified to include the following hardware to support hydrographic survey systems and survey operations:

1. Port-side davit and capstan utilized for CTD casts and bottom sample collection.
2. Measured and indexed Inertial Motion Unit (IMU) mounting plate.
3. Starboard-side multibeam transducer pole mount. The pole is fabricated from thick-walled stainless steel pipe and attached to the hull and cabin with a rigid 2-position mount that enables transducer depth adjustment. The mounting system employs precision machined index pins and alignment holes to allow repeatable, accurate alignment for multiple draft settings. Draft remained constant during Surveys H11896, H11897 and H11898.
4. Electric multi-purpose cable winch with level wind and slip ring.

5. Stern A-frame with hydraulic system to extend side scan sonar tackle aft of the engines.
6. AC generator with uninterruptible power supply (UPS).
7. Reference points were established on the vessel to define a fixed reference frame, vessel reference point (RP), draft measurement locations, and sensor mounting locations. These points were “surveyed” using a precision total station optical theodolite and electronic distance meter. Survey offsets and estimated measurement accuracies were incorporated into the CARIS vessel configuration file. Refer to Section C.1 Vessel Configuration and Offsets for additional details

A.2 Acquisition Hardware

Major data acquisition system components employed on this survey are summarized in Table 1 below. A brief description of the equipment follows.

Table 1
Acquisition Hardware

System	Data	Manufacturer	Model/ Version No.	Firmware Ver.	Serial No.
Multibeam Echo Sounder	Soundings	Reson	8101	8101-1.08-C215	3707078
Side Scan Sonar	Imagery/Contacts	Klein	3000	11.2	575
Sound Speed Profiler	Sound Speed	Sea-Bird	SeaCAT SBE 19+ CTD	V.2	6107
Sound Speed Profiler	Sound Speed	Sea-Bird	SeaCAT SBE 19 CTD	3.1	1801
Sound Speed Profiler	Sound Speed	Sea-Bird	SeaCAT SBE 19 CTD	3.1	2864
Sound Speed Sensor (Real-Time Surface Water Sound Speed)	Sound Speed	Sea-Bird	MicroCAT SBE37	2.2	36SI5137-6372
Primary Navigation DGPS	Position	Applanix/ Trimble	POS MV 320 V.4	HW 2.5-6 SW 03.42	2149
Secondary Navigation DGPS (Position Integrity Alarm)	Position	Trimble	MS750	1.58	220209817
Motion Compensation	Pitch, Roll, Heave	Applanix/ Trimble	POS MV 320 V.4	HW 2.5-6 SW 03.42	2149
Heading Compensation	Heading	Applanix/ Trimble	POS MV 320 V.4	HW 2.5-6 SW 03.42	2149
U.S.C.G. Differential Beacon Receivers (2)	GPS correctors	Trimble	Probeacon	3	0220033958 0220181939
Bar Check	Soundings	OSI	Lead Disk	N/A	1
SSS Cable Payout Indicator	SSS Fish Position	Hydrographic Consultants	SCC16”	2	1603
Survey GPS	Position	Trimble	5700	V3.01	220332818
Ponar Grab Sampler	Bottom Samples			NA	NA

A.2.1 Multibeam Echo Sounder Reson - SeaBat 8101

The SeaBat 8101 is a 240 kHz Multibeam Echo Sounder (MBES) System, which measures the relative water depths across a wide swath perpendicular to a vessel's track. The 8101 system illuminates a swath on the seafloor that is 150º across track by 1.5º along track. The swath consists of 101 individual 1.5º by 1.5º beams with a bottom detection range resolution of 1.25 cm. The installed system was equipped with the Extended Range projector (Option 040) and designed to comply with International Hydrographic Organization (IHO) standards to measure the seafloor to a maximum depth of 450 meters.

Digital data were output through the Ethernet data port and displayed in real time on a high-resolution color monitor. Power and gain settings were monitored and adjusted to optimize bottom detection for the inner 130 degrees of swath coverage. Range settings were monitored and adjusted for observed depths to maintain maximum ping rates for the outer beam ranges. In deeper water, the power, gain and range settings were adjusted to acquire maximum bottom detection and ping rates for the useable center of the swath.

The installed 8101 system was equipped with Backscatter/side scan Upgrade, Option 033. HYPACK HYSWEEP format Snippets and MBES side scan data were acquired during survey operations. SWMB backscatter data were not processed for this project, but are submitted for future application.

UTC date and time information output from the POS MV was used for accurate time stamping of bathymetry and side scan output data. The Reson 81P processor received a serial $UTC NMEA format timing string from the POS MV.

Transducer offsets and mounting angles, relative to the vessel frame and a vessel reference position (RP), were measured using standard optical survey equipment and techniques. Residual alignment and calibration offsets were documented in the patch test results. Refer to Section C.1 Vessel Configuration and Offsets for additional details.

A.2.2 Vessel Navigation Systems

A.2.2.1 Primary Positioning: Applanix POS MV

An Applanix POS MV 320 V.4 system was installed on the survey vessel to provide position and attitude data. The POS MV (Position and Orientation System for Marine Vessels) consists of a rack mountable POS Computer System (PCS), a separate Inertial Measurement Unit (IMU) and two GPS receivers.

The POS MV combines the IMU and GPS sensor data into an integrated, blended, navigation solution. There are two navigation algorithms incorporated into the system, namely tightly coupled and loosely coupled inertial/GPS integration. Tightly coupled inertial/GPS integration involves the processing of GPS pseudorange, phase and Doppler observables. In this case, the GPS receiver is strictly a sensor of the GPS observables and the navigation functions in the GPS receiver are not used. With loosely coupled inertial/GPS integration, the GPS position and velocity solution are processed to aid the inertial navigator.

The POS MV was operated using United States Coast Guard differential beacon corrections (DGPS) and provided position accuracy of 0.5-5 meters. The real-time position accuracy alarm was set at 2 meters and monitored during data acquisition using the MV-POSView controller software.

IMU and antenna offsets and mounting angles, relative to the vessel frame and a vessel reference position (RP), were measured with precise optical survey methods. The primary GPS antenna position, with respect to the IMU and RP, was determined using the MV POSView controller calibration procedure. Residual alignment and calibration were derived during the patch test procedure. Refer to Section C.1 Vessel Configuration and Offsets for additional details.

A.2.2.2 Secondary Positioning: Trimble MS750

A secondary or "position integrity alarm" GPS system consisted of a Trimble MS750 GPS operating in DGPS mode. The secondary system position was compared to the primary position system and monitored continuously in HYPACK during survey operations.

A.2.2.3 Differential GPS Correction: Trimble Pro Beacon DGPS Receivers

Trimble Pro Beacon DGPS beacon receivers were manually tuned to local USCG differential beacon stations and interfaced to each of the aforementioned GPS systems. Refer to the Horizontal and Vertical Control Report for additional details of DGPS position correctors.

A.2.2.4 Precise Positioning: Trimble 5700 GPS System

Prior to and during the course of the survey the accuracy of the primary positioning system was verified by means of a physical measurement to a project horizontal control point established at the vessel's berth. A Trimble 5700 GPS system was configured with a Trimble Zephyr Geodetic antenna installed over the project horizontal control point to conduct a static position observation. GPS data files were submitted to the National Geodetic Survey (NGS) On-line Positioning User Service (OPUS) and processed to determine a position of the horizontal control point. Each data file that was submitted was processed with respect to 3 CORS sites. NGS provided an OPUS Report which included both ITRF and NAD83 coordinates along with position accuracy information.

Daily position confidence checks were made by comparing the distance of the vessel reference point to the horizontal control point computed by the navigation system versus the distance of the vessel reference point to the horizontal control point measured with a steel tape. Details of the horizontal control points along with the OPUS report are included with the Horizontal and Vertical Control Report. A tabulation of navigation system performance checks is included with the Survey Descriptive Report (DR) Separate 1.

A.2.2.5 Applanix POSPac MMS Post-Processing Data

POSPac data were acquired and logged during survey operations. POSPac MMS is a post-processing software module, which significantly increases the efficiency, accuracy, and robustness of mapping and surveying using GPS data. Using POSPac MMS in post processing, reliable decimeter level or better accuracy can be obtained from existing reference station networks without having a dedicated station located close to the project area.

POSPac data were post processed and evaluated for quality assurance and development purposes. These data were not used for final sounding positions. Processed POSPac navigation data were implemented to confirm Coast Guard DGPS navigation solutions and to corroborate system offsets.

A.2.3 Attitude and Heading Measurement - Applanix POS MV

The POS MV generates attitude data in three axes (roll, pitch and heading) within 0.02 degree accuracy. Heave measurements supplied by the POS MV maintain an accuracy of 5-centimeters or 5% of the measured vertical displacement for movements that have a period of up to 20 seconds. The heave bandwidth filter was configured with a dampening coefficient of 0.707. The cutoff period of the high pass filter was determined by estimating the swell period encountered during the survey. A heave bandwidth filter of 10 seconds was employed during Surveys H11896, H11897, and H11898.

Applanix “TrueHeave” data were acquired and recorded during survey operations. The TrueHeave algorithm uses a delayed filtering technique to increase heave measurement accuracy, reducing error caused by IMU drift and long-period ocean swell. The TrueHeave data corrections were applied to soundings during post processing in CARIS HIPS.

The GPS Azimuth Measurement Subsystem (GAMS) allows the POS MV system to achieve high- accuracy heading measurement. The GAMS subsystem uses two GPS receivers and antennas to determine a GPS-based heading that is accurate to 0.02° or better (using a two-meter antenna baseline) when blended with the inertial navigation solution. POS MV uses this heading information as aiding data together with the position, velocity and raw observations information supplied by the primary GPS receiver. GAMS operation was employed for all survey data acquisition and GAMS status was monitored continuously during survey operations using the MV-POSView controller software.

IMU and antenna offsets and mounting angles, relative to the vessel frame and a vessel reference position (RP), were measured with a precise survey. An Applanix-specified GAMS calibration procedure was conducted prior to survey data acquisition.

A.2.4 Side Scan Sonar System - Klein 3000

Side scan sonar imagery was acquired employing a Klein 3000 dual-frequency sonar operating at 100 and 500 kHz. The system consists of a Transceiver Processor Unit (TPU), coaxial double armored steel tow cable, electric winch, digital cable payout meter, and sonar tow fish. System components are interfaced to the computer software acquisition system via a local network hub and cable connections.

