W00213

NOAA FORM 76-35A

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

DESCRIPTIVE REPORT

Type of Survey	**Outside Source Bathymetric Survey**
Project No.	**M-I905-NF-09**
Registry No.	**W00213**

LOCALITY

State	**Puerto Rico**
General Locality	**Caribbean Sea**
Sub-locality	**Southeast Coast of Isla de Vieques**

2009

CHIEF OF PARTY
Timothy A. Battista
HYDROGRAPHER
Michael L. Stecher

LIBRARY & ARCHIVES

DATE December 2, 2010

SURVEY W00213

SPECIAL NOTE

Survey W00213 was originally submitted as "H12005". After submission to the Atlantic Hydrographic Branch (AHB), survey H12005 was found to be in noncompliance with *National Ocean Service Hydrographic Survey Specifications & Deliverables* (NOS HSSD) requirements for basic hydrographic surveys. As a result, survey H12005 was re-registered as survey "W00213" and is considered as Outside Source Data.

The deliverables for survey W00213 did not include a Descriptive Report (DR). The following Data Acquisition & Processing Report (DAPR) shall serve as the report of survey for W00213. In addition, AHB has appended a Compilation Log and an H-Cell Report to this document, which have been written to supplement and/or clarify the original DAPR and pass critical compilation information to the cartographers in the Marine Chart Division.

During office review, AHB made comments in the DAPR using ***Red, Bold, and Italic*** text.

Data Acquisition & Processing Report

Type of Survey: Benthic Habitat and Hydrographic

Project No. ~~NF-09-01-USVI~~ ***M-I905-NF-09***

Time Frame: March 26, 2009 - April 2, 2009

Localities

Isla De Culebra, Puerto Rico

Registry Number ~~H12005~~ ***W00213***

Isla De Vieques, Puerto Rico

Registry Number ~~H12006~~ ***W00214***

2009

Chief Scientist

Timothy A. Battista

Lead Hydrograher

Mike L. Stecher

Data Acquisition & Processing Report

~~NF-09-01-USVI~~ *M-I905-NF-09*

March 26, 2009 - April 2, 2009

NOAA Ship NANCY FOSTER

Chief Scientist

Timothy A. Battista

Lead Hydrograher

Mike L. Stecher

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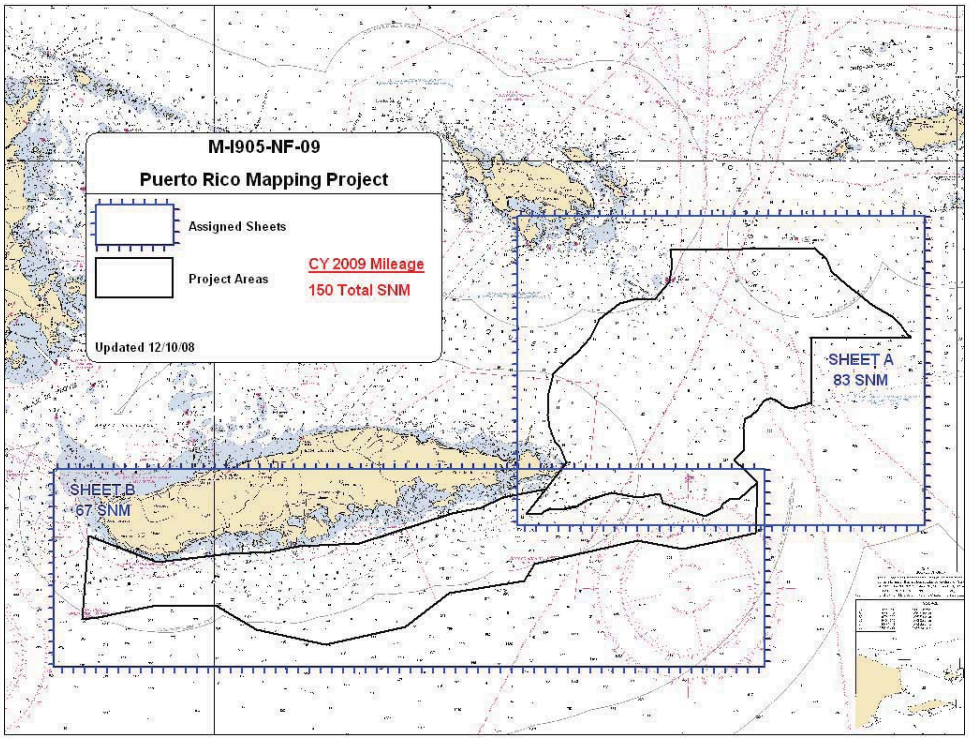
Appendices

I. Background

In June 1998, the U.S. Coral Reef Task Force (USCRTF) was established by Presidential Executive Order 13089. The USCRTF mission is to lead, coordinate, and strengthen U.S. government actions to better preserve and protect coral reef ecosystems. The National Oceanic and Atmospheric Administration's (NOAA) Center for Coastal Monitoring and Assessment (CCMA) Biogeography Team is supporting the USCRTF mandate. The Biogeography Team completed its sixth year of an ongoing scientific research mission on board the NOAA Ship NANCY FOSTER from March 26 to April 2, 2009. The objective of this project was to collect a multibeam bathymetry dataset with 100% seafloor ensonification, along with multibeam backscatter suitable for seafloor characterization in high priority conservation areas within Puerto Rico. Scientists collected high-resolution multibeam in mid-water depths from approximately 10 to 1020 meters. The multibeam data was collected to conform to IHO Order 1 (<100m) and Order 2 (>100m) accuracy standards. The strategies developed for each survey area took into account the minimum depths, general bathymetry, and time allotment. The delineation and identification of seafloor habitats within areas mapped during the mission was assisted by the use of an ROV with video and camera capabilities.

II. Area

The mission explored and mapped moderate depth bathymetry with the NANCY FOSTER's Simrad EM1002 & Reson 7125 multibeam systems for natural resource management and seafloor characterization. Priority areas for 2009 included southern portions of Isla de Culebra (Registry Number ~~H12005~~ ***W00213***, Sheet A) and Isla de Vieques (Registry Number ~~H12006~~ ***W00214***, Sheet B) offshore of western Puerto Rico. Actual areas mapped were greatly reduced due to ship transit delays en-route to the Caribbean.



III. Equipment

Vessel

The NOAA Ship NANCY FOSTER (R352) is 57 meters in length, has a beam of 12 meters and draws approximately 3 meters of water. During the Charleston, South Carolina drydock period in November of 2005, numerous survey hardware and software installations were implemented by NOAA's Aviation and Marine Operations division (NMAO) to make multibeam data acquisition a more integral component of the ship's research support. NMAO funded the permanent installation of a Simrad EM1002 multibeam sonar, an Applanix POS/MV positioning system, ancillary sensors and support equipment. The NANCY FOSTER was also temporarily mobilized with a Reson 7125 multibeam system in Puerto Rico on March 26, 2009 for the shallow water bathymetry portions of this cruise. For more details on the performance review of the Simrad multibeam system please refer to the Hydrographic Systems Readiness Review (HSRR) for the NOAA Ship Nancy Foster, 2006.

Sonar Systems

The Simrad EM1002 multibeam echosounder is permanently hull-mounted between two fiberglass hydrodynamic fittings starboard of the keel line, aft of the bow. The EM1002 is a 95-kHz system with a 150° swath consisting of 111 individually formed, electronically roll-stabilized 2° beams, with a maximum ping rate of 10Hz, depending on water depth. The EM1002 has three different automatically adjusted pulse lengths to maximize coverage in deeper waters at 0.2, 0.7 and 2 milliseconds respectively. A combination of phase and amplitude detection was used, resulting in measurement accuracy practically independent of beam angle. The system is compensated in real-time for sound velocity changes at the transducer array, to assist the electronic beam steering capabilities. CCMA performed the EM1002 multibeam patch test during the research cruise on March 28 - 29, 2009 (Appendix I).

Fig 1: EM1002 transducer fairing

Fig 2: EM1002 transducer

The EM1002 sonar system is controlled with a UNIX based operator system (SUN Solaris 8) that utilizes the Common Desktop Environment and Kongsberg's MERLIN V 5.2.2 acquisition and control program. Before surveying commenced and periodically thereafter, the EM1002 system self-test (BIST test) was performed to confirm the sonar's operating status. Sonar errors were not observed during the survey. As per advice from the Kongsberg representative during the SAT, the automatic and default parameters were used to control the sonar during data acquisition. The EM1002 backscatter default options were verified with Adel Sterling and the Hawaii Mapping Resource Group who have extensive experience acquiring backscatter imagery with the EM1002 system onboard the R/V KILO MOANA. The equidistant beam spacing mode was chosen to give a uniform distribution of soundings on the seafloor. The ping rate was set by the system and was automatically adjusted according to the depth below the transducer. Only limited runtime parameters changed during the survey including the maximum port and starboard angles, which did not exceed 60°.

A Reson 7125 multibeam echosounder was mobilized for this cruise to map the shallow water habitats in water depths of less than 75 meters. The system was mounted from the moon pool flange of the NANCY FOSTER. The 7125 is a dual frequency system (200/400 kHz) that measures water depths across a 128° swath, consisting of 512 individual beams. The sonar was set to a maximum ping rate of 50 Hz. The ping rate was reflected by the range scale set by the operator of the sonar, the shallower the range scale, the faster the ping rate. A variety of ranges were used during acquisition, however the 100m range or less dominated the majority of survey. A spreading loss of 30 log decibels and absorption value of 50 decibels per kilometer were used as general values recommended by Reson for working in seawater. The power was maintained at 220dB and the gain varied between 33dB and 50dB. The sonar data (snippets and bathy) was collected via ethernet with Reson PDS 2000 acquisition software. Unfortunately the 7125 did not operate as developed. Reson provided a sonar technician for the cruise and she was unsuccessful in determining the reason behind numerous data quality issues during the survey. These issues included dropped pings, beam steering inconsistencies and wrong swath widths reported from the sonar to the topside unit. Fortunately the data still meets the IHO requirements for the survey. These issues will be described thoroughly with an explanation from Reson in Appendix L. Versions of all hardware and software used for this survey can be found in Appendix B.

Fig 3: 7125 Mulibeam w/moon pool flange mount

Vessel Positioning & Orientation

The Applanix POS/MV 320 V4 (POS) is a vessel positioning and orientation system. The GPS aided Inertial Motion Unit (IMU) provides measurements of roll, pitch and heading that are all accurate to $\pm$ 0.02°. Heave measurements supplied by POS maintain an accuracy of 5% of the measured vertical displacement or $\pm$ 5cm for swell periods of 20 seconds or less. The accuracy and stability of measurements delivered by the system remain unaffected by vessel turns, changes of speed, wave-induced motion (sea state dependent), or other dynamic maneuvers. The IMU is located on the keel line in the forepeak void, port of the EM1002 transducer; refer to Appendix H for the vessel offset diagram. An additional IMU was located below decks on the moonpool shaft to compensate for motion during operations with the 7125. A POS 7125 vessel configuration was also created for the additional IMU.