The tow fish was equipped with an optional pressure sensor which was used to measure tow fish depth. The pressure sensor was reset frequently at the surface to account for changes in atmospheric pressure. The pressure sensor data were interfaced and converted to depth with Chesapeake Technologies, Inc. Sonar Wiz side scan sonar data acquisition system. Depth data and length of cable deployed were used for layback calculations to determine an accurate tow fish position relative to the vessel primary navigation.

The SSS hardware was interfaced with the navigation system using Chesapeake Technologies, Inc. “Sonar Wiz” side scan sonar data acquisition system. The waterfall display within the Klein “Sonar Pro” side scan sonar data acquisition system was employed in display mode only. Refer to Section A.3 Computer Hardware and Software for additional details of side scan sonar data processing.

A.2.5 Sound Speed Determination

A.2.5.1 Water Column profiles – Primary SBE 19+ SEACAT Profiler CTD

Water column conductivity, temperature and pressure (depth) profiles were acquired using a Sea-Bird Electronics SBE 19+ SEACAT Profiler CTD. The SBE 19+ unit was configured to sample at 4 Hz, providing an accurate, high-resolution profile of the water column. Water sound speed profiles were calculated from raw CTD data using NOAA NOS Coast Survey Development Laboratory (CSDL) Velocwin software. All sound speed corrections were applied in post processing with CARIS HIPS software. Refer to section A.3 Computer Hardware and Software for additional details of sound speed data processing.

A.2.5.2 Water Column Profiles – Secondary SBE 19 SEACAT Profiler CTD

Weekly sound velocity quality assurance (DQA) checks were performed using NOAA CSDL Velocwin software by comparing the primary SBE 19+ SEACAT Profiler CTD sound speed profile to a secondary SBE 19 Profiler CTD sound speed profile. A tabulation of sound speed casts and record of DQA results are included with the DR Separate II.

Profiler CTD units were calibrated in accordance with the Hydrographic Surveys Specifications and Deliverables, April 2007 (HSSD 2007). Copies of the calibration certificates are included with the DR in Separate II.

A.2.5.3 Surface Sound Speed - SBE37

The Sea-Bird Electronics SBE 37 is a high-accuracy conductivity and temperature sensor capable of calculating and transmitting sound speed via a standard RS232 serial data interface. The SBE 37 transmitted real-time surface sound speed data to the Reson 8101 multibeam system and the HYPACK acquisition computer.

The SBE37 was installed behind the multibeam transducer at the draft of the phase center. Real-time surface sound speed values were transmitted to the Reson 81P topside unit and subsequently recorded with multibeam echo sounder data in the raw HYPACK .HSX data files. Sound speed data were also transmitted to the HYPACK acquisition software which was configured to display a visual alarm if the surface sound speed exceeded a threshold of +/- 2 m/s. Variations in surface sound speed were monitored and evaluated as an indicator of surface water temperature fluctuation and potential water column variation which would necessitate additional sound-speed profile measurements.

Daily sound velocity quality assurance (DQA) checks were performed using NOAA CSDL Velocwin software by comparing the SBE37 surface sound speed to the surface sound speed of the first CTD sound speed profile. A tabulation of daily DQA results is included in DR Separate II.

Surface sound speed data were used by the Reson 8101 system for range determination. However, all sound speed corrections used to calculate depths from raw data were performed during post processing in CARIS HIPS using the full water column sound speed profile data.

The SBE37 was calibrated prior to survey data acquisition. A copy of the calibration certificate is included with the DR in Separate II.

A.2.6 Bar Check/Lead Line

Multibeam echo sounder accuracy checks were performed by means of a “bar check” or lead line measurement comparison. A bar check/lead line was constructed of a 20 pound, 12-inch round lead disk attached to stranded stainless steel wire with permanent index markers installed at measured 5-meter intervals. The bar check procedure consists of lowering the disk (acoustic target) to the deepest practical depth directly below the multibeam transducer and recording the echo sounder depth. The acoustic target is then raised to successively shallower index markers and depth values at those depths are recorded. The lead line comparison procedure consisted of sounding the seafloor directly below the multibeam transducer with the lead line (lead disk) while simultaneously observing the digital nadir multibeam depth.

Prior to survey data acquisition, the bar check was measured with a steel survey tape to verify index mark accuracy.

A.2.7 SSS Cable Out Indicator

Determination of SSS layback was accomplished by means of a Hydrographic Consultant, Ltd. SCC Smart Sensor Cable Payout Indicator. The payout indicator consists of a topside display/controller, deck cable, and 16” diameter block fitted with a magnetically triggered counting sensor.

The cable out indicator was calibrated according to manufacturer specifications before data acquisition by measuring the sheave circumference and entering a calibration value into the topside controller software. Cable out readings were verified daily at the beginning of survey operations, and at regular intervals, by observing measured index marks on the tow fish cable with respect to a reference position on the winch.

The cable out indicator was interfaced with Chesapeake Technologies, Inc. Sonar Wiz side scan sonar data acquisition system. The length of cable deployed, along with tow fish pressure sensor information were used to determine an accurate tow fish position relative to the vessel reference point. Refer to Section A.3 Computer Hardware and Software for additional details of side scan sonar data processing.

A.2.8 Bottom Sampler

A Ponar Type Grab sampler was employed to obtain seafloor sediment samples within the survey area. This modified Van Veen type self-tripping sampler features center hinged jaws and a spring-loaded pin that releases when the sampler makes impact with the bottom. It is constructed of stainless steel with zinc-plated steel arms and weights. The sampler was deployed from the launch using a davit and PowerWinch system.

A.3 Computer Hardware and Software

Computer hardware and software utilized during this survey are itemized in Table 2 below.

Table 2
Computer Software

Manufacturer	Application	Platform	Version	Version Date
HYPACK	HYPACK SURVEY	WXP	8.0.1.2	Dec 23, 2008
HYPACK	HYSWEEP SURVEY	WXP	8.0.3.0	Dec 23, 2008
Chesapeake Technology, Inc.	SonarWiz Map	WXP	4.04.014	Dec 2, 2009
L3 Klein	Sonar Pro	WXP	11.2	Apr 24, 2007
L3 Klein	VX, Works	WXP	6.18	Feb 21, 2008
Universal Systems, Ltd.	CARIS HIPS/SIPS	WXP	6.1	June 1, 2008
Universal Systems, Ltd.	CARIS Notebook	WXP	3.0	June 5, 2008
Universal Systems, Ltd.	CARIS Easy View	WXP	1.0	2008
NOAA	NOAA Velocwin	WXP	8.92	May 8, 2008
Global Mapper Software LLC	Global Mapper	WXP	10	Aug 27, 2008
AutoDesk Inc.	AutoCAD	WXP	2004	Feb 14, 2003
Microsoft	Office (WORD, EXCEL)	WXP	2007	Oct 18, 2008
Sea-Bird Electronics	SeaTerm	WXP	1.59	Dec 22, 2008
Sea-Bird Electronics	SBE Data Processing	WXP	7.18b	2008
Applanix	MV POS View	WXP	4.0.2.0	Dec 1, 2008
Hydrographic Consultants	CALLOAD	WXP	2.0	Dec 18, 2005
Trimble	MS Controller	WXP	1.1.0.0	May 21, 2002
Trimble	Pro Beacon	DOS	5.0	March 5, 1991

A.3.1 HYPACK

A.3.1.1 Vessel Navigation

Survey vessel trackline control and position fixing were accomplished by using a computer-based data-logging and navigation software package (HYPACK). Vessel position data were output from the POS MV at 50 Hz frequency and transmitted to the navigation computer system, which processed these data in real-time into the desired mapping coordinate system (UTM Zone 17 North, NAD 83). Raw and processed position data were continuously logged onto the computer hard drive and displayed on a video monitor, enabling the vessel's helmsman to guide the survey vessel accurately along pre-selected tracklines. Tracklines and survey features were displayed on the helm monitor with geographic reference data that included NOAA raster nautical charts (RNC), vector shoreline data, and S-57 electronic nautical chart (ENC) data. Multibeam echo sounder data were monitored in real-time using

2-D and 3-D data display windows. Motion and predicted tide-corrected sounding data were displayed as HYPACK gridded depth models and coverage matrices. HYPACK was also used to “mark” the location and time of significant observations during data acquisition.

Raw, geographic position data (NAD83 degrees latitude and longitude) were time tagged with UTC time by the POS MV and recorded by HYPACK in .RAW format line files.

The HYPACK computer was also used for sensor monitoring and data quality review while data were acquired. Utilities in the acquisition module of HYPACK notify the operator with a visual alert in the event of a sensor malfunction or, in some cases, when a sensor parameter drifts out of operator-set limits (e.g. DGPS position comparison or sound speed change).

A.3.1.2 Multibeam Data Acquisition

A dedicated computer was used to record all multibeam sounding data as well as all associated vessel position, motion, and heading data. Multibeam data were logged with HYPACK HYSWEEP software using a Windows XP computer which has a 3.4 GHz Pentium IV processor, 300-gigabyte hard drive, and 2.0 gigabytes of RAM.

Multibeam echo sounder raw beam ranges, intensities, quality flags and backscatter data were time tagged with UTC time by the Reson 81P processor and recorded by HYPACK in HSX format line files.

Motion and attitude data (heave, pitch, roll, heading) were time tagged with UTC time by the POS MV and recorded by HYPACK in HSX format line files.

Snippet multibeam backscatter data were recorded separately by HYSWEEP SURVEY program and stored in binary HYPACK 81X format line files. Snippet data were not processed for this survey; however, they were collected and submitted for future applications.

Data were copied at the end of every survey day from the acquisition computer onto a removable hard drive and archived locally. Raw multibeam data and supporting data (acquisition logs, svp profiles) were transferred to Ocean Surveys’ home office via high-speed internet connection or courier delivery.

A second computer was employed on the survey vessel to monitor the MV POSView controller, record POSPac data, process water column sound speed data and maintain project and acquisition logs. This computer is a Windows XP machine which has a 1.7 GHz Pentium M processor, 56-gigabyte hard drive, 1.99 gigabytes of RAM. All onboard project computers were interfaced via an Ethernet connection.

A.3.1.3 Multibeam Data Processing

The HYPACK HYSWEEP SURVEY calibration module was used to determine preliminary alignment correctors from multibeam sonar calibration patch tests. All patch test values were verified in CARIS HIPS and entered into the vessel configuration file. Refer to Section C.3 Motion, Timing Errors and Sensor Alignment.

A.3.2 Chesapeake Technologies, Inc. (CTI) SonarWiz.Map

A.3.2.1 Side Scan Sonar Data Acquisition

A dedicated computer was used to record all side scan sonar data and display real-time side scan sonar (SSS) waterfall and mosaic imagery. Side scan sonar data were logged with SonarWiz.Map software using a Windows XP computer which has a 3.4 GHz Pentium IV processor, 300-gigabyte hard drive, and 2.0 gigabytes of RAM.

SonarWiz.Map was configured to display slant-range corrected, scrolling waterfall displays of both the 100 and 500 KHz frequency side scan sonar data. Scrolling imagery was monitored continuously for data quality and to identify significant features. Confidence checks observed across the full range (e.g. sand waves, cables, buoy blocks) were recorded frequently to verify system operation and object detection capabilities. Confidence checks were recorded with line names, observation times, and comments in the daily acquisition log.

A real-time side scan sonar mosaic was generated on a second monitor and used to identify gaps in coverage caused by deviations from planned tracklines.

SonarWiz.Map compiled side scan sonar data with vessel position, towfish position, layback and cable out values and recorded raw data in .XTF format line files.

Two hundred percent (200%) SSS coverage was attained in the survey area from the 18-foot contour out to about 65-100 feet of water employing line spacing and side scan sonar range scales tabulated in Table 3 below.

Table 3
SSS Line Spacing and Range Scales

Trackline Offset (meters)	SSS Range Scale (meters)
30	37.5
40	50
65	75

Vessel speed was maintained such that any $1m^3$ object would be ensonified more than three times per pass at the operating range scale. In general, the towfish height was maintained at 8-20 percent of the range scale. In very shallow water, it was not possible to maintain the towfish more than 2 meters above the bottom. The range scale of 37.5 meters was maintained, but additional lines of data were acquired at lesser line spacing for contact identification and side scan coverage.

Data were copied at the end of every survey day from the acquisition computer onto a removable hard drive and archived locally. Raw side scan sonar data and supporting data (acquisition logs) were transferred to Ocean Surveys' home office via high-speed internet connection or courier delivery.

A.3.2.2 Towfish Layback and Position Computation

SonarWiz.Map was configured to receive navigation from the POS MV, pressure sensor data from the towfish, and cable out from the topside cable counter controller. Towfish depth was calculated from the pressure sensor data. Towfish layback was calculated in SonarWiz.MAP from depth and cable out using Pythagorean Theorem and a percentage of cable out value to correct for the catenary effect. The towfish position was calculated assuming that the towfish was directly behind the vessel relative to the navigation track.

A.3.2.3 SonarWiz.Map Side Scan Sonar System Calibration

SSS system function and target positioning accuracy/capability were verified prior to commencing side scan sonar operations by surveying a regularly spaced array of 1-meter experimental reef structures which were deployed by researchers at Nova Southeastern University (Figure 2, per conversation with K. Robinson). The structures were surveyed with reciprocal and orthogonal track lines and multiple contacts were positioned from slant-range corrected imagery (Figure 3). Accurate positions of the structures were determined from multibeam sonar echo sounder data (Figure 4) and used to evaluate side scan sonar object detection as well as contact position accuracy and precision. In general, side scan sonar positions were within a 5-meter radius from the designated multibeam sounding. All objects were readily detected in the side scan sonar and multibeam echo sounder data. This calibration also demonstrates the object detection capabilities of the multibeam sonar system (Figures 5 and 6).

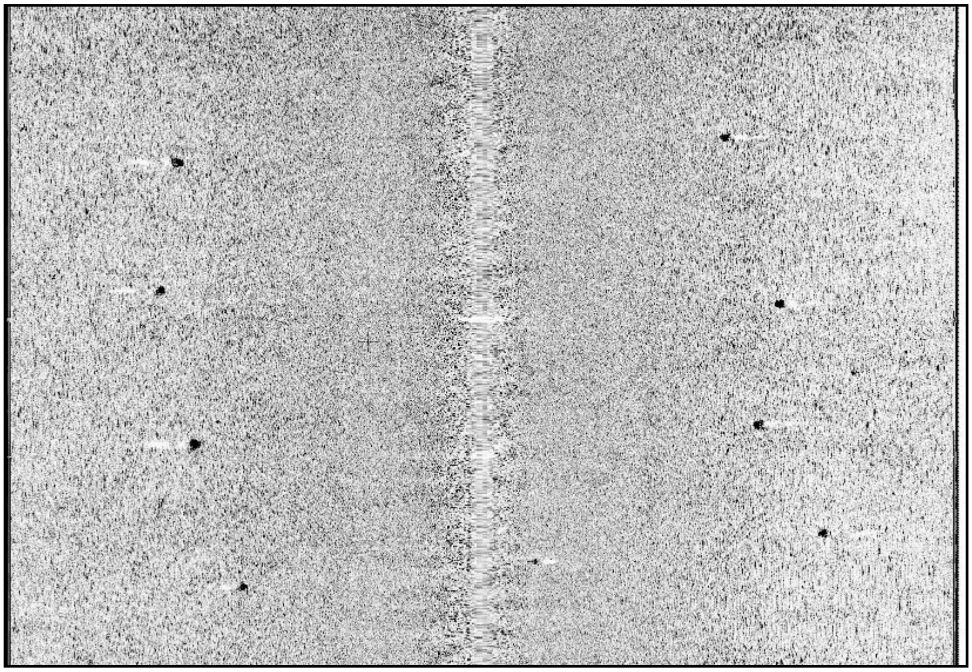

Figure 2. Side scan sonar image of 1-reef structures.

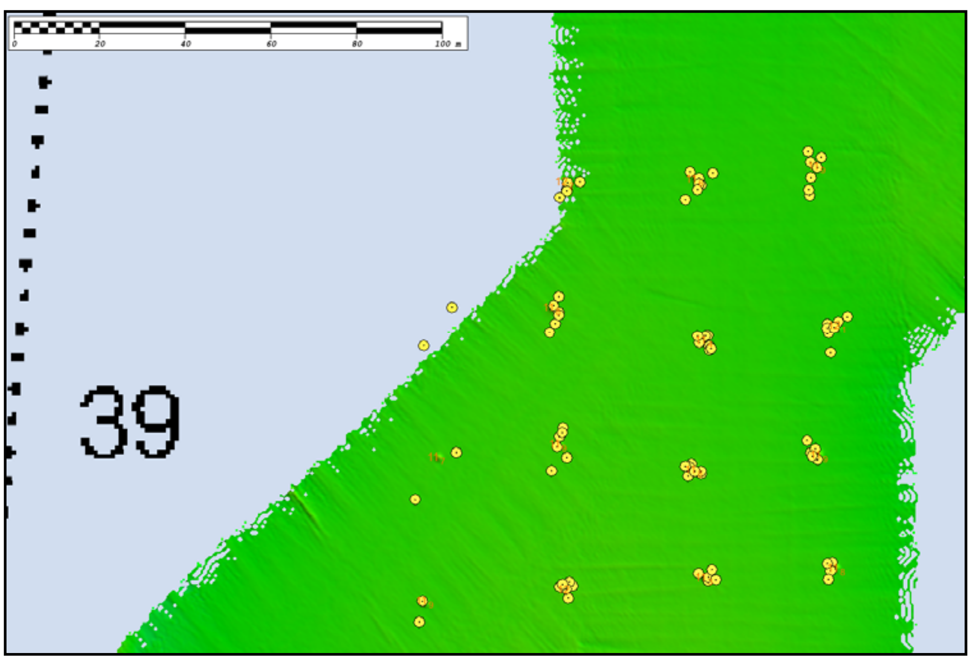

Figure 3. BASE surface of 1-meter reef structures.

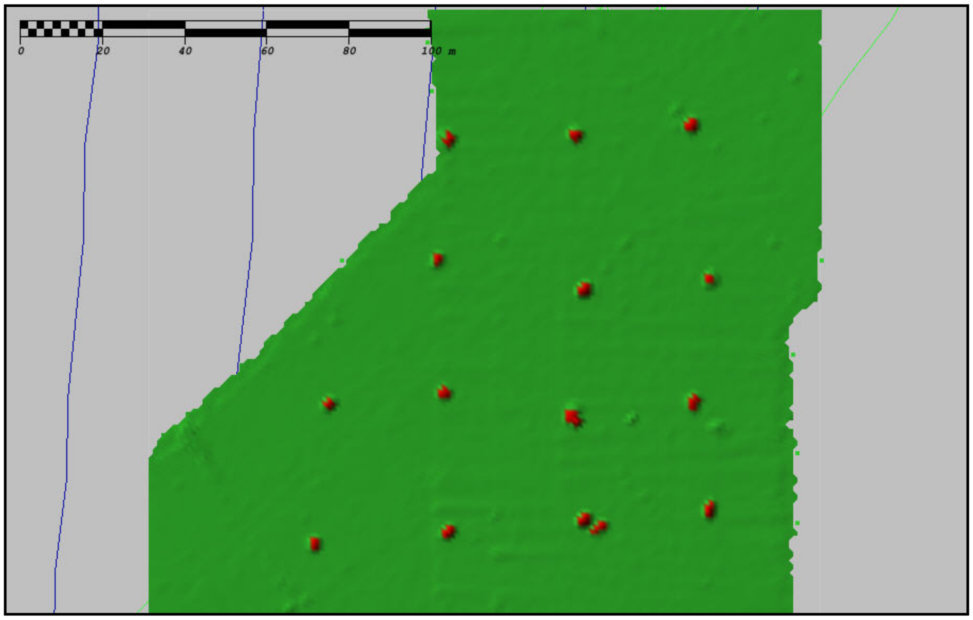

Figure 4. Contact locations of 1-meter reef structures.