The POS obtains its positions from two dual frequency Trimble Zephyr GPS antennae. The two POS antenna are located above the bridge deck on the port side. An auxiliary Trimble DSM 132 DGPS system provided an RTCM differential data stream to the POS. The DSM 132 received differential beacon transmittals from the U.S Coast Guard Continually Operating Reference Station (CORS) station Port Isabel, Puerto Rico at an operating frequency of 295.0 kHz.

The vessels motion data were supplied from the POS system via serial communications to the EM1002 Processing Unit (PU) at an update frequency of 100 Hz. The POS heave bandwidth was set to 18.0 seconds with a dampening ration of .707. Roll, pitch, and heave positive sense were port up, bow up, and heave up respectively. The multipath was set to low, due to the proper placement of the two GPS antennae. Position updates were supplied to the MERLIN acquisition system via serial communications at a frequency of 1 Hz. The POS also provided the pulse per second (PPS) strobe and the NMEA ZDA message that the EM1002 uses to continually synchronize the system clock.

There were also ethernet and serial connections from the POS to the PDS2000 acquisition system and the Reson 7125 topside. The ethernet connection to the PDS 2000 provided all the positioning and attitude data via Group 102, 111 and 113. The POS PPS and NMEA ZDA serial data was split to synchronize the PDS2000 and Reson 7125 systems to a common time reference.

Sound Velocity

The NANCY FOSTER is equipped with a hull-mounted SBE 45 thermosalinograph (TSG), near the EM1002 transducer. The TSG measures near-surface conductivity and temperature to calculate sound velocity in real-time. The data from the TSG streamed to the EM1002's MERLIN acquisition and control software to aid in electronic beam steering. The Reson was also equipped with a real time sound velocity probe (Reson SVP 70) at the sonar head and interfaced with the topside unit. The primary CTD's for determining sound velocity throughout the water column were a Seabird

Electronics SBE-911 and a SBE-19 Plus. Sound velocity casts were deployed approximately every four hours during survey operations. Sound velocity casts were processed with NOAA's Velocwin V8.85 software and converted to Simrad & CARIS format. The NANCY FOSTER's hydraulic winch was rigged through the block of the port J-Frame davit, which provided a consistent rate of descent for acquisition of the sound velocity data. Calibration reports from Seabird Electronics are documented in Appendix D.

Acquisition Systems

The EM1002 MERLIN V5.2.2 acquisition and control system is based on the Sun Microsystems Solaris 8 UNIX operating system. The MERLIN system integrated the auxiliary sensors with the sounding data from the Processing Unit (PU) to create "datagrams". The datagrams combine the positioning, attitude, sound velocity and sounding data. The data was logged in the .ALL format.

The 7125 sonar was controlled with the Windows based 7-P Sonar Processor Unit VMR6, and collected with Reson's PDS2000 V3.4.0.2 acquisition software.

Coastal Oceanographics Hypack Max 2009 provided the navigation information to the helms display and was used along with MapInfo to create line plans for the project areas. Coverage BASE surfaces were created with CARIS's HIPS and SIPS during data acquisition to verify coverage. The BASE surfaces were then exported in GeoTiff format to Hypack for creating holiday line plans and delineate ROV transect locations.

IV. Quality Control

The HIPS Conversion Wizard uses the .ALL and .PDS formats to convert the multibeam data into CARIS HDCS data files. During the conversion process a depth limit of 1000m was applied to reject any soundings that exceeded the depth rating of the EM1002. The vessel configurations used for the data conversion was the R352_MB.hvf (Simrad) and NF_7125.hvf (Reson) files. These files include the patch test results, dynamic draft, waterline and the Total Propagated Error (TPE) values (*.hvf & TPE Report, Appendix E). The data was projected to the North American Datum of 1983, Universal Transverse Mercator Zone 20, Northern Hemisphere (NAD83 UTM20N). All the acquired data was converted and preliminary processed in the field.

Preliminary data processing consisted of: Application of true heave, sound velocity, zoned predicted tides, navigation editing, attitude editing, swath editing and subset editing. Navigation edits included reviewing for time jumps greater than 0.2 seconds and removing data in vessel turns. Attitude data was reviewed for gaps, and none were identified. Depth filtering occurred prior to editing and was used to eliminate large outliers in the water column, minimum and maximum values varied by survey area. If the there was adequate coverage from neighboring swaths, then across track filters were used to limit the swath's outer beams. Processing with the swath edit mode

removed remaining fliers, as well as down-sloping beams where the survey lines crossed over the reef escarpment providing unreliable soundings.

The Hips Subset Editor and BASE surface creation were the second phase of editing. Subset editing enabled the hydrographer to evaluate each swath against its neighboring swath while identifying potential tidal and motion artifacts. The verification and alignment of features from adjacent lines also confirmed sensor offsets. BASE surfaces were created to illustrate adequate sonar coverage and to also identify systematic errors or artifacts within the data set. The Bathymetry Associated with Statistical Error (BASE) surfaces created from the merged and TPE calculated soundings are geo-referenced images of a weighted mean surface. The BASE surface uses a combination of range, uncertainty and swath angle weights to assign nodes depth values to create an image of the seabed surface. The BASE surface images were reviewed with multiple resolutions, sun angles, sun azimuths and vertical exaggerations. The BASE surface routine produced images representing depth, shoal-biased depth, deep-biased depth, mean depth, standard deviation, sounding density, and depth uncertainty. During acquisition in the field editing steps were expedited to create BASE surfaces to confirm adequate multibeam coverage for each survey area and to identify ROV transects. The contract Lead Hydrographer completed final processing of the datasets after field operations. This included the re-application of sound velocity profiles adjusted by Reson B.V. to try and compensate for beam steering inaccuracies and the application of final tides. Refer to Appendix F for a multibeam processing flow chart. The following two images depict the areas surveyed by the BASE depth surface.

Fig 4: 2009 bathymetry coverage, 20 km^2, shown as 8m grid, SE of Isla De Culebra, E Puerto Rico.

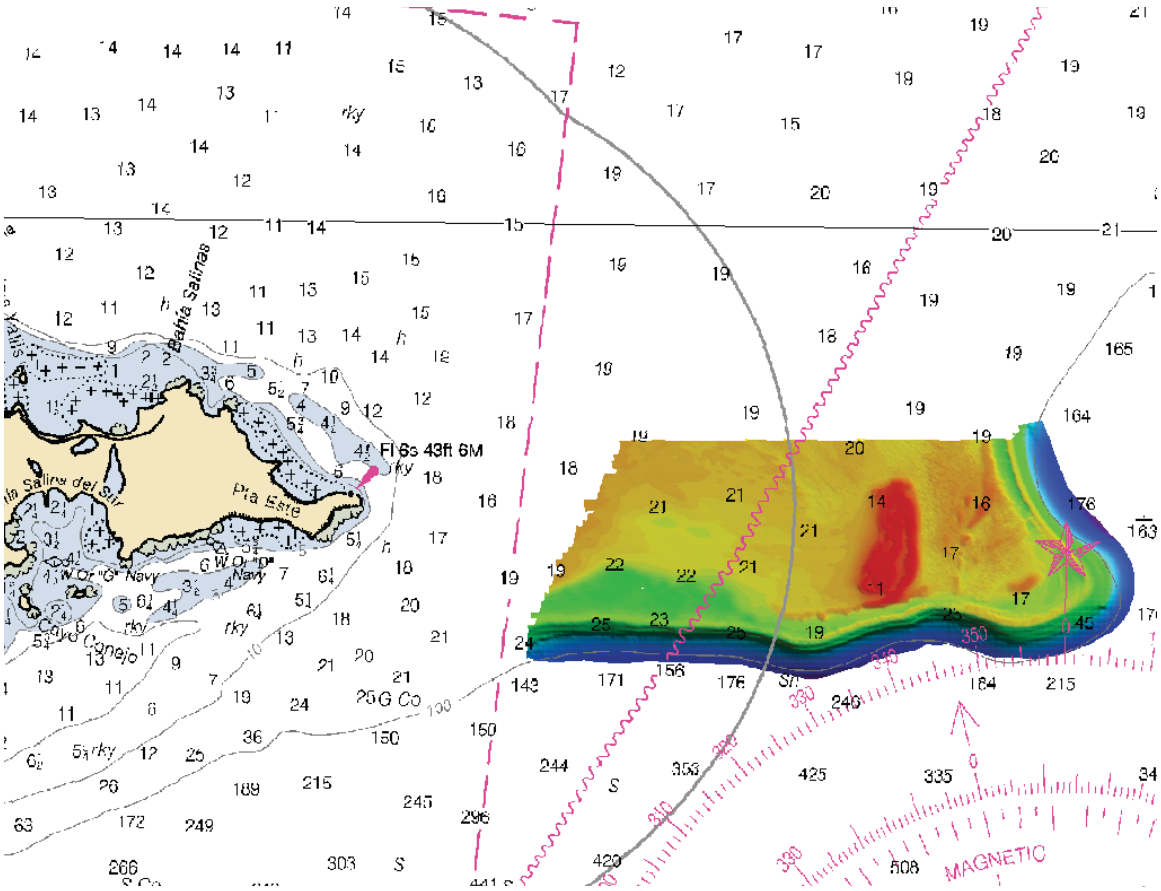


Fig 5: 2009 bathymetry coverage, 35km^2, shown as 8m grid, S Isla DeVieques, E Puerto Rico

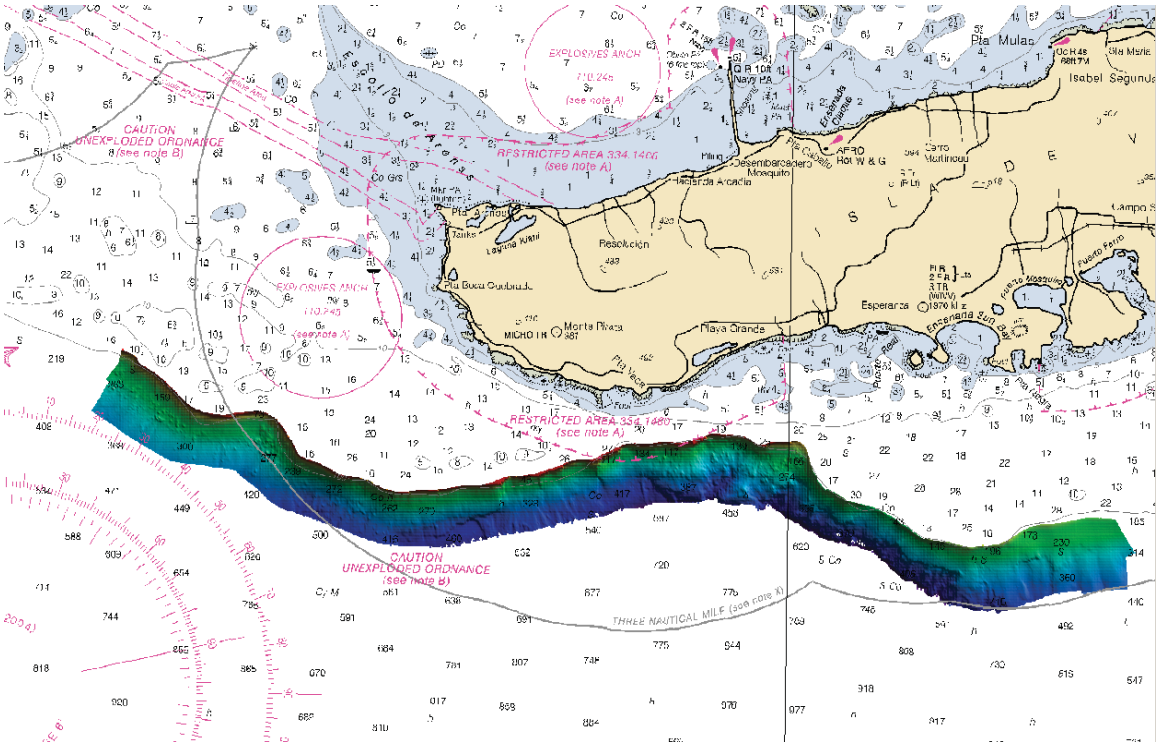


Table 1: BASE Surface Resolutions and Depth Thresholds

Resolution (meters)	Depth Thresholds (meters)
1m	0m to 23m
2m	20m to 52m
4m	46m to 115m
8m	103m to 350m
16m	+350m

Multiple resolution BASE surfaces with different depth thresholds were created for each survey area to demonstrate multibeam coverage according to section 5.1.2.2 in the NOAA Specs and Deliverables, April 2009. The surfaces were also stitched together with the combine surface command, therefore creating a single layer and retaining the information from each surface used to create the combined surface. The HIPS export wizard produced 24-bit sun-illuminated geo-referenced images of the BASE depth surfaces, and ASCII XYZ text exports at resolutions in accordance with the depth thresholds for each survey area and as a combined surface. A final analysis was performed on the BASE depth surfaces with the Hips Quality Control Report and is discussed in the Assessment of IHO Compliance section.