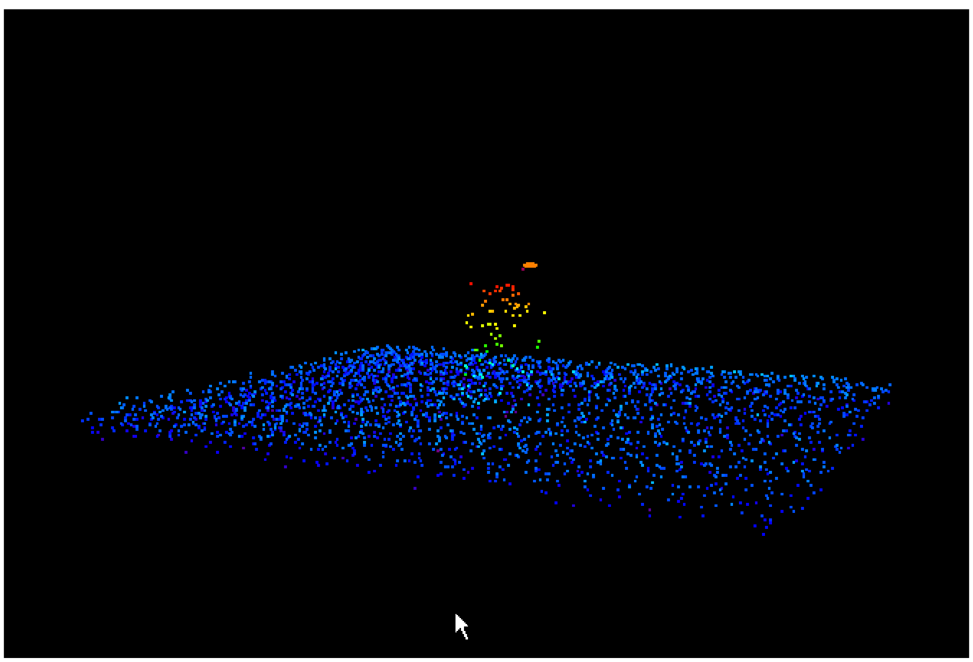

Figure 5. 3D subset soundings on 1-meter reef structures.

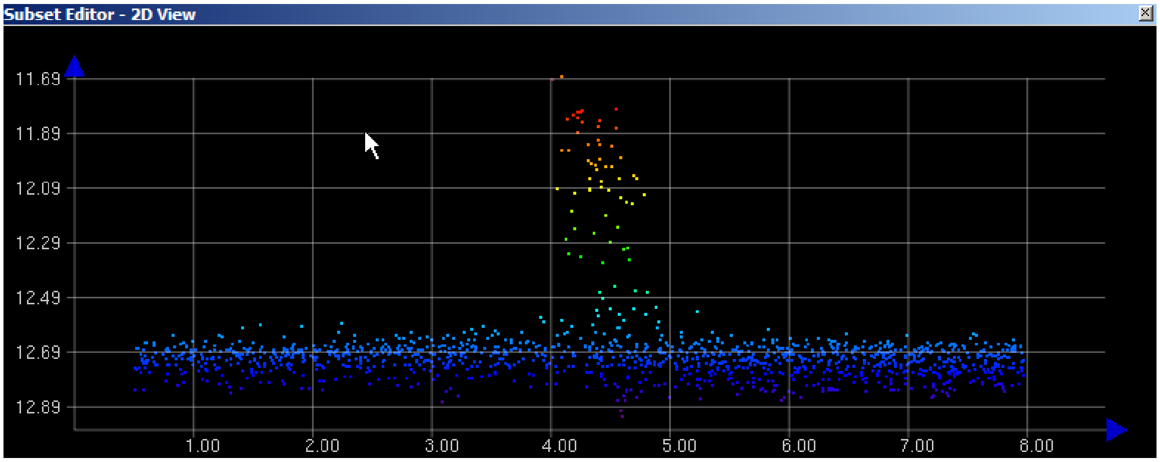

Figure 6. 2D subset soundings on 1-meter reef structures.

A.3.3 L3 Klein Sonar Pro

L3 Klein Sonar Pro software was configured in "slave mode" to the side scan sonar TPU and configured to display an uncorrected, scrolling waterfall display of the side scan sonar data. Scrolling imagery was monitored continuously for data quality and to identify water column noise or interference (e.g. fish, wake).

A.3.4 CARIS Hydrographic Information Processing System (HIPS) and Sonar Image Processing System (SIPS)

All multibeam echo sounder data were converted from raw HYPACK format data files and processed using CARIS HIPS software Version 6.1 (Service Pack 2) for the Microsoft Windows XP environment.

All SSS data were converted from raw XTF format line files to HDCS format using the CARIS SIPS software, Version 6.1 (Service Pack 2) for the Microsoft Windows environment.

Refer to Section B. PROCESSING AND QUALITY CONTROL.

A.3.5 CARIS Notebook

The S-57 features were created in CARIS Notebook to emphasize navigationally significant objects discovered during the survey and to provide information for these objects that could not be portrayed in the BASE surfaces. Features were digitized in reference to final BASE surfaces and an S-57 feature file was created for submission with the hydrographic survey data.

Refer to Section B. PROCESSING AND QUALITY CONTROL.

A.3.6 CARIS Easy View

CARIS Easy View was used to review multiple sources of data during processing, quality review and chart comparisons. Raster and vector reference data included CARIS soundings, BASE surfaces, contours, HOB format files, S-57 000 format files, ENC, RNC, and AutoCAD drawing exchange files (dxf).

A.3.7 AutoCAD 2004

AutoCAD drafting and geographic information system was employed for pre-survey planning, line file construction, hydrographic data QC, and the production of presentation graphics.

A.3.8 Microsoft Office Word and Excel

MS Excel was used for log keeping (field and processing), sound velocity profile display and review, organization and preparation of field and office tasks, report table production and statistical data analysis. MS Word was used for report generation.

A.3.9 Adobe Acrobat

Adobe Acrobat was used to prepare final reports with digital signatures in accordance with the Statement of Work (SOW) and HSSD.

A.3.10 Global Mapper 10

This 3-D visualization software and geographic information system was employed to create detailed sun-illuminated Digital Terrain Model (DTM) images, display vector geographic data and convert file formats. These data were used for QC checks and presentation purposes.

A.3.11 Trimble Applanix MV-POSView

The MV POSView controller software was used to configure and monitor the POS MV navigation and inertial motion unit system. IMU, navigation and GAMS status were monitored continuously at the navigation and acquisition stations. Visual alarms were configured to alert the operator in the event that attitude, position, velocity, heading or heave accuracy was degraded.

The MV POSView controller was also configured to record TrueHeave, navigation and motion correction data (POSPac).

A.4 Acquisition Procedures

Project Management Overview

All data acquisition and processing was performed under the supervision of the OSI Lead Hydrographer and Chief of Party. Field acquisition was performed under the supervision of a Senior Hydrographer with at least 3 years of experience conducting hydrographic surveys.

A.4.1 Project Planning

Prior to the survey, a review of the current charted data was conducted to identify critical features and areas including ship channels, fish havens, disposal sites and questionable charted features (obstructions, wrecks, reported PA, ED charted features). General depth areas were delineated from current charted information or DTM of high-density sounding data from prior surveys (if available from the NGDC digital archive). A line plan was created to meet requirements specified in the SOW. Specific line plans and survey coverage are described in the DR.

A.4.2 Data Acquisition Quality Control

Data acquisition quality control was established and performed to ensure survey data met requirements specified in the SOW and HSSD. The following quality control checks were performed during daily survey operations:

- Position
  - Daily horizontal control confidence checks were performed in reference to an established high-accuracy position. Refer to Section C.3 for additional information.
  - The POS/MV position accuracy status indicators were monitored in real time on the support computer monitor.
  - Position information from the primary and secondary DGPS receivers were compared in HYPACK and status indicators were monitored in real time.
- Attitude
  - The POS/MV GAMS heading accuracy status indicator was monitored in real time on the support computer monitor.
  - The POS/MV heave, pitch and roll were monitored in real time on the support computer monitor .
  - TrueHeave and POSPac data were acquired at least 5 minutes prior to and after SWMB acquisition.
- Static Draft
  - Daily static draft measurements were conducted prior to SWMB acquisition.
  - Static draft measurements were conducted after fueling.

- Sound Speed Profile (SSP)
    - Seabird CTD's were operated in accordance with Coast Surveys Development Lab (CSDL) guidance: 3 minutes of warm up at the surface, 2 minutes operation at the surface, 1 meter per second depth descent.
    - A CTD cast was acquired daily prior to SWMB acquisition in the relative location of operations. Daily CTD confidence checks were performed and logged in Velocwin by comparing the CTD surface sound speed to the SWMB sound speed probe.
    - Weekly confidence checks were performed and logged in Veolocwin by comparing casts from the primary CTD with the secondary CTD.
    - CTD data were acquired at a minimum interval of 1 cast per 4 hours; more frequent casts were acquired if variable sound speed (SS) was observed in either a cast or the surface data.
    - Casts were acquired to measure sound speed for the deepest depths of the survey in accordance with the HSSD. All casts were reviewed and the profiles extended in Velocwin to accurately describe the deep water sound speed slope.
    - Casts were acquired for specific survey areas (e.g. channels, deep water) if necessary.
    - All casts were combined and reviewed in a custom MS Excel worksheet and graph (Figure 7) to monitor cast-to-cast differences and daily variations.

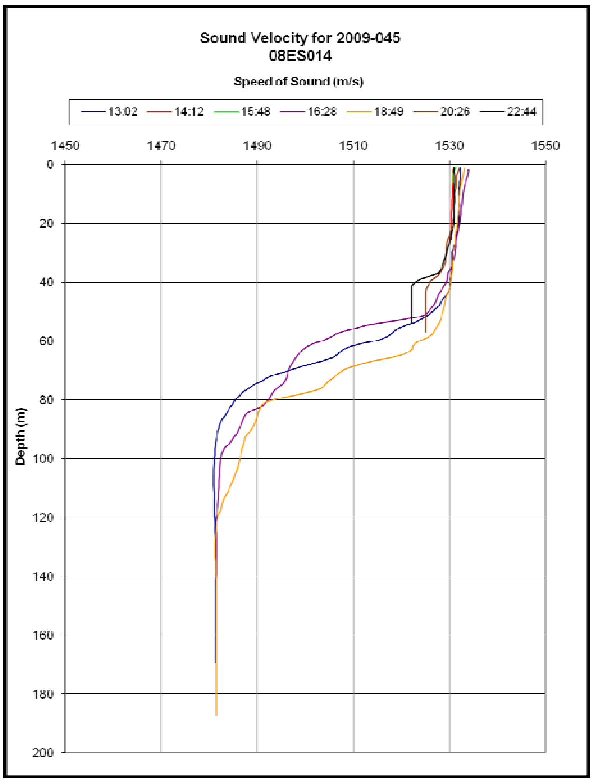

Figure 7. Daily SSP Comparison in Microsoft Excel.

- SWMB
  - Initial system calibration was performed in an acoustically quiet environment and reviewed in the Byte screen. SS probe operation, and UTC time stamp were verified during the calibration.
  - A weekly bar check or leadline spot check was performed to verify echo sounder draft offset and sounding accuracy.
  - A weekly lead line comparison was performed to verify echo sounder accuracy.
  - The Reson real-time bottom detection profile and water column display was monitored in real time.
  - Real-time SWMB waterfall displays and digital terrain model coverage displays were monitored in HYPACK HYSWEEP.

- SSS
  - The pressure transducer was calibrated daily prior to towfish deployment and throughout the day by bringing the SSS towfish to the surface.
  - The cable payout meter was calibrated daily prior to SSS acquisition and throughout the day via index marks on the SSS tow wire.
  - Cable payout meter confidence checks were performed regularly using measured marks on the towfish cable.
  - SSS imagery confidence checks were recorded frequently on recognizable features (e.g. sand waves, cables).
  - A SSS coverage mosaic was displayed in real time.
  - A slant-range corrected SSS waterfall display was monitored in real time. Contact targets were positioned from the slant-range corrected data and displayed on the helmsman map.
  - An uncorrected SSS waterfall display was monitored in real time to observe water column interference and nadir contacts.

- Digital Acquisition Logs
  - Daily activities
  - Weather and sea state observations
  - Survey trackline ID and time
  - Unusual conditions and events
  - Water column noise
  - Vessel traffic and interference
  - Significant contacts
  - Deviation from planned tracklines
  - Data gaps

B. PROCESSING AND QUALITY CONTROL

B.1 Data Flow and Processing Procedures

B.1.1 Sound Speed Profile Processing

Sound speed profiles (svp format files) were calculated from raw CTD data using Velocwin software. Procedurally, daily sound speed profiles, attributed with position and time of cast information, were concatenated to allow the SWMB data to be automatically corrected for sound speed within CARIS HIPS either by time or distance from the cast location. Individual profiles were applied to specific lines when necessary.

B.1.2 SWMB Processing

SWMB processing procedures were designed to meet all requirements described in the SOW and HSSD.

I. Multibeam Sonar Conversion and Batch Processing

Multibeam sonar data were processed using the CARIS HIPS Batch Processor. The Batch Processor runs a user defined script which accomplishes the following standard tasks without user intervention:

1. Convert the pre-process HYPACK HYSWEEP HSX and RAW data to the HDCS data format.
2. Load daily True Heave files.
3. Load zoned, observed preliminary tides and verified tides once available.
4. Load and apply sound speed (SS) profile data. SS profiles were generally loaded with the CARIS *previous in time* convention. When location-specific SS data were collected (e.g. deep water cast, channel), SS profiles were applied to individual lines as required. HIPS slant-range corrects SWMB data with the application of SS data.
5. *Merge* data to apply heave, vessel offsets/alignment, position, attitude, tide, and dynamic draft correctors to bathymetry. HIPS/SIPS computes the fully corrected depth and position of each sounding during the *merge* process.
6. Compute TPU (Figure 8). Total Propagated Uncertainty (TPU) is calculated in CARIS HIPS from contributing uncertainties in the echo sounder, positioning and motion sensor measurements as well as uncertainties associated with sound speed and water level correction. The standard CARIS devicemodel.xml was used to create the HIPS Vessel File (HVF). HVF uncertainty values are provided in Section C.1 Vessel Configuration and Offsets. Sound speed TPU values were estimated from manufacturer accuracy of the Sea-Bird 19plus and SBE37. Tide TPU values used were in accordance with Section 4.1.6 Error Budget Considerations of the HSSD. (TPU is currently referred to as Total Propagated

Error, TPE, in HIPS Version 6.1 and will be modified to TPU in the subsequent version).

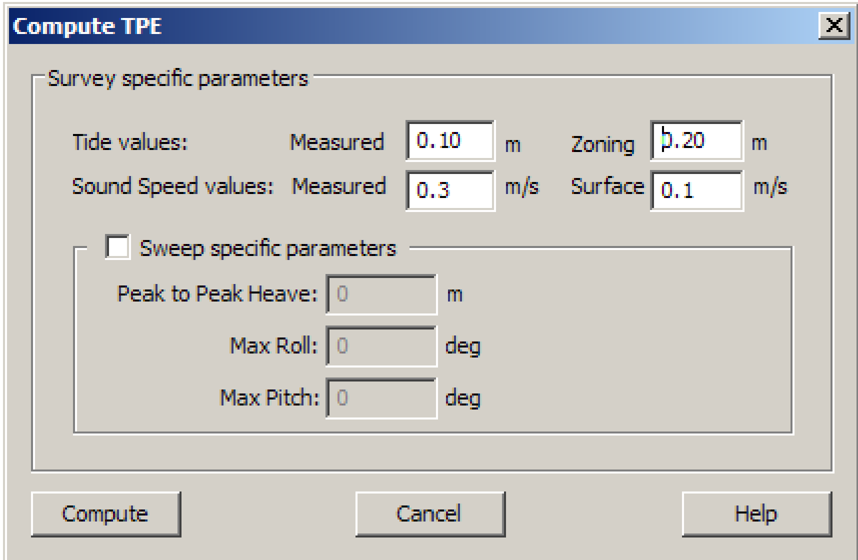

Figure 8. Tide and Sound Speed TPU parameters.

7. Filter data according to the following criteria:
   a. Reject soundings beyond 65^{o} off-nadir to remove outer beam noise and refraction errors.
   b. Reject soundings with poor quality flags, (0, 1, 2 for Reson system).
   c. Reject soundings that exceed IHO Order 1 error budget according to depth.

II. Preliminary BASE Surface Generation

Preliminary BASE surfaces were created using the *CARIS Uncertainty* algorithm for reviewing and cleaning full-density soundings. Daily data review and cleaning were performed using 1–5-meter resolution BASE surfaces as a guide for directed editing. Depth, Standard Deviation and Shoal surface models were viewed with vertical exaggeration and sun illumination to highlight areas that would require immediate investigation. Standard deviation BASE surfaces were reviewed to evaluate data for consistency between overlapping coverage and cross lines; and to detect systematic position, motion, tide, and sound velocity errors.

III. Data Cleaning and Editing

1. The CARIS Swath Editor was used to clean noise, multipath returns, and gross fliers which are most easily reviewed and edited in this time-based (ping) display. Data were filtered on a line-by-line basis to isolate unique environmental conditions, events and features. Soundings were colored by depth and reviewed in multi-directional profile and 3-dimensional displays. Line-specific range filtering was performed in Swath Editor to reduce outer-beam noise in deep areas. Tracklines and swath boundaries were viewed in the CARIS Map window in reference to BASE surfaces, charted data (RNC, ENC), SSS contacts and field annotations (HYPACK target files).
2. The CARIS Subset Editor was used to clean fully-corrected, geospatially located soundings in 2-D and 3-D displays. Soundings were colored with line, depth and uncertainty attributes. Areas with multiple sounding coverages from adjacent survey lines were evaluated to increase confidence in outer beams and over significant features. Subset boundaries were viewed in the CARIS Map window in reference to BASE surfaces, charted data (RNC, ENC), SSS contacts and field annotations (HYPACK target files). A complete final sounding review was performed for the entire survey coverage area and tracked with subset tiles.

IV. Sounding Selection (*Designated Soundings*)

In areas of complicated or high relief, critical soundings were designated on outstanding shoal features to ensure the representative least depth for the area would be included in the final BASE surfaces. BASE surfaces were reviewed to ensure that shoal soundings were accurately represented by the surface resolution. In less than 20m of water, soundings were designated for features when the most probable sounding was shoaler than the BASE surface by greater than one-half the allowable IHO S-44 Order 1 error. Full density soundings were reviewed for each SSS contact in the CARIS Swath Editor and a sounding was designated for the representative least depth of each contact (or Primary/Secondary contact pair).

V. Final BASE Surface Creation

Final BASE surfaces were created using the CARIS HIPS implementation of the CUBE (Combined Uncertainty and Bathymetry Estimator) algorithm. The CUBE algorithm generates surface models from multiple hypotheses that represent the most accurate possible depths at any given position. Hypotheses with lower combined Total Propagated Uncertainty (TPU) are given higher significance for incorporation into the final surfaces.

The following options were selected when final CUBE surfaces were created:

- Surface Type – CUBE
- IHO (International Hydrographic Organization) S-44 Order 1
- Include status – Accepted, Examined and Designated
- Disambiguation method - Density & Locale
- Shallow configuration for less than 20 meters depth (Figure 9). Default configuration for greater than 20 meters depth.

Final BASE surfaces were created at the highest resolution supported by the beam footprint of the SWMB echo sounder and as a function of surface relief, sounding density, and depth. Critical soundings were incorporated into the BASE surfaces when finalized. Final BASE surface resolutions are unique for each survey area and are described specifically in the descriptive report.