V. Corrections to Echo Soundings

Instrument corrections

An initial leadline confidence check was measured against the EM1002 multibeam echosounder prior to the start of field operations on March 28, 2009 while tied up at Isla De Vieques, Puerto Rico. The purpose of this check was to verify the system during static conditions by confirming that the digital depths being recorded reflected the actual depths. A sound velocity cast and leadline was performed on the starboard side of the multibeam system. The sonar's acquisition system was logging data while the leadline were performed. The CARIS swath editor was then used to verify the depth soundings. Soundings were queried approximately 4.1 meters to starboard of the nadir beam and verified to the leadline values. No instrument correction was necessary because of insufficient evidence of systematic error.

A leadline was unable to be performed for the 7125 due to sight limitations and deployment issues. Vertical elevations were verified with a check line against the EM1002.

Sensor Offsets

On the February 7th, 2006 the NOAA Ship NANCY FOSTER had her sensor offsets surveyed by the Power & Control Systems Group of L3 Communications. The IMU, GPS antennas, EM1002 transducer and the center of rotation were surveyed with respect to the RP of the vessel. The values obtained from the vessel survey are documented in Appendix G & H.

On March 10, 2009 the NGS Field Operation Branch conducted an additional survey for the second IMU. The field crew based there observations on alignment cubes and the coordinate report from the L3 Communications survey. The values obtained from the vessel survey are also documented in Appendix G & H.

These offsets were entered into the MERLIN acquisition software, POS/MV software and into the Caris vessel configuration file in the appropriate areas. The offsets used for the sonar's and positioning systems are documented Appendix A, C and E.

Static and Dynamic Draft Corrections

Static draft values were obtained from visual observations of the projection draft marks on the starboard side of the NANCY FOSTER for the EM1002. The static draft recorded on March 28, 2009 was 3.66m while tied up at Isla de Vieques, Puerto Rico. Subtracting the initial draft value of 3.66m from the fixed offset (1.68m) for the Reference Point to the EM1002 gives the final draft reading of -1.98m, which was entered into the MELIN software and confirmed with the leadline procedure previously discussed. The final EM1002 draft reading at the end of the cruise (April 2nd) was negligible.

The 7125 draft was measured at the beginning and end of the cruise. The initial draft reading for the 7125 at the moon pool was 3.46m. The final 7125 draft reading at the end of the cruise (April 2nd) was also negligible.

The dynamic draft survey was performed during the Sea Acceptance Test (SAT) offshore of Charleston, South Carolina in March of 2006. Representatives from the NOAA Aviation and Marine Operations (NMAO) performed the survey and evaluated the results. The dynamic draft was determined using the reference surface method as per the NOS Field Procedures Manual. Results of the dynamic draft survey were entered into the vessel configuration files. Refer to Appendix I for further information on draft corrections.

System Alignment and Calibrations

System Alignment and calibration procedures are for both sonars are fully documented in Appendix I, the Multibeam Calibration Procedures & Patch Test Report. The calculated patch test values for latency, roll, pitch and yaw were entered into the vessel configuration files.

Tide Corrections

Existing water level stations were used in conjunction with height and time correctors in a CARIS tide zone definition file (ZDF). Predicted tides, adjusted to MLLW, and ZDFs were supplied by NOAA CO-OPS prior to the commencement of survey operations. Verified six-minute interval water level and final tide zone correctors were applied while post processing the data. During the computation of the TPE, survey specific parameters including the estimated tidal errors, were applied. The estimated tidal error contribution to the total survey error budget was 0.12 meters at the 95% confidence level, and included the estimated gauge measurement error, tidal datum computation error, and tidal zoning error. It should be noted that the tidal error component could be significantly greater than stated if a substantial meteorological event occurred during time of hydrography, although none were observed. The tide requirements and Tide Note for Hydrographic Survey is located in Appendix J.

VI. Statement of Accuracy and Suitability for Charting

Assessment of horizontal control

Positioning equipment and methods

The horizontal datum for this project is the North American Datum of 1983 Universal Transverse Mercator Zone 20, Northern Hemisphere (NAD83 UTM20N). Differential GPS (DGPS) corrected positions from the POS/MV were supplied to all the acquisition systems. Each acquisition system has visual alarms to notify the operator if the DGPS fix is lost or if HDOP values of 4.0 are exceeded; none were observed. Differential beacon corrections were received from U.S. Coast Guard Continually Operating Reference Station (CORS) Isabel, Puerto Rico at a frequency of 295.0 kHz

with the Trimble DMS 132 receiver.

Quality control

Position checks between two independent DGPS systems were observed and recorded with HYPACK on March 28, 2009 while docked at Isla De Vieques. Both the EM1002 and 7125 POS/MV configuration files were checked with this method. The Trimble DMS 132 was logged as raw DGPS positions with no offsets applied. Then the POS/MV DGPS data was logged with the offsets positioning the vessel at the Reference Point (RP) and at the moonpool mounted 7125. Both systems DGPS data were collected for at least one minute, and checked well within DGPS positioning standards.

Statement of accuracy and compliance with HSSDM

Based on a combination of the positioning system confidence check, real-time tolerance monitoring and seafloor feature alignment, the hydrographer feels that the horizontal control should be considered adequate for the purposes of this survey.

Assessment of vertical control

Water level measuring equipment and methods

The Vertical Datum for this survey was Mean Lower-Low Water (MLLW). The National Water Level Observation Network (NWLON) primary tide stations at Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) served as the primary sources for vertical datum control. Six-minute predicted tides were obtained from the CO-OPS home page (www.co-ops.nos.noaa.gov) and were applied during preliminary processing onboard the vessel. Verified tides with final zoning were applied during post-processing.

Tides Zoning

The tidal zoning data, time and height corrections were provided by NOAA CO-OPS (refer to Appendix J). The verified tides were zone corrected with the I905NF2009CORP.zdf file provided by CO-OPS.

Statement of accuracy and compliance with HSSDM

The hydrographer believes that the zoning of tide correctors between the three primary tide stations is adequate for the purpose and location of the survey.

Assessment of sensors

Ancillary sensors

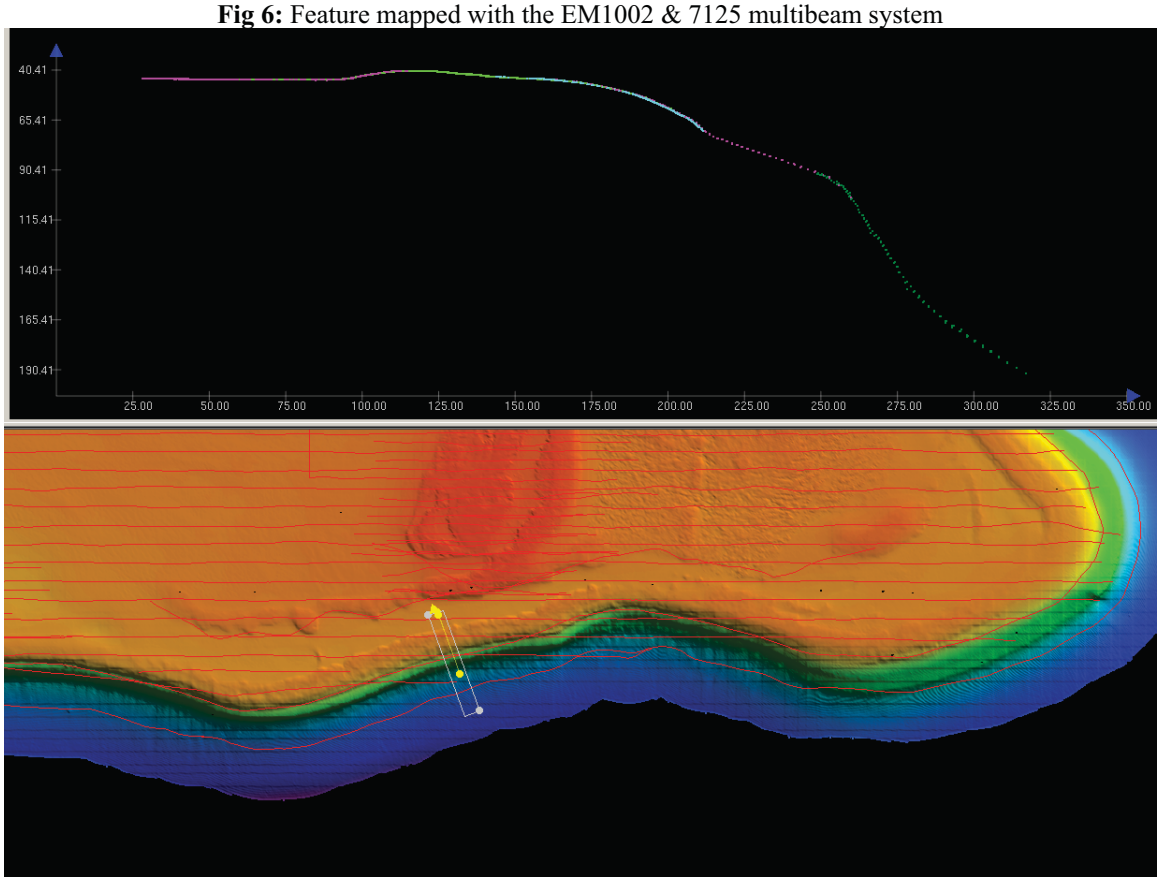
Sound velocity profiles were acquired using the NANCY FOSTER's SeaBird Electronics (SBE) 19 Plus Conductivity, Temperature, and Depth (CTD) profiler (S/N 0355) and the SBE 911 CTD (S/N 3269). Raw CTD data was processed using NOAA's Velocwin V8.85 software, which generated the sound velocity profiles required for real-time sounding corrections. Casts were recorded to the full depth of the area being surveyed.