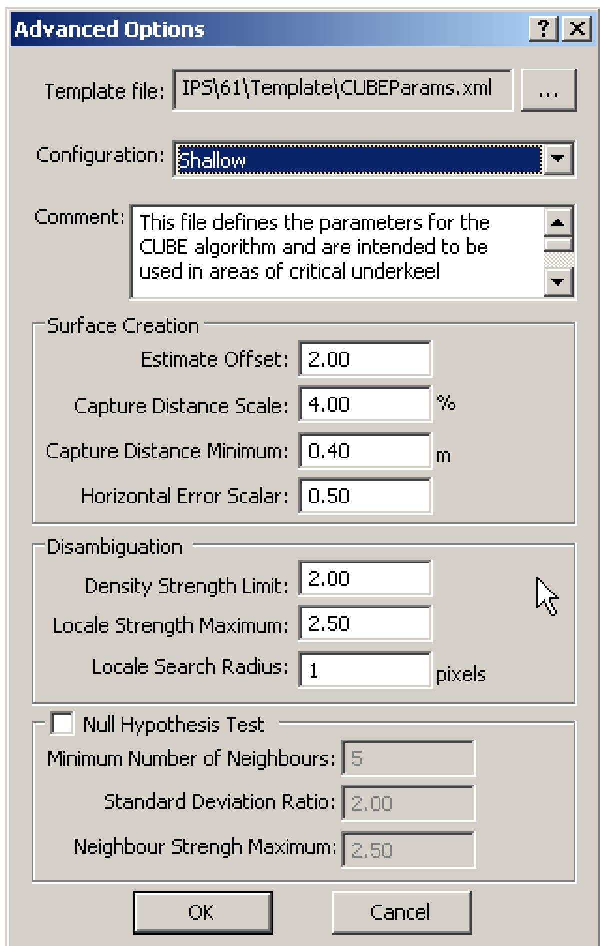

Figure 9. CUBE Parameter selection.

VI. Combined Final Surface

All final BASE surfaces were combined at the coarsest resolution in a field sheet that encompassed the entire survey area. The combined final surface was used to generate contours and soundings for chart comparisons and final product review.

VII. Quality Control (QC)

1. Cross Lines
   Cross line data were acquired in accordance with the HSSD. Statistical quality control information is generated by comparing the nadir beams of each cross line to a combined BASE surface. Cross line evaluations are performed with respect to IHO uncertainty specifications with the CARIS QC Report Utility, and are presented in Separate IV of the DR.
2. BASE Surface QC Reports
   The TPU for final BASE surface depths was evaluated with the CARIS BASE surface QC Report Utility with respect to IHO uncertainty specifications. BASE surface QC reports are presented in Separate IV of the DR.

B.1.3 Side Scan Sonar (SSS) Processing

SSS processing procedures were designed to meet all requirements described in the SOW and HSSD. Side scan sonar data were processed using CARIS SIPS and the following processes/procedures:

1. Convert the pre-process CTI SonarWiz.Map XTF data to the HDCS data format in CARIS' Conversion Wizard. Vessel trackline positions were converted from the XTF bathymetry/ship position field. Towfish positions were converted from the XTF sensor position field and fish heading was computed from course made good (CMG) from vessel navigation. SonarWiz.Map calculated the towfish position from layback and fish depth; therefore, it was not necessary to re-compute the towfish navigation or position in CARIS SIPS. Low frequency data were converted, reviewed and processed for main scheme SSS coverage. High frequency data were acquired for the entire project; however, these data were highly susceptible to noise and phase interference and, therefore, were not utilized in the development of the final products.
2. SSS line imagery was reviewed in CARIS SIPS for water column interference and accurate bottom tracking. Bottom tracking was re-digitized when necessary, automatically by SIPS, or manually to ensure accurate slant range correction.
3. Slant range correct SSS imagery – A flat-bottom model and 1500 meter/second sound velocity was used to slant range correct line imagery at 0.1-meter resolution.
4. Beam Pattern Correction (BPC) – A towfish beam pattern was calculated in SIPS from an area with uniform backscatter. BPC normalized backscatter return for varying side-to-side and range-dependent towfish transducer sensitivity.

5. Time varying gain (TVG) correction was applied to normalize backscatter return for distance across the range.
6. Contact processing:
   a. Slant range corrected line imagery was reviewed in SIPS to identify objects by the presence of sonar shadows.
   b. Shadow lengths were measured and converted to heights.
   c. Contacts with significant heights were positioned and created at the top of the shadow. Significant contacts were identified based upon height above the seafloor bottom in accordance with the SOW and HSSD (Table 4).
   d. Contacts were attributed with the following information:
      i. Height
      ii. Width (if significant)
      iii. Length (if significant)
      iv. Feature type (e.g. rock, obstruction, wreck, unknown)
      v. Processor remarks

Table 4
Significant Contact Selection Criteria

Surrounding Depth or Area (meters)	Significant Contact Height (meters)
Channel	0.5
0-5	0.5 - 1
5-20	1
>20	10% of surrounding depth

7. Contact correlation and bathymetric feature resolution
   a. All contacts were visually correlated between 100% and 200% coverages in the CARIS Map window (Figure 11). Once correlated, contacts were evaluated with respect to BASE surfaces (i.e depth and standard deviation), charted information, trackline swaths, and designated soundings. All contacts (or contact pairs) were evaluated in full density sounding subsets to ensure that there was adequate SWMB coverage. Soundings were designated on all significant contacts to obtain an accurate position and least depth.
   b. Significant contacts were visually correlated with designated soundings in the CARIS Map window.
   c. Contacts, contact images and designated soundings were exported from CARIS and processed in MS Excel to produce a contact spreadsheet as specified in the SOW and HSSD. A custom macro displayed contact images and remarks, calculated contact and designated sounding relationships (i.e. distances, depths), updated processing flags/remarks and associated contact/sounding pairs (Figure 10). Unique contact ID's were created from line-profile-range data. The contact spreadsheet is attributed with NAD83 positions and can be imported into a GIS.

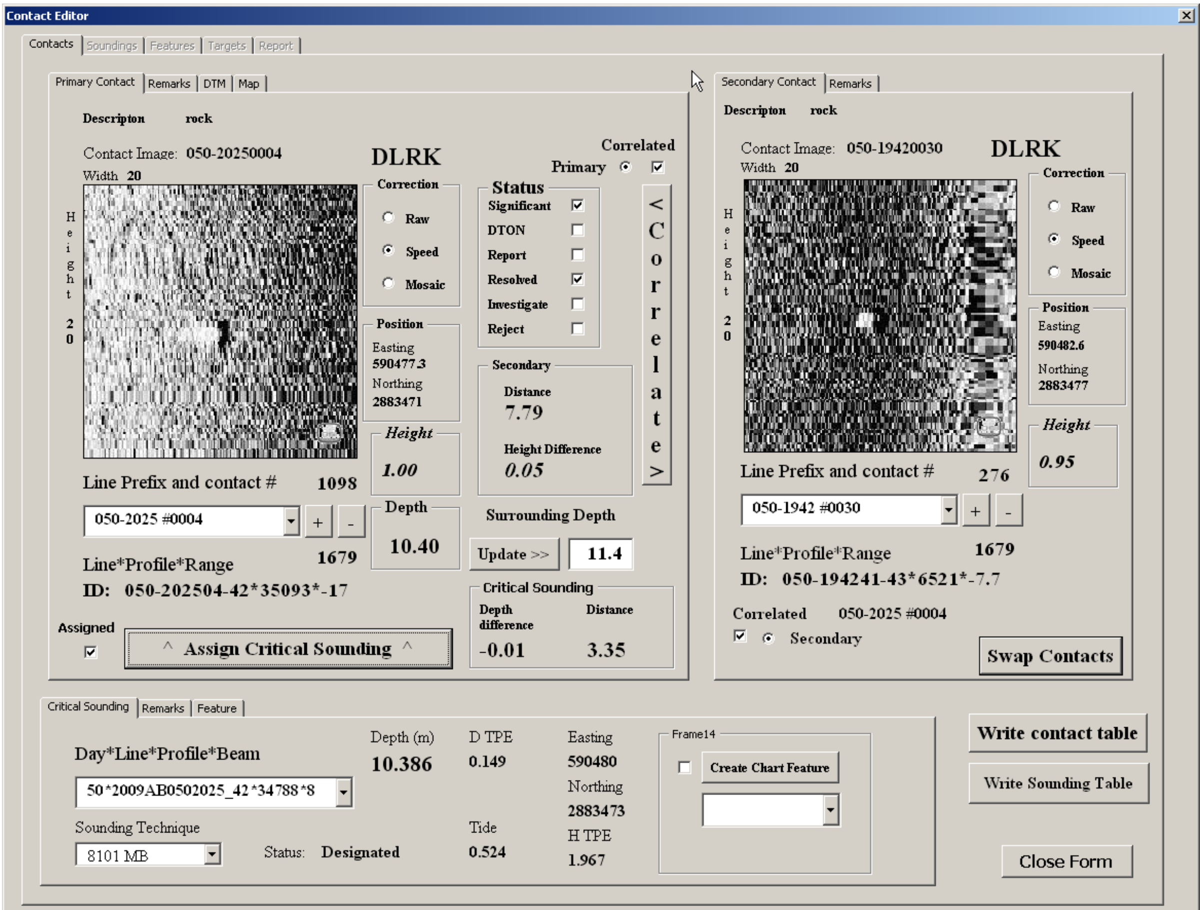

Figure 10. Spreadsheet correlation macro.

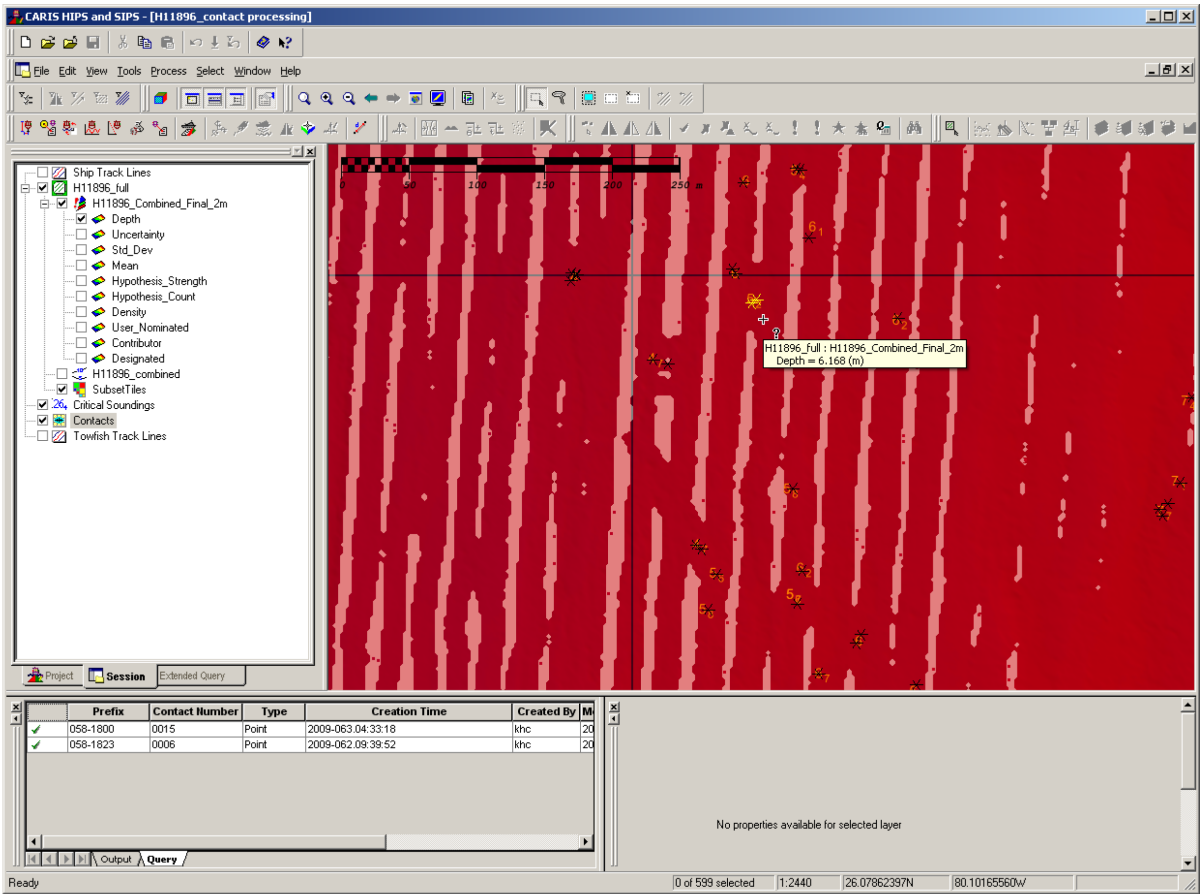

Figure 11. CARIS Map View Correlation Window.

B.1.4 S-57 Feature Processing

An S-57 feature file was created in CARIS Notebook to emphasize navigationally significant objects discovered during the survey and to provide information for these objects that could not be portrayed in the BASE surfaces. Features' depths (VALSOU – value of sounding) and positions were extracted from soundings generated from the final combined BASE surface. Bottom samples were included as attributed SBDARE (Seabed Area) point objects. Separate CARIS HOB format and a combined S-57 format 000 files were created for each survey.

All S-57 features were attributed in accordance with guidance provided in the SOW and HSSD using the following conventions:

- INFORM was used for survey descriptive information to aid in chart application. SBDARE bottom sample object INFORM attributes contain the original field descriptions of the sediment samples.
- SORDAT was attributed with the final date of the survey.
- SORIND was attributed with the country codes and survey registry (e.g. US, US, Surveys, H11896, H11897, and H11898).

C. CORRECTIONS TO ECHO SOUNDINGS

C.1 Vessel Configuration and Offsets

C.1.1 CARIS Vessel Configuration Files and Device Models

SWMB CARIS Vessel Configuration Files (.hvf format with TPU calculation) (Figure 12) were created to convert HYPACK RAW and HSX data files. The Reson 8101 device was configured from the default CARIS devicemodel.xml. Multibeam data were converted from RAW/HSX line file pairs. All raw geographic position data were converted from the HYPACK RAW format line files. All raw attitude sensor data were converted from HSX file structure. Vessel offsets, alignments, and sensor installation accuracies were entered into the .hvf and used for TPU calculation.

SSS CARIS Vessel Configuration files were created to convert CTI SonarWiz.Map XFT data files. The SSS vessel file is a "zero" configuration because all towpoint offset and layback calculations were performed in SonarWiz.Map. No additional towfish position calculation was necessary in CARIS SIPS.

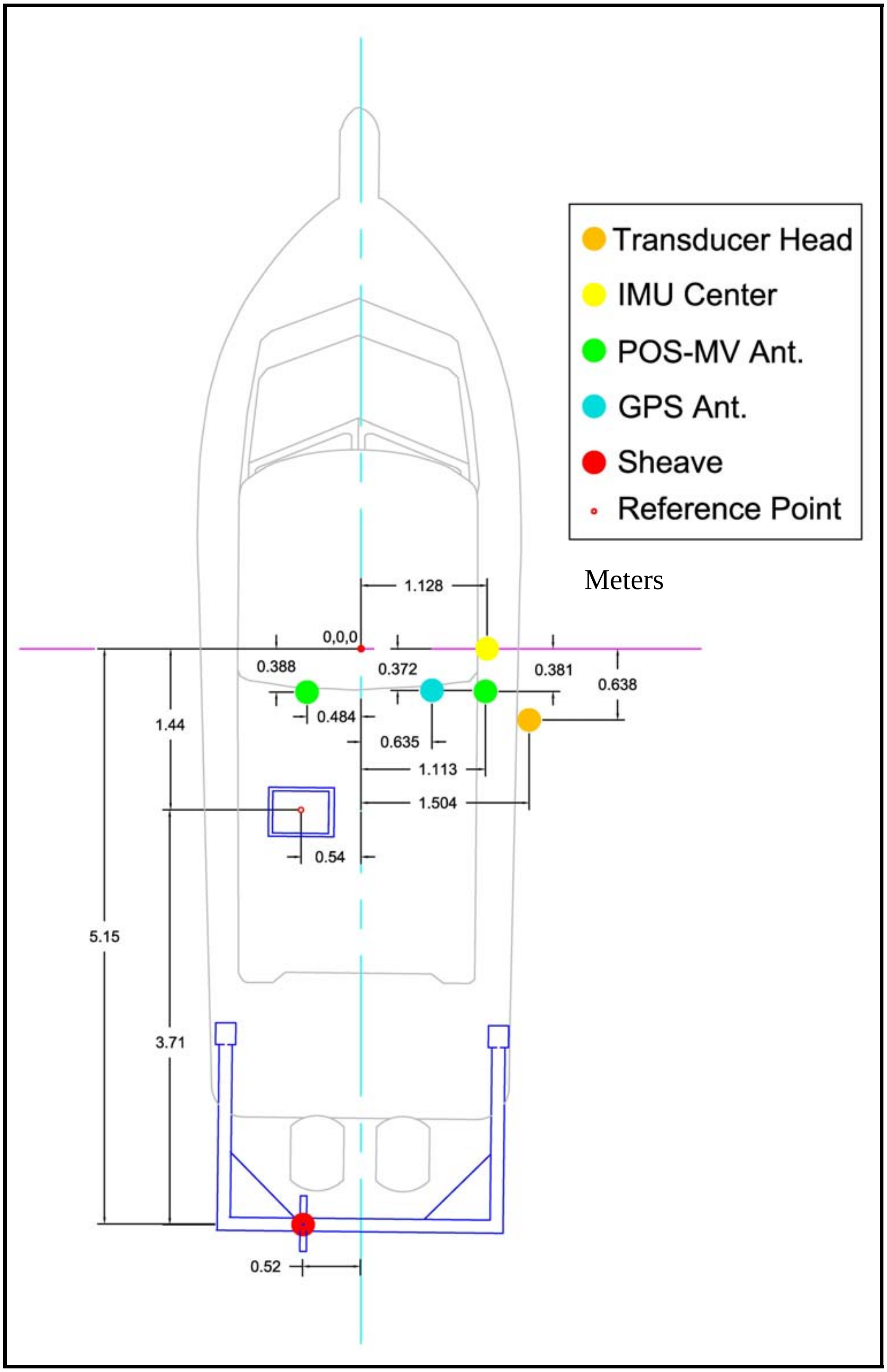

Figure 12. R/V Able II equipment offsets and configuration.

C.1.2 Offsets and Uncertainty Estimates

Tables of instrument offsets and Total Propagated Uncertainty (TPU) values input to the CARIS vessel configuration file are included in Tables 5-7 below.

Table 5
Sensor Offsets (see Figure 12)

R/V Able II Offsets via Topcon Total Station Survey. Offsets are relative to Reference Point (R/P) or Waterline	**Forward Positive (m)**	**Starboard Positive (m)**	**Up Positive w.r.t R/P (m)**	**Up Positive w.r.t. waterline (m)**
R/P Washer On deck Vessel 0,0,0	0.000	0.000	0.000	0.069
GPS POS Antenna Phase center Port	-0.388	-0.484	2.344	2.413
GPS POS Antenna Phase center Starboard	-0.381	1.113	2.343	2.412
GPS Antenna Phase center	-0.372	0.635	2.368	2.437
Transducer Phase Center	-0.638	1.504	-0.957	-0.888
Top Of Sheave (Wire at top of sheave)	-5.151	-0.518	2.065	2.134
IMU Center	0.000	1.128	0.358	0.427
Top Center of Winch Drum	-1.442	-0.538	0.846	0.915

Table 6
CARIS Vessel File Transducer TPU Offsets

TPU Offsets	**IMU/Navigation to Transducer (m)**
X Head	0.391
Y Head	0.638
Z Head	1.010

Table 7
CARIS Vessel File TPU Estimates

TPU Values Included in CARIS VCF			
Gyro Measurement Error (deg)	0.02	Pitch Timing Error (sec)	0.01
Heave % Amplitude	5.00	Roll Timing Error (sec)	0.01
Heave Error (m)	0.03	Vessel Speed Error (Kt)	0.005
Roll Measurement Error (deg)	0.02	Loading Error (m)	0.03
Pitch Measurement Error (deg)	0.02	Draft Error (m)	0.03
Navigation Measurement Error (m)	1.00	Delta Draft Error (m)	0.03
Transducer Timing Error (sec)	0.01	Tide Measurement Error (m)	0.10
Navigation Timing Error (sec)	0.01	Tide Zoning Error (m)	0.20
Gyro Timing Error (sec)	0.01	Sound Speed Error (m/s)	0.30
Heave Timing Error (sec)	0.01	Sound Speed Error Surface (m/s)	0.10

C.2 Static and Dynamic Draft Measurements

C.2.1 Static Draft

Static draft was measured from a permanent benchmark on the starboard gunwale to the waterline using a steel tape. The vessel attitude was adjusted to level the roll axis during the measurement. The draft measurement was corrected to the vessel reference point and recorded in the acquisition log. Static draft values were time stamped and entered into the CARIS vessel configuration file.