The speed of sound through the water was determined by a minimum of one cast every four hours during multibeam acquisition. The primary CTD was checked against the secondary unit and was in general agreement. Each unit had been calibrated prior to use for this survey; refer to Appendix D for the SBE calibration reports.

Assessment of Patch Test and Results

The Hydrographer believes that the values of the latency, pitch, roll and gyro coupled with a thorough review of the patch test lines in Caris HIPS HDCS editor, adequately meet the alignment requirements for both systems. The following image represents an area of feature alignment that was collected with a combination of six lines of multibeam data from both sonar systems.

Fig 6: Feature mapped with the EM1002 & 7125 multibeam system

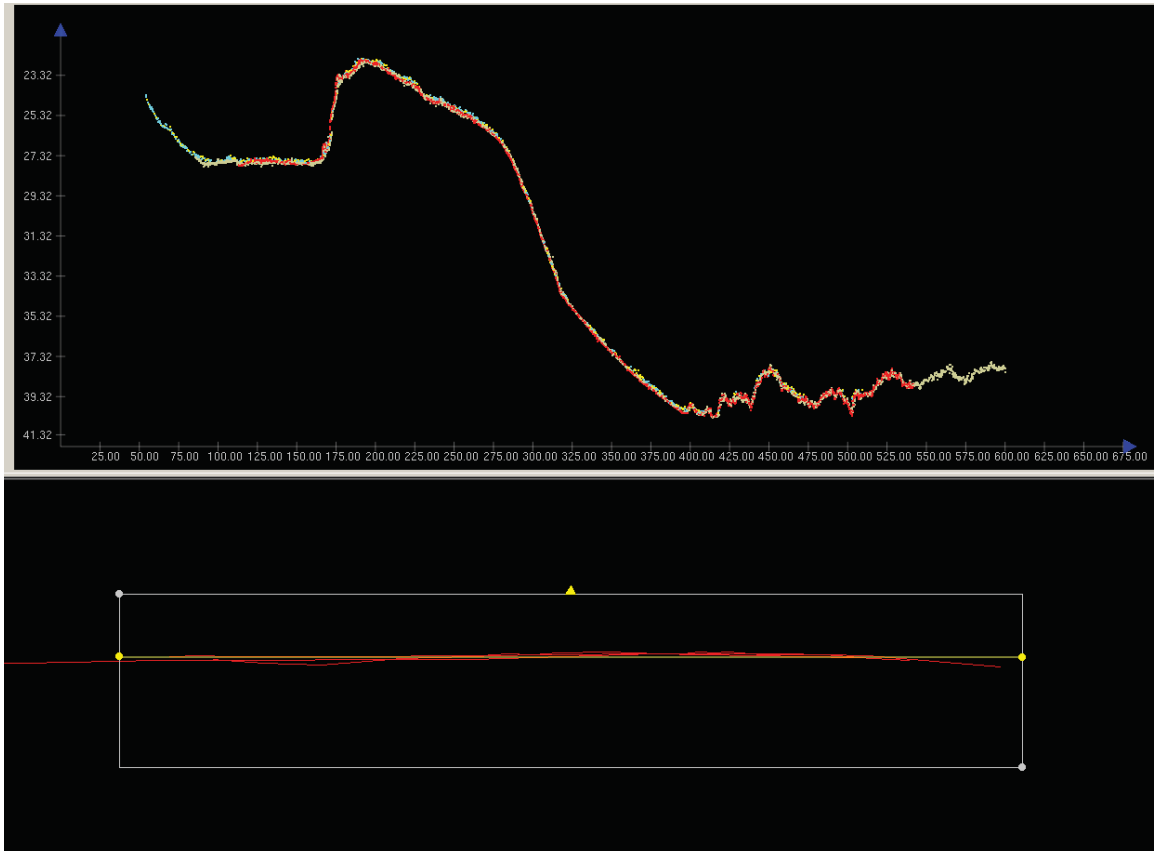


Assessment of Dynamic and Static Draft

Dynamic draft values for the NANCY FOSTER were performed during the Sea Acceptance Test (SAT) offshore of Charleston, South Carolina in March of 2006. Representatives from the NOAA Aviation and Marine Operations (NMAO) performed the survey and evaluated the results. Four-RPM levels were used to determine the dynamic draft: 790, 1000, 1300 and 1600. The observed changes in draft were negligible, with a maximum corrector of 0.041m. The values of the dynamic draft were entered into the vessel configuration files and were applied during the merge process.

Static draft observations were made for the both systems the day of departure under full load, and at the end of the cruise in San Juan, Puerto Rico. Subtracting the RP from the projection draft markings on the starboard side of the NANCY FOSTER resulted in the draft for the EM1002. For the 7125 a fiberglass tape was lowered into the moonpool until it reached the flange of the mount. A water elevation was recorded, which was then added to the acoustic center of the 7125. The total loss of draft observed during the cruise for both systems was negligible. The initial draft values for the EM1002 were verified with lead line observations while tied up at Isla De Vieques. There were difficulties reading the leadline from the fantail of the ship for the 7125, and the leadline was not completed. To verify the elevations of the 7125 a reciprocal test line was ran with both the EM1002 and the 7125. There was excellent feature alignment as well as agreement vertically. The Lead Hydrographer feels that the dynamic and static draft corrections are adequate for this survey.

Fig 7: EM1002 & 7125 vertical/horizontal QA/QC check line



Assessment of Horizontal and Vertical offsets

Sensor Offsets

The Power & Control Systems Group (PacOrd) surveyed the offsets to a maximum error of +/-5cm, with most of the critical offsets measured to within +/-0.5cm. Maximum errors of the angles surveyed did not exceed +/-1.0°. During the SAT, Chuck Hoeing (Kongsberg Rep), Nick Forfinski from NMAO and the Lead Hydrographer verified the sensor offset inputs for the EM1002, POS/MV and the R352_MB vessel configuration file.

The second IMU is attached to a plate welded to starboard of the moonpool shaft below deck, aft of the engine room. The offset survey was conducted on March 10, 2009 at the Old Naval Shipyard in Charleston, South Carolina by the National Geodetic Survey Field Operations Branch. Control for the survey was based on alignment cubes recovered and a coordinate report for the survey submitted February 2, 2006 by L3 Communications.

For this cruise the Lead Hydrographer and Ed Owens (NOS) confirmed the offsets for the moonpool mounted 7125 and EM1002 settings. Refer to Appendix E and the 2006 Hydrographic Systems Readiness Review (HSSR) for the NANCY FOSTER for more information.

Assessment of Sensor Calibrations

Each sensor associated with this survey underwent calibration prior to commencement of operations. The digital depths, draft and horizontal offsets were confirmed with a leadline and position checks while docked at Isla De Vieques. The EM1002 and 7125 elevations and positions were also confirmed with a cross check confirmation line surveyed by each sonar system. The offsets to these systems were accurately measured during the PacOrd and NGS surveys and verified by the Lead Hydrographer as well as other participating hydrographers. The CTD values were confirmed by comparing the two units against each other and both received calibrations by the manufacturer within the previous year. The Patch Test occurred during the SAT trials and was confirmed again with the documented NF-03-06, NF-07-06, NF-08-04-USVI and NF-09-01-USVI cruise calibration procedures. Based on these results the Lead Hydrographer feels that all the systems are adequately calibrated for the purpose of this survey.

Assessment of Object Detection

The EM1002 system's sonar ping rates are controlled automatically and are dependent on water depths. The 7125 ping rates are range dependent and set by the sonar operator. During acquisition, outer beam overlap was planned at 10%. The goals of the survey were to meet object detection requirements that satisfy IHO Order 1 in waters shoaler than 100m and IHO Order 2 deeper than 100m.

Bottom Coverage and Line Spacing

The survey lines were generally planned parallel to the contours of the seafloor. Line spacing was determined by depth using 10% overlap with 45° to 60° cutoff angles, port and starboard for the EM1002 and 7125. The line plan spacing did not exceed three times average water depth. Holiday lines were planned according to BASE surfaces created in the field. The resolutions for creating holiday plans were 1m for the shelf regions and 8m for depths generally greater than 100m. Preliminary review of the data in the field by the Lead Hydrographer determined that the bottom coverage and line spacing were considered adequate for the purposes of this survey.

Vessel speed

Survey operations were primarily conducted at a vessel speed of approximately 4 knots for deep water and approximately 6 knots for the shallow shelf regions. The Field Operations Officer (FOO) of the NOAA ship THOMAS JEFFERSON, which also operates an EM1002, supplied speed and ping rate tables for the EM1002. This table was designed to meet the requirement of the NOAA Specs and Deliverables section 5.2.2: "The hydrographer shall ensure that the vessel speed is adjusted so than no less than 3.2 beam foot prints, center-to-center, fall within 3 m, or a distance equal to 10 percent of the depth, whichever is greater, in the along track direction". Vessel speeds were adjusted to follow this table and to meet project requirements. Additionally, survey speeds were decreased during periods of increased sea state. In the opinion of the Lead Hydrographer, the vessel speeds and the sonar parameters used in this survey adequately ensonified the

seafloor.

Assessment of IHO Compliance and Quality Control Report

Crosslines totaling approximately 5% of mainscheme were surveyed for Registry # ~~H12005~~ ***W00213***. Only one cross line was completed for Registry #~~H12006~~ ***W00214*** due to time restraints. CARIS generated Quality Control Reports were compiled for each survey area. This routine compares the crosslines for each project against the 2m depth BASE surface. The graphs in Appendix K are a cumulative representation of the IHO compliance of each region against the BASE depth surface. The results of the QC report are based on individual HDCS soundings from the crosslines, to a BASE surface created from the mainscheme data. Comparing HDCS crossline data to a mainscheme BASE surface may introduce, or reduce, errors, depending on results of comparisons between surfaces and individual soundings. In addition to comparing the crosslines to mainscheme data, the CARIS BASE surface QC report was also performed. This utility compares uncertainty values contained in the surface to IHO standards and created a compliance report that is included in Appendix K. Registry Number ~~H12005~~ ***W00213*** met and exceeded IHO compliance for IHO order 1 for depths shoaler than 100m, and IHO order 2 for depths deeper than 100m. Registry Number ~~H12006~~ ***W00214*** partially met and exceeded IHO compliance for IHO order 1 for depths shoaler than 100m, and IHO order 2 for depths deeper than 100m. It is a high probability that this is a result of only one cross line of data was available for comparisons.

VII. Summary Of Submitted Data:

The following documentation and data will accompany this survey upon completion:

Data

- Raw multibeam sonar sounding files in ALL & PDS format
- Processed multibeam sounding files in CARIS HDCS format
- Raw and processed sound velocity data files
- Predicted and Verified tides correctors
- Tidal zoning prepared by NOAA CO-OPS
- XYZ files
- Sun-Illuminated GeoTiffs
- CARIS Hydrographic Vessel Files (HVF)
- CARIS Session Files
- CARIS Fieldsheets

Approval Sheet (Separate Signed Document Verifying DAPR information)
APPROVAL

As Lead Hydrographer, I have ensured that standard field surveying and processing procedures were followed during this project in accordance with the Hydrographic Manual, Fourth Edition; Hydrographic Survey Guidelines; Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables Manual, as updated for 2008.

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Approved and Forwarded: _____

APPENDIX A:

EM1002 Parameters

EM1002 installation parameters NOAA SHIP NANCY FOSTER
Cruise# NF-09-01-USVI

Software:

SPTX : 1.0.6 991014
SPRX : 1.0.6 991014
BSP : 1.5.5 050809
PU : 2.2.1 031031
Hull Unit Included: No

Motion Sensor:

Source = Attitude Sensor, Port 2
Starboard Pos. = 0.00
Forward Pos. = 0.00
DownwardPos. = 0.00
Sensor Delay = 0
Roll Offset = 0.00
PitchOffset = 0.00
Heading Offset = 0.00
Roll Ref. Plane= Pitch-Roll Axis Plane

Waterlevel:

Downward Pos. = -1.98

Transducer:

Forward Pos. = 0.81
Starboard Pos. = 1.86
Downward Pos. = 1.68
Heading Re Bow = 0.03
Roll = -0.01
Pitch = 0.05

Heading:

Source = Attitude Sensor
Offset = 0.00
Format = NMEA HDT
1PPS = In Use
Clock Offset (s)= 0

Serial port no. 1

Port will read: GGA ZDA
Baud Rate = 19200 baud
Data Bits = 8 bits
Stop Bits = 1 bits
Parity = None

Serial port no. 2

Port will read: Attitude
Baud Rate = 19200 baud
Data Bits = 8 bits
Stop Bits = 1 bits
Parity = None

Serial port no. 3

Port will read: None
Baud Rate = 9600 baud
Data Bits = 8 bits
Stop Bits = 1 bits
Parity = None

Serial port no. 4

Port will read: None
Baud Rate = 9600 baud
Data Bits = 8 bits
Stop Bits = 1 bits
Parity = None

Ethernet

Port will read: None

Clock Synchronization:

Sync. To: External Clock

Active Pos. Sys. on Port 1

Positioning System on Port 1

Motion Correction = Enabled
Geoid = WGS_84
Forward Pos. = 0.00
Starboard Pos.= 0.00
Downward Pos .= 0.00
Pos.Delay = 0.0
Time To Use = From Datagram

Positioning System on Port 3

Motion Correction = Disabled
Geoid = WGS_84
Forward Pos. = 0.00
Starboard Pos.= 0.00
Downward Pos .= 0.00
Pos.Delay = 0.0
Time To Use = From System

Positioning System on Port 4

Motion Correction = Disabled
Geoid = WGS_84
Forward Pos. = 0.00
Starboard Pos.= 0.00
Downward Pos .= 0.00
Pos.Delay = 0.0
Time To Use = From System

Positioning System on Ethernet

Motion Correction = Disabled
Geoid = WGS_84
Forward Pos. = 0.00
Starboard Pos.= 0.00
Downward Pos .= 0.00
Pos.Delay = 0.0
Time To Use = From System

EM1002 runtime parameters NOAA SHIP NANCY FOSTER
Cruise# NF-09-01-USVI

Sounder Main:

Sounder Mode = Off
Ping Mode = Auto

Sounder Depth is supposed to be within:

Min. Depth = 1 m
Max. Depth = 1200 m

Sector / Beams:

Max Port Angle = 45 deg
Max Starboard Angle = 45 deg
Max Port Coverage = 600 deg
Max Starboard Coverage = 600 m

Beam Spacing = Equidistant
Angular Coverare = Automatic

Tracking = Auto

Depth To Normal Incidence = 60m
Normal Incidence Backscatter = -25dB
Oblique Backscatter = -25dB

Sound Speed:

Sound Speed Profile = 00011_06069183.98.asvp
Tx Sound Speed = 1538.7 m/s
Sound Sensor Offset = 0.0 m
Sound Speed Source = Probe

Seabed Imaging:

TVG Law Crossover Angle= 25 deg.

Gain:

Absorbtion Coeff. = 30.00 dB
Range Gate = Normal

Filtering:

Slope Filter = Active
Sector Tracking Filter = Active

Manual Control:

Tx Power = -10 dB
Fixed Gain = 30 dB

Simulator:

Min. Depth = 50 m
Max. Depth = 50 m
Slant X = 0 deg
Slant Y = 0 deg

APPENDIX B:

Hydrographic Hardware/Software Inventory

Hydrographic Systems Inventory Cruise# NF-09-01USVI				HARDWARE
Equipment type	Manufacturer	Model	Serial #	Firmware
Transducer	Kongsberg/Simrad	EM1002	288	N/A
Transceiver Unit	Kongsberg/Simrad	EM1002	303	N/A
Transducer	Reson	7125	1008231	N/A
Transceiver Unit	Reson	7-P	51530	MR6
Inertial GPS PCS	Applanix	POS/MV 320 V4	2249	3.2
IMU	Applanix	LN 200	447	N/A
IMU	Applanix	LN 200	047	N/A
DGPS	Trimble	DSM 132	224096283	3.0
Acquisition	Sun MicroSystems	Solaris 8	TT32220431	N/A
SVP	SBE	SBE 911	1448	N/A
SVP	SBE	SBE 19	0355	N/A
SVP	Reson	SVP 70	N/A	N/A

Hydrographic Systems Inventory Cruise# NF-09-01 USVI			SOFTWARE
Equipment type	Manufacturer	Model	Software Version
Inertial GPS PCS	Applanix	POS/MV 320 V4	4.22
Navigation	Coastal Oceanographics	N/A	2009a
Acquisition	Kongsberg/Simrad	MERLIN	5.2 V2
Acquisition	Reson	PDS 2000	3.4.0.2
Processing	NOAA	Velocwin	8.85
Processing	CARIS	HIPS & SIPS	6.1 SP2

APPENDIX C:

POS/MV 320 V4 Configuration Reports

applanix

Certificate of Conformance

Applanix Corporation certifies that the material listed below has been tested in accordance with approved test procedures and was found to meet or exceed published specifications.

1) Description: **IMU LN200**
Applanix Part Number: **10001506-4**
IMU Serial Number: **408471 (Top Hat # 447)**

Return Material Authorization #: 09-003

Customer: NOAA
Atlantic Branch at MOC
Ship Nancy Foster

16 February, 2009

Certified By:
Bruce Francis
Customer Support Engineer

Date:

applanix

Certificate of Conformance

Applanix Corporation certifies that the material listed below has been tested in accordance with approved test procedures and was found to meet or exceed published specifications.

1) Description: **IMU LN200**
Applanix Part Number: **10001506-4**
IMU Serial Number: **(Top Hat # 047)**

Return Material Authorization #: L09-010

Customer: NOAA
Atlantic Marine Center
Norfolk, VA

10 March, 2009

Certified By:
Bruce Francis
Customer Support Engineer

Date:

POS/MV Set-up EM1002

COM1
Baud Rate=19200
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Flow Control=None
Output Select=NMEA

NMEA Output=GGA,ZDA,VTG Update Rate=1Hz Talker
ID=IN
Roll Positive Sense=Port UpPitch Positive Sense=Bow UpHeave
Positive Sense=Heave Up Input Select=None

COM2
Baud Rate=19200
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Flow Control
Output Select=Binary

Binary Output Update Rate=100 Hz Frame=Sensor 1 Formula Select=SIMRAD 1000
(Tate-Bryant) Roll Positive Sense=Port UpPitch Positive Sense=Bow UpHeave Positive
Sense=Heave Up Input Select=None

COM3
Baud Rate=19200
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit
Flow Control=None
Output Select=None
Input Select=Base 1 GPS
Base GPS Input

Input Type=RTCM 1 or 9Line=Serial

Ethernet Logging ControlLogging Group Select=111,113 Logging Control
Output Rate (groups 1, 102, 103)=20 Hz

Ethernet Realtime Output ControlOutput Group Select=1,22,3,7,10,111,113 Output Control
Output Rate (groups 1,102, 103)=2 Hz

Events Event 1=Positive Edge Trigger
Event 2=Positive Edge Trigger

GAMS Parameter Setup
Two Antenna Separation (m)=2.253Heading Calibration Threshold (deg)=0.700Heading
Correction (deg)=0.000 Baseline Vector

X Component (m)=-2.253 Y Component (m)=0.027 Z Component (m)=0.011

Heave Filter
Heave Bandwith (sec)=18.000
Damping Ratio=0.707

Lever Arms & Mounting AnglesLever Arms & Mounting Angles
Ref. to IMU Lever Arm X (m)=0.737 Y (m)=0.001 Z (m)=-0.125
IMU Frame w.r.t. Ref. Frame X (deg)= -0.009 Y (deg)=-0.006 Z (deg)=0.057
Ref. to Primary GPS Lever Arm X (m)=6.571 Y (m)=-4.740 Z (m)=-16.308
Ref. to Vessel Lever Arm X (m)=0.000 Y (m)=0.000 Z (m)=0.000
Ref. to Centre of Rotation Lever Arm X (m)=-12.295 Y (m)=0.000 Z (m)=-1.965
Sensor Mounting
Ref. to Aux. 1 GPS Lever Arm X (m)=0.000 Y (m)=0.000 Z (m)=0.000
Ref. to Aux. 2 GPS Lever Arm X (m)=0.000 Y (m)=0.000 Z (m)=0.000
Ref. to Sensor 1 Lever Arm X (m)=0.000 Y (m)=0.000 Z (m)=0.000
Sensor 1 Frame w.r.t. Ref. Frame
X (deg)=0.000
Y (deg)=0.000
Z (deg)=0.000
Ref. to Sensor 2 Lever Arm
X (m)=0.000
Y (m)=0.000
Z (m)=0.000
Sensor 2 Frame w.r.t. Ref. Frame
X (deg)=0.000
Y (deg)=0.000
Z (deg)=0.000

Tags, Multipath & AutoStart
Time Tag 1=UTC Time
Time Tag 2=GPS Time
AutoStart=Enabled
Multipath=Low

Statistics POS Version= MV-320,VER4,S/N2249,HW2.7-7,SW03.22-Feb08/06,ICD03.17,OS425B14,IMU2,PGPS13,SGPS13,RTK-0,THV-0,DPW-0
GPS Receivers Primary Receiver=BD950;SN:4520A58693,v.00211,channels:24 Secondary Receiver=BD950:SN:4520A58705,v.00211,channels:24

Statistics
Total Hours=1238.4
Total Runs=31
Average Run (hours)=39.9
Longest Run (hours)=623.0
Current Run (hours)=111.8

Navigator ConfigurationFrame Contol=User Frame Auxiliary GPS Position=NormalPrimary GPS

Measurement=NormalGAMS=unchecked Disable GAMS Solution

POS Internet Address POS Internate Address=010.048.002.012 Subnet Mask=255.000.00.000

Gps Receiver ConfiguratioinPrimary GPS Receiver Primary GPS GPS Output Rate=1 Hz

GPS 1 Port
Baud Rate=9600
Parity=None
Data Bits=8 Bits
Stop Bits=1 Bit

Auto Configuration
Enabled
Secondary GPS Receiver
Secondary GPS
GPS Output Rate=1 Hz
GPS 2 Port
Baud Rate=9600