C.2.2 Settlement and Squat (Dynamic Draft)

Dynamic draft was determined using RTK GPS method. An RTK GPS base station was set onshore near the test area. The POS MV was operated in Fixed RTK mode and a series of dynamic draft measurements were recorded while running tracklines in opposite directions at varying engine RPM intervals (Figure 13). Tidal variations were monitored and corrected by recording the static elevation of the vessel while at rest, before and after each pair of runs. Speed through water was calculated by averaging opposing runs to offset the effects of currents. Final dynamic draft values were obtained from the average of each pair of tracklines (Table 8). Dynamic draft values were entered into the CARIS vessel configuration file and applied with respect to vessel speed over ground.

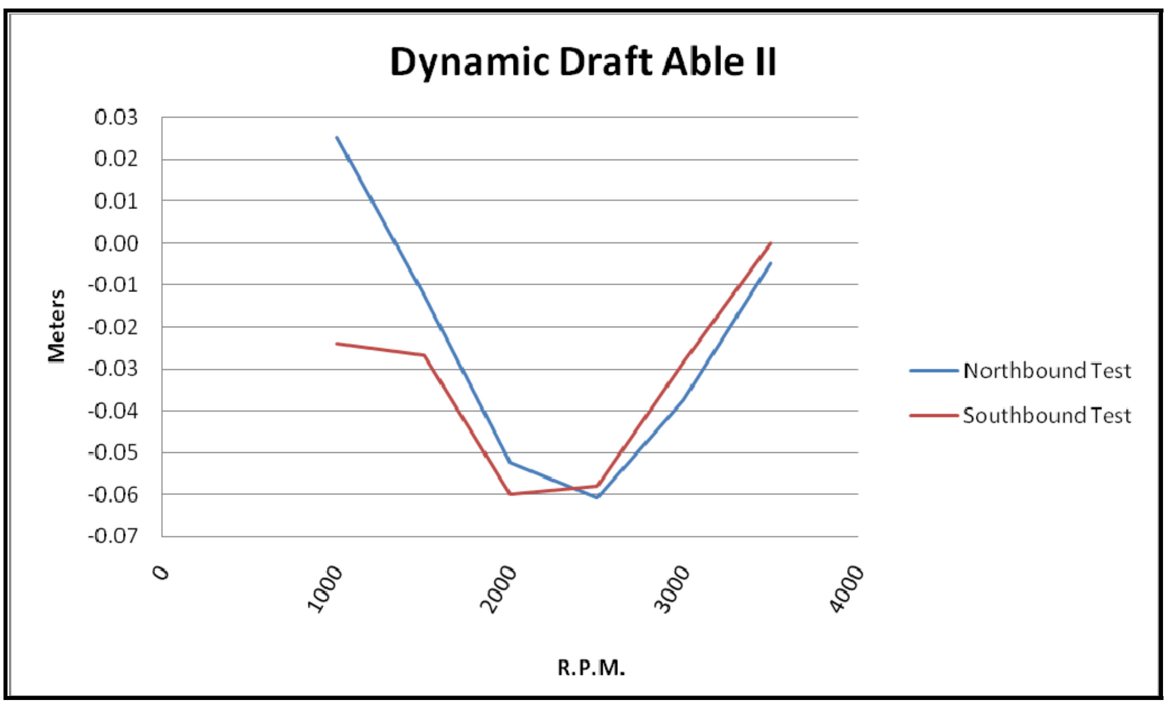

Figure 13. ABLE II Dynamic Draft Curves.

Table 8
Dynamic Draft Correctors

R/V Able II 8101 Multibeam/SSS Dynamic Draft Correctors			
RPM's	Speed over Ground		Dynamic Draft
Both Engines	M/S	Knots	Meters
1,000	1.74	3.39	-0.001
1,500	2.74	5.33	0.019
2,000	3.52	6.84	0.056
2,500	4.04	7.85	0.059
3,000	4.47	8.70	0.033
3,500	4.98	9.69	0.002

C.3 Motion, Timing Errors and Sensor Alignment

An Applanix POS MV 320 V.4 was employed for motion, heading, and position determination. Manufacturers stated accuracy and resolution values are tabulated below in Table 9.

Table 9
POS MV Specifications

POS MV 320 V.4 Manufacturers Specifications		
Parameter	**Accuracy**	**Resolution**
Roll	0.02°	0.01°
Pitch	0.02°	0.01°
Heave	5cm or 5% of wave height	0.01m
Heading	0.02°	0.01°

Prior to commencement of survey operations, a sensor alignment or patch test was performed. The patch test, run on JD044 2009, was conducted in order to determine biases in roll, pitch, heading and navigation timing. Data were acquired in accordance with HSSD April 2007 Section 5.1.4.1.

The HYPACK HYSWEEP patch test multibeam calibration procedure calculates latency, roll, pitch, and yaw bias values by comparing sounding data from coincident line pairs. The HYPACK patch test routine employs statistical analysis of the surfaces and calculates a “best fit” angular or time offset. HYPACK HYSWEEP patch test histograms depict the “best fit” angular and time offsets resulting from the various alignment tests (Figure 14). For each parameter, multiple iterations were performed and the final offset values were averaged from all tests.

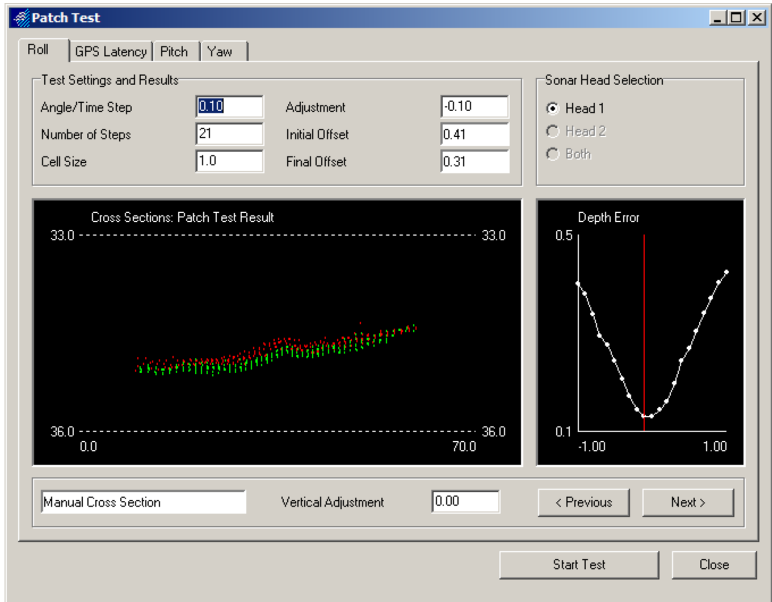

Figure 14. HYPACK HYSWEEP Patch Test Utility.

Each set of patch test lines were run multiple times to ensure system repeatability. Patch test biases were determined in the following order: navigation timing error (latency), pitch, roll, and heading. The patch tests results were of high quality and repeatability. The final applied values are shown in Table 10. All patch test values were verified in CARIS HIPS and saved with time stamps in the vessel configuration file.

Table 10
Patch Test Alignment Correctors

HYPACK Patch Test Results	
Latency	0.0 sec
Pitch	-0.87 deg
Roll	0.41 deg
Yaw (heading)	0.68 deg

C.4 Water Levels

The tidal datum for this project is Mean Lower Low Water (MLLW). All sounding depths are referenced to MLLW. The operating National Water Level Observation Network (NWLON) station at Virginia Key, FL (8723214) served as datum control for this project.

The water level station at Virginia Key, FL (8723214) is the reference station for predicted, preliminary observed and verified tides for hydrography near Virginia Key, FL. The time and range ratio correctors for applicable zones were applied to all tide correctors in CARIS

HIPS during the preliminary and final processing phases of this project. Predicted and preliminary observed zoned tides were applied to sounding data for preliminary processing. Verified tide data were downloaded from the NOAA CO-OPS Internet page http://tidesandcurrents.noaa.gov/olddata and applied with final zoning for all final soundings and BASE surfaces. Water levels used for DTON submissions are specified in the reports. Additional information is provided for this survey in the HVCR and DR.

D. APPROVAL SHEET

LETTER OF APPROVAL

REGISTRY NOS. H11896, H11897, AND H11898

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of Surveys H11896, H11897, and H11898 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.

George G. Reynolds
Ocean Surveys, Inc.
Chief of Party
October 5, 2009

B.1 Equipment Addendum

The Reson 8101 was replaced with the Reson 8125 for survey days April 29 (DN 119) to May 14 (DN 134). The Reson Seabat 8125 is a 455 kHz Multibeam Echo Sounder (MBES) System, which measures the relative water depths across a wide swath perpendicular to a vessel's track. The 8125 system illuminates a swath on the seafloor that is 120º across track by 1.0º along track. The swath consists of 240 individual 0.5º across-track beams with a bottom detection range resolution of 0.6 cm. The installed system was designed to comply with International Hydrographic Organization (IHO) standards to measure the seafloor to a maximum depth of 120 meters.

UTC date and time information output from the POS MV was used for accurate time stamping of bathymetry and backscatter data. The Reson 81P processor received a serial $UTC NMEA format timing string from the POS MV.

Transducer offsets and mounting angles, relative to the surveyed vessel frame and a vessel reference position (RP), were measured from established benchmarks using a steel tape. Offsets were entered into the CARIS vessel configuration file.

B.2 Quality Control (QC) Addendum

A calibration survey (patch test) and bar check were performed for the Reson 8125 system on April 29 (DN 119). Additional calibration data were acquired on April 30 and 31 (DN 120 and 121) to verify alignment values and to complete a system performance test.

CARIS Vessel File Transducer Acoustic Center Offsets

Offsets	IMU/Navigation to Transducer (m)
X	1.494
Y	-0.718
Z	1.1

Patch Test Alignment Correctors

HYPACK Patch Test Results	
Latency	0.0 sec
Pitch	-1.30 deg
Roll	0.050 deg
Yaw	0.390 deg