Parity=None Data Bits=8 Bits Stop Bits=1 Bit
Auto Configuratiion
Enabled

User Parameter Accuracy
RMS Accuracy
Attitude (deg)=0.050
Headinig (deg)=0.050
Position (m)=2.000
Velocity (m/s)=0.500

POS/MV Set-up 7125 400kHz

Source Name: NF_7125_400.nvm

Message 37 - Base GPS 1 Setup

Input Data Type Port 1 - Accept RTCM 1/9

Message 38 - Base GPS 2 Setup

Input Data Type Port 2 - Accept RTCM 1/9

Message 34 - COM Port Setup

Number of COM ports = 5
COM1 - Protocol: 19200,No Parity,8 data,1 stop,None
Input Selection: No Input
Output Selection: NMEA Message

COM2 - Protocol: 19200,No Parity,8 data,1 stop,None
Input Selection: No Input
Output Selection: Real-time Binary

COM3 - Protocol: 9600,No Parity,8 data,1 stop,None
Input Selection: Base GPS 1
Output Selection: No Output

COM4 - Protocol: 19200,No Parity,8 data,1 stop,None
Input Selection: No Input
Output Selection: NMEA Message

COM5 - Protocol: 9600,No Parity,8 data,1 stop,None
Input Selection: No Input
Output Selection: NMEA Message

Message 51 - Display Port Control

Number of groups selected for Display Port = 25
1 2 3 4 5 6 7 8 9 10 11 12
13 14 17 20 23 24 99 102 103 104 105 110
20000

Message 53 - Logging Port Control

Number of groups selected for Logging Port = 0
Logging Port Output Rate 1 Hz
AutoLog Select Disabled

Message 135 - NMEA Message Select

Number of Port 3
Assigned port number COM1
Update Rate Selection 1 Hz
Output Selection GGA ZDA VTG

talker ID $IN
Roll Sense Port Up
Pitch Sense Bow Up
Heave Sense Heave Up
Assigned port number COM4
Update Rate Selection 1 Hz
Output Selection ZDA
talker ID $GP
Roll Sense Port Up
Pitch Sense Bow Up
Heave Sense Heave Up
Assigned port number COM5
Update Rate Selection 1 Hz
Output Selection GGA HDT ZDA VTG SHR UTC
talker ID $IN
Roll Sense Port Up
Pitch Sense Bow Up
Heave Sense Heave Up

Message 136 - Binary Message Select

Number of Port 1
Assigned port number COM2
Update Rate Selection 100 Hz
Output Selection SIMRAD-1000(TB)
Selected frame Sensor1
Roll Sense Port Up
Pitch Sense Bow Up
Heave Sense Heave Up

Message 33 - Event Discrete Setup

Event 1 Trigger Positive edge
Event 2 Trigger Positive edge

Message 30 - Primary GPS Setup

GPS AutoConfig True

Message 31 - Secondary GPS Setup

GPS AutoConfig True

Message 24 - User Accuracy Specifications

User Attitude Accuracy 0.05
User Heading Accuracy 0.05
User Position Accuracy 2
User Velocity Accuracy 0.5

Message 52 - Real-time Data Port Control

Number of groups selected for Real-time Data Port = 18
1 2 4 5 9 10 99 102 104 110 111 113 10001 10007 10008 10009 10011 10012
Data Port Output Rate 50 Hz

Message 61 - Data Port Control

Number of groups selected for Data Port = 17
1 2 4 5 9 10 99 102 110 111 113 10001
10007 10008 10009 10011 10012
Data Port Output Rate 50 Hz

Message 20 - General Installation Parameters

Ref to IMU Lever Arm -0.000 -0.000 0.000 [Wavemaster User => -0.008 -0.022 0.073]
Ref to Pri GPS Lever Arm 29.096 -6.295 -14.577
Ref to Aux1 GPS Lever Arm 27.896 -6.295 -14.577
Ref to Aux2 GPS Lever Arm 0.000 0.000 0.000
IMU to Ref Mounting Angle 0.000 0.000 0.000
AutoStart Enabled
Multipath Low

Message 120 - Sensor Parameter Set-up

Sensor1 Ref Mount Angle 0.000 0.000 0.000
Sensor2 Ref Mount Angle 0.000 0.000 0.000
Ref Sensor1 Lever Arm -0.135 -0.455 2.445
Ref Sensor1 Lever Arm 0.000 0.000 0.000
Ref to CoR Lever Arm 10.230 -1.550 -0.675

Message 121 - Vessel Installation Parameter Set-up

Ref to Vessel Lever Arm -0.135 -0.455 2.445

Message 106 - Heave Filter Set-up

Heave Bandwidth 12.000
Heave Damping Ratio 0.707

Message 105 - Analog Port Set-up

Roll Scale 1.00
Pitch Scale 1.00
Heave Scale 1.00
Roll Sense Port Up
Pitch Sense Bow Up
Heave Sense Clockwise
Formula Select - TSS Trig
Analog Port Enabled True
Output Frame Sensor 1

Message 21 - GAMS Installation Parameters

Two Antenna Separation 2.259

Baseline Vector -2.259 0.024 -0.002
Heading Calibration Threshold 0.700
Heading Correction 0.000

APPENDIX D:

SBE Calibration Reports

SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	52765	Date of Report:	12/17/2008
Model Number	SBE 19-02	Serial Number:	192523-0355

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients using the program SEACON. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/17/2008 Drift since last cal: 0.0000 PSU/month*

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: PSU/month*

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	52765	**Date of Report:**	12/15/2008
Model Number	SBE 19-03	**Serial Number:**	19867 1-1448

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients using the program SEACON. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/13/2008 **Drift since last cal:** +0.00020 **PSU/month***

Comments:

'CALIBRATION AFTER CLEANING & REPLATINIZING' ☐ Performed ☑ Not Performed

Date: **Drift since Last cal:** **PSU/month***

Comments:

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0355
CALIBRATION DATE: 17-Dec-08

SBE19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

g = -4.11939362e+000
h = 4.91410094e-001
i = 1.27924869e-003
j = -2.55898270e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 1.31712247e-002
b = 4.75196395e-001
c = -4.10407485e+000
d = -9.96466266e-005
m = 2.3
CPcor = -9.5700e-008 (nominal)

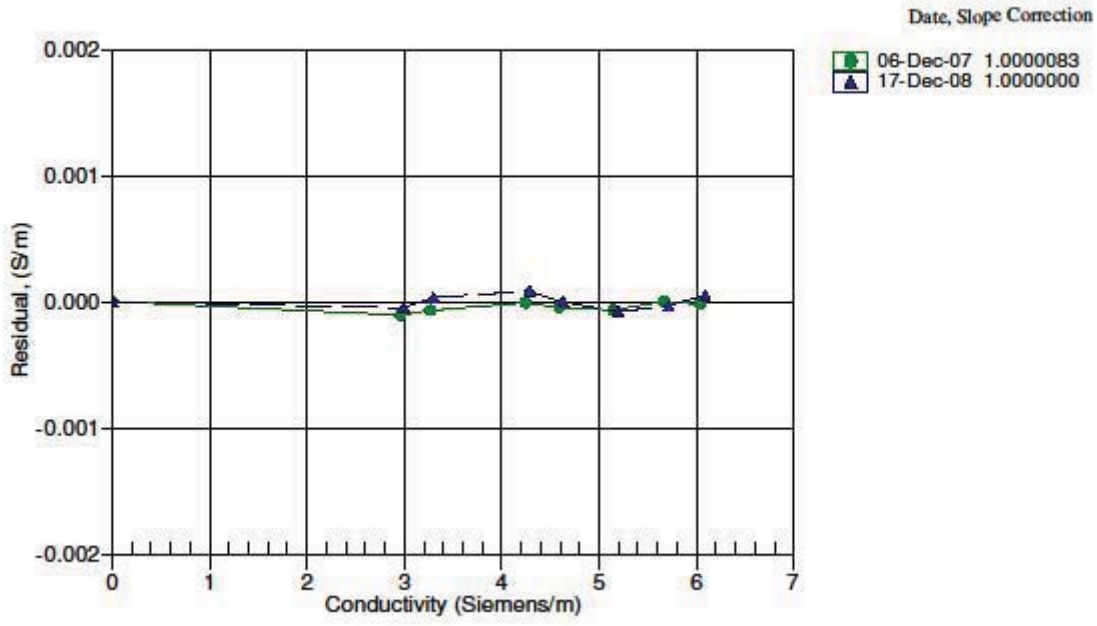
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88512	0.00000	0.00000
1.0000	34.9944	2.98973	8.24638	2.98968	-0.00005
4.5000	34.9742	3.29815	8.60960	3.29818	0.00003
15.0000	34.9315	4.28425	9.67824	4.28433	0.00008
18.5000	34.9219	4.63086	10.02632	4.63086	-0.00000
24.0000	34.9104	5.19107	10.56433	5.19099	-0.00008
29.0000	34.9015	5.71470	11.04325	5.71466	-0.00003
32.5000	34.8953	6.08820	11.37241	6.08826	0.00005

$Conductivity = (g + hf^2 + if^3 + jf^4)/10(1 + \delta t + \varepsilon p)$ Siemens/meter

$Conductivity = (af^m + bf^2 + c + dt)/[10(1 + \varepsilon p)]$ Siemens/meter

t = temperature[°C]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1448
CALIBRATION DATE: 13-Dec-08

SBE19 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.06736703e+000
h =  4.84617149e-001
i =  1.46036909e-003
j = -4.39331929e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.82816481e-002
b =  4.33931014e-001
c = -4.05916562e+000
d = -1.58694218e-004
m =  2.1
CPcor = -9.5700e-008 (nominal)
```

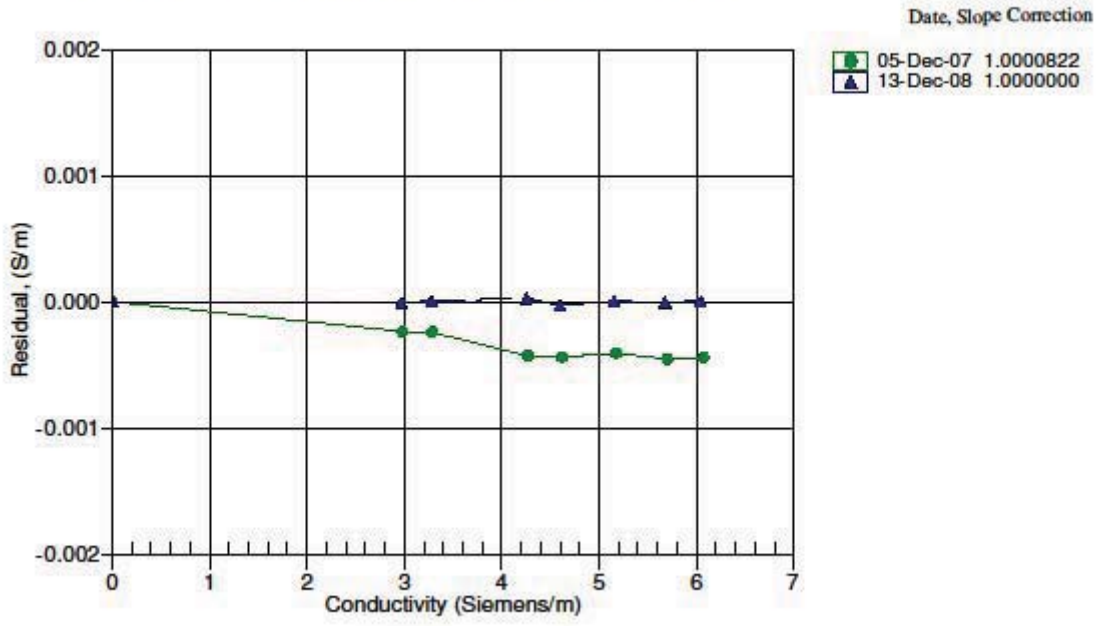
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88563	0.00000	0.00000
1.0000	34.7199	2.96851	8.26849	2.96850	-0.00001
4.5000	34.6999	3.27482	8.63331	3.27483	0.00001
15.0000	34.6565	4.25408	9.70714	4.25411	0.00003
18.5000	34.6470	4.59833	10.05713	4.59830	-0.00003
24.0000	34.6364	5.15482	10.59842	5.15482	0.00000
29.0000	34.6297	5.67519	11.08050	5.67518	-0.00001
32.5001	34.6249	6.04639	11.41190	6.04639	0.00001

$Conductivity = (g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

$Conductivity = (af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0355
CALIBRATION DATE: 08-Jan-09

SBE19 PRESSURE CALIBRATION DATA
1450 psia S/N 2651317 TCV: -140

QUADRATIC COEFFICIENTS:

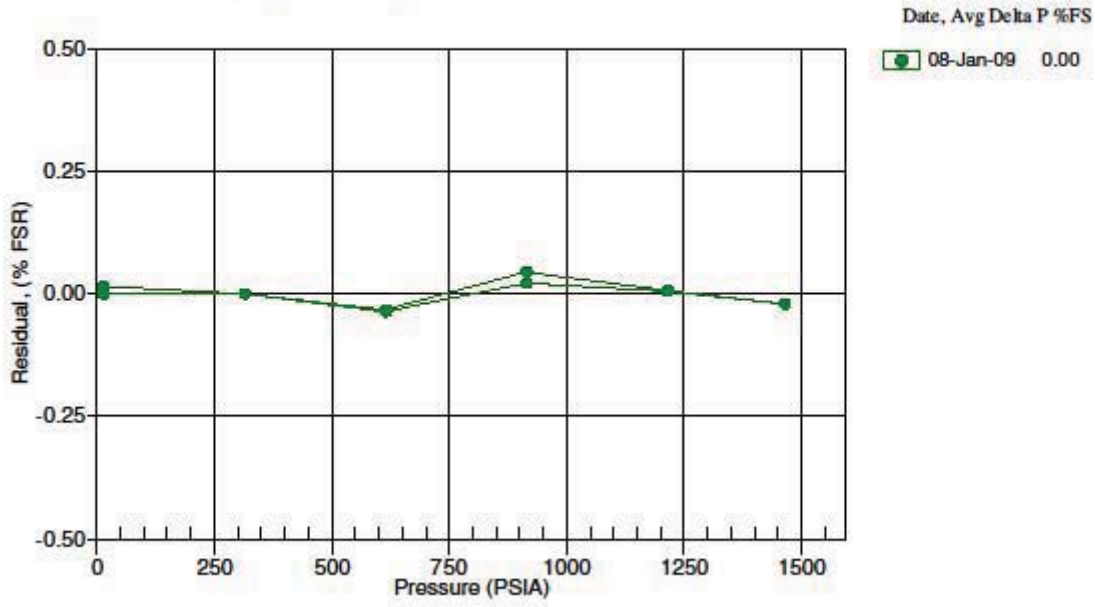
PA0 = 8.554592e+002
PA1 = -2.389059e-001
PA2 = -3.737426e-008

STRAIGHT LINE FIT:

M = -2.389544e-001
B = 8.553286e+002

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.53	3518.0	14.53	-0.00	14.69	0.01
314.86	2262.0	314.86	-0.00	314.81	-0.00
614.90	1009.0	614.37	-0.04	614.22	-0.05
914.87	-250.0	915.18	0.02	915.07	0.01
1214.86	-1505.0	1214.93	0.00	1214.95	0.01
1464.97	-2551.0	1464.66	-0.02	1464.90	-0.00
1214.83	-1505.0	1214.93	0.01	1214.95	0.01
914.79	-251.0	915.42	0.04	915.31	0.04
614.84	1009.0	614.37	-0.03	614.22	-0.04
314.87	2262.0	314.86	-0.00	314.81	-0.00
14.55	3517.0	14.76	0.01	14.93	0.03

Straight Line Fit:
Pressure (psia) = M * N + B (N = binary output)
Quadratic Fit:
pressure (psia) = PA0 + PA1 * N + PA2 * N^2
Residual = (instrument pressure - true pressure) * 100 / Full Scale Range



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1448
CALIBRATION DATE: 10-Dec-08

SBE19 PRESSURE CALIBRATION DATA
300 psia S/N 133250 TCV: 192

QUADRATIC COEFFICIENTS:

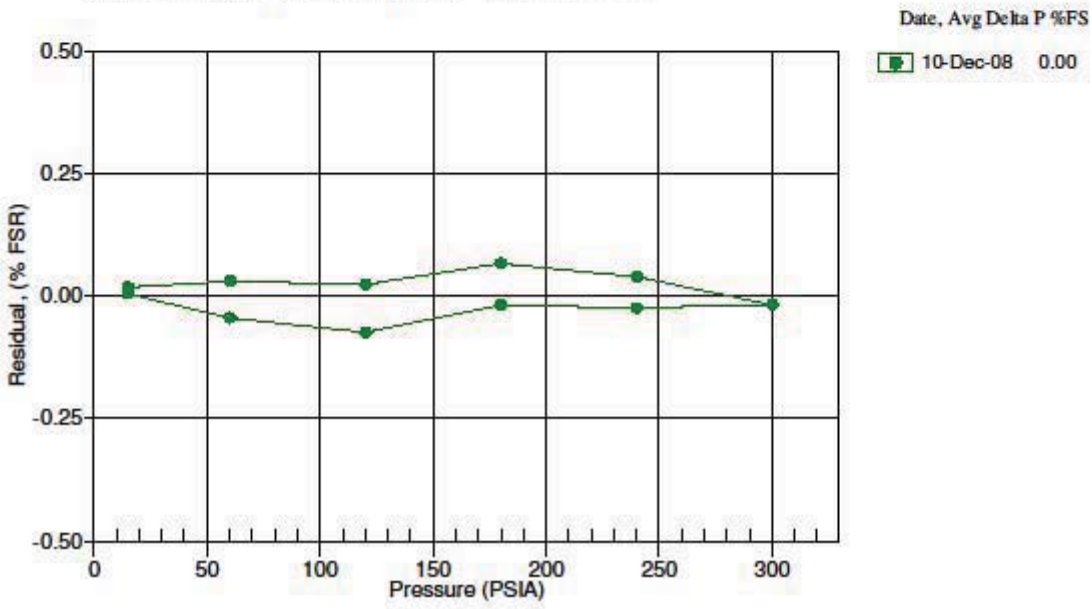
PA0 = 1.478659e+002
PA1 = -3.897773e-002
PA2 = 2.710559e-008

STRAIGHT LINE FIT:

M = -3.897646e-002
B = 1.480191e+002

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.86	3420.0	14.88	0.00	14.72	-0.05
60.09	2259.0	59.95	-0.04	59.97	-0.04
120.08	719.0	119.85	-0.07	120.00	-0.03
180.10	-825.0	180.04	-0.02	180.17	0.03
240.12	-2361.0	240.04	-0.02	240.04	-0.02
300.11	-3894.0	300.06	-0.02	299.79	-0.11
240.12	-2366.0	240.24	0.04	240.24	0.04
180.12	-832.0	180.31	0.07	180.45	0.11
120.14	710.0	120.21	0.02	120.35	0.07
60.14	2252.0	60.23	0.03	60.24	0.04
14.87	3419.0	14.92	0.02	14.76	-0.04

Straight Line Fit:
Pressure (psia) = M * N + B (N = binary output)
Quadratic Fit:
pressure (psia) = PA0 + PA1 * N + PA2 * N^2
Residual = (instrument pressure - true pressure) * 100 / Full Scale Range



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0355
CALIBRATION DATE: 17-Dec-08

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.15704572e-003
h = 5.80560969e-004
i = -1.57862719e-007
j = -2.54097829e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.64763917e-003
b = 5.75069881e-004
c = 6.57522528e-006
d = -2.54085220e-006
f0 = 2411.399

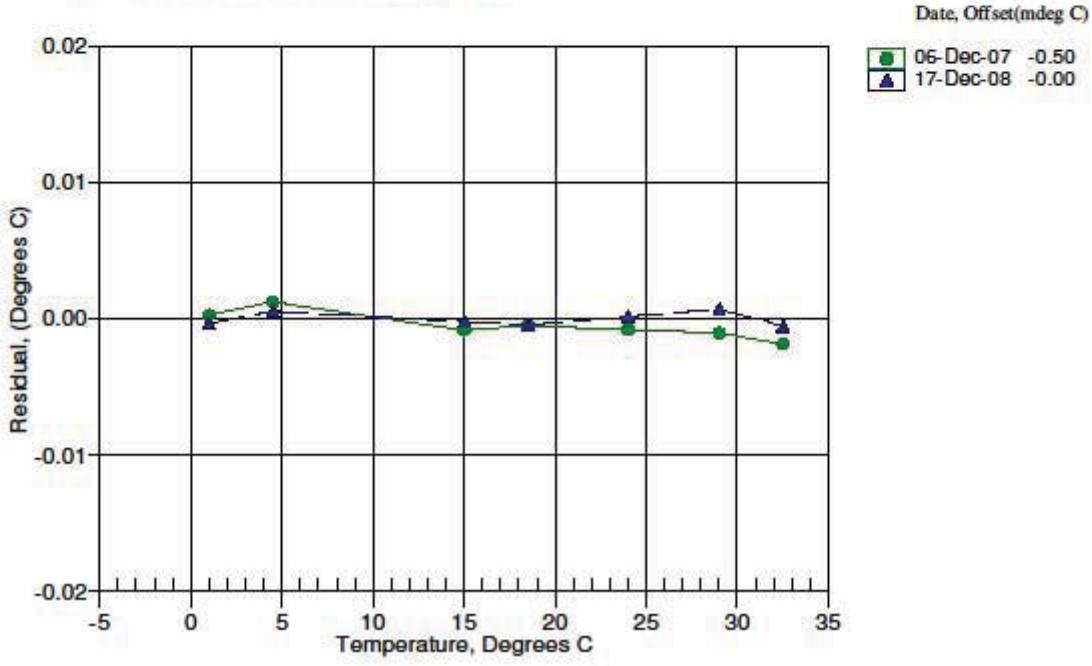
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2411.399	0.9997	-0.00032
4.5000	2612.426	4.5006	0.00056
15.0000	3286.041	14.9998	-0.00019
18.5000	3535.343	18.4996	-0.00044
24.0000	3953.539	24.0002	0.00017
29.0000	4362.699	29.0007	0.00072
32.5000	4665.970	32.4995	-0.00049

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1448
CALIBRATION DATE: 13-Dec-08

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.21715331e-003
h = 5.91982917e-004
i = 5.06082430e-007
j = -2.61060178e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.64763555e-003
b = 5.83822537e-004
c = 8.10247620e-006
d = -2.61035134e-006
f0 = 2629.596

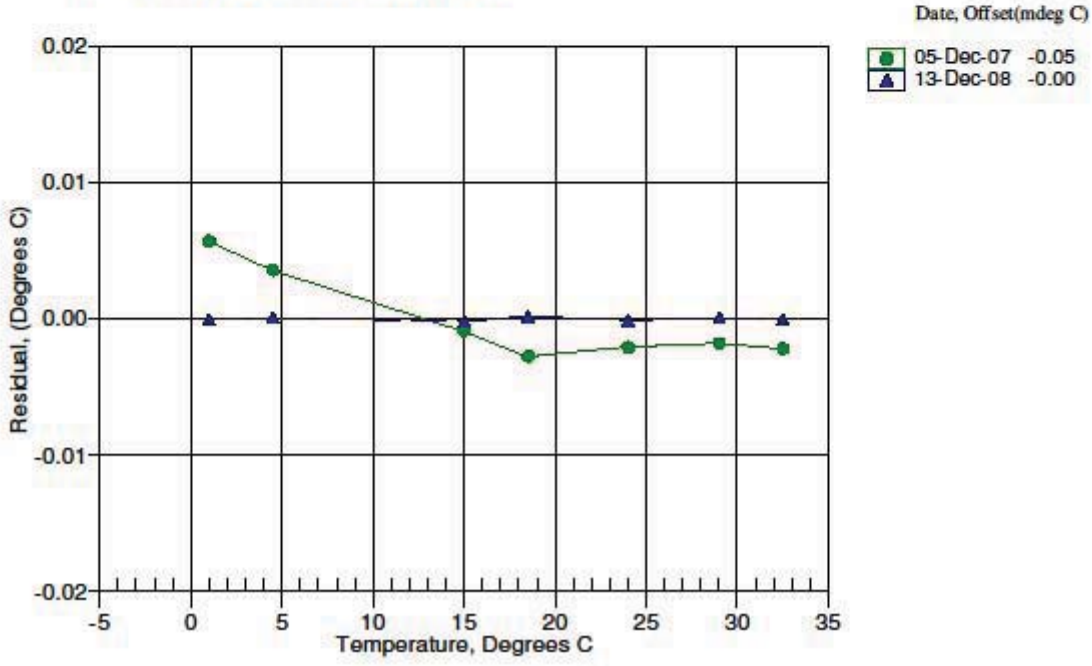
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2629.596	1.0000	-0.00004
4.5000	2845.388	4.5001	0.00009
15.0000	3567.523	14.9998	-0.00019
18.5000	3834.451	18.5002	0.00019
24.0000	4281.693	23.9999	-0.00010
29.0000	4718.926	29.0001	0.00009
32.5001	5042.927	32.5001	-0.00004

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.
1808 - 136th Place Northeast, Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	52765	Date of Report:	12/17/2008
Model Number	SBE 19-02	Serial Number:	192523-0355

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients using the program SEACON. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/17/2008 Drift since last cal: +0.00048 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

SEA-BIRD ELECTRONICS, INC.
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Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Temperature Calibration Report

Customer:	Atlantic Marine Center		
Job Number:	52765	Date of Report:	12/15/2008
Model Number	SBE 19-03	Serial Number:	19867 1-1448

Temperature sensors are normally calibrated 'as received', without adjustments, allowing a determination sensor drift. If the calibration identifies a problem, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing coefficients to convert sensor frequency to temperature. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients using the program SEACON. The coefficient 'offset' allows a small correction for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/13/2008 Drift since last cal: +0.00005 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

APPENDIX E:

Vessel Configurations & TPE Report

```
Vessel Name: R352_MB.hvf
Vessel created: September 20, 2007


Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2006-064 00:00

 Transduer      #1:
 -------------
 Pitch      Offset:     0.900
 Roll      Offset: -0.110
 Azimuth      Offset:   -0.200

 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000

 Manufacturer:
 Model:                   em1002
      Serial Number:

Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2007-044 00:00

 Transduer      #1:
 -------------
 Pitch      Offset:     1.490
 Roll      Offset: 0.040
 Azimuth      Offset:   0.500

 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000

 Manufacturer:
 Model:                   em1002
      Serial Number:

Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2008-051 00:00

 Transduer      #1:
 -------------
 Pitch      Offset:     0.140
 Roll      Offset: -0.080
 Azimuth      Offset:   -0.400

 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000
```

```
 Manufacturer:
 Model:                  em1002
      Serial Number:

Depth Sensor:

      Sensor Class:      Swath
      Time Stamp:  2009-088 00:00

 Transduer      #1:
 -------------
 Pitch      Offset:     0.140
 Roll      Offset: -0.080
 Azimuth      Offset:   -0.700

 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000

 Manufacturer:
 Model:                  em1002
      Serial Number:

_____________________________________________________________
Navigation Sensor:

      Time Stamp:  2006-064 00:00

 Comments
 Latency      0.000
 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000

 Manufacturer:
 Model:
      Serial Number:


      Time Stamp:  2009-088 00:00

 Comments
 Latency      0.200
 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000

 Manufacturer:
 Model:
      Serial Number:

_____________________________________________________________
Gyro Sensor:

      Time Stamp:  2006-064 00:00

 Comments      (null)
```

```
 Latency      0.000

      Entry 0) Draft: 0.000   Speed: 0.000
_____________________________________________________________
Heave Sensor:

      Time Stamp:  2006-064 00:00

      Comments Caris TechNote - SV Corrections for Simrad.pdf  072303
 Apply      No
 Latency      0.000
 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000
 Offset:          0.000

 Manufacturer:           (null)
 Model:                  (null)
      Serial Number:     (null)


_____________________________________________________________
Pitch Sensor:

      Time Stamp:  2003-111 00:00

      Comments Caris TechNote - SV Corrections for Simrad.pdf  072303
 Apply      No
 Latency      0.000
      Pitch offset: 0.000

 Manufacturer:           (null)
 Model:                  (null)
      Serial Number:     (null)


_____________________________________________________________
Roll Sensor:

      Time Stamp:  2006-064 00:00

      Comments Caris TechNote - SV Corrections for Simrad.pdf  072303
 Apply      No
 Latency      0.000
      Roll offset: 0.000

 Manufacturer:           (null)
 Model:                  (null)
      Serial Number:     (null)


_____________________________________________________________
Draft Sensor:

      Time Stamp:  2006-064 00:00

 Apply      Yes
 Comments      (null)
      Entry 1) Draft: 0.007   Speed: 5.054
      Entry 2) Draft: 0.041   Speed: 6.143
```

Entry 3) Draft: 0.002 Speed: 7.911
Entry 4) Draft: 0.032 Speed: 9.778

TPE

Time Stamp: 2006-064 00:01

Comments
Offsets

Motion sensing unit to the transducer 1
X Head 1 1.856
Y Head 1 0.074
Z Head 1 1.800
Motion sensing unit to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000
Navigation antenna to the transducer 1
X Head 1 6.596
Y Head 1 5.760
Z Head 1 17.984
Navigation antenna to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

Roll offset of transducer number 1 -0.014
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000'' of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 2.000
Transducer timing error: 0.000
Navigation timing error: 0.000
Gyro timing error: 0.010
Heave timing error: 0.010
PitchTimingStdDev: 0.010
Roll timing error: 0.010
Sound Velocity speed measurement error: 0.600
Surface sound speed measurement error: 0.500
Tide measurement error: 0.010
Tide zoning error: 0.100
Speed over ground measurement error: 0.250
Dynamic loading measurement error: 0.000
Static draft measurement error: 0.030
Delta draft measurement error: 0.000
StDev Comment: 0>„J ˜†J@3†Jp4†J 1†J0˜…J .†J0^„J`}€J°˜†Ja

Svp Sensor:

Time Stamp: 2006-064 00:00

```
Comments      (null)
Svp      #1:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          1.856
DeltaY:          0.811
DeltaZ:          1.676

SVP      #2:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          0.000
DeltaY:          0.000
DeltaZ:          0.000


     Time Stamp:  2007-044 00:00

Comments      (null)
Svp      #1:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          1.856
DeltaY:          0.811
DeltaZ:          1.676

SVP      #2:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          0.000
DeltaY:          0.000
DeltaZ:          0.000


     Time Stamp:  2008-051 00:00

Comments      (null)
Svp      #1:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          1.856
```

```
DeltaY:          0.811
DeltaZ:          1.676

SVP      #2:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          0.000
DeltaY:          0.000
DeltaZ:          0.000


     Time Stamp:  2009-088 00:00

Comments      (null)
Svp      #1:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          1.856
DeltaY:          0.811
DeltaZ:          1.676

SVP      #2:
-------------
Pitch      Offset:     0.000
Roll      Offset: 0.000
Azimuth      Offset:   0.000

DeltaX:          0.000
DeltaY:          0.000
DeltaZ:          0.000
```

```
WaterLine:

     Time Stamp:  2009-080 00:00

Comments
Apply      No
WaterLine      -1.980
```

Vessel Name: NF_7125.hvf
Vessel created: April 13, 2009

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2009-087 00:00

Transduer #1:

Pitch Offset: -2.180
Roll Offset: -0.250
Azimuth Offset: 3.380

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer:
Model: sb7125d
Serial Number:

Navigation Sensor:

Time Stamp: 2009-087 00:00

Comments (null)
Latency 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2009-087 00:00

Comments
Latency 0.000

Heave Sensor:

Time Stamp: 2009-087 00:00

Comments (null)
Apply Yes
Latency 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

```
 Offset:          0.000

 Manufacturer:           (null)
 Model:                  (null)
      Serial Number:     (null)

_____________________________________________________________
Pitch Sensor:

      Time Stamp:  2009-087 00:00

 Comments      (null)
 Apply      Yes
 Latency      0.000
      Pitch offset: 0.000

 Manufacturer:           (null)
 Model:                  (null)
      Serial Number:     (null)

_____________________________________________________________
Roll Sensor:

      Time Stamp:  2009-087 00:00

 Comments      (null)
 Apply      Yes
 Latency      0.000
      Roll offset: 0.000

 Manufacturer:           (null)
 Model:                  (null)
      Serial Number:     (null)

_____________________________________________________________
Draft Sensor:

      Time Stamp:  2009-087 00:00

 Apply      Yes
 Comments      (null)
      Entry 1) Draft: 0.007   Speed: 5.054
      Entry 2) Draft: 0.041   Speed: 6.143
      Entry 3) Draft: 0.002   Speed: 7.911
      Entry 4) Draft: 0.032   Speed: 9.778
_____________________________________________________________
TPE

      Time Stamp:  2009-060 00:00

 Comments
 Offsets

      Motion sensing unit to the transducer 1
            X Head 1 -0.170
            Y Head 1 -0.135
            Z Head 1 2.445
```

```
      Motion sensing unit to the transducer 2
            X Head 2 0.000
            Y Head 2 0.000
            Z Head 2 0.000
      Navigation antenna to the transducer 1
            X Head 1 -6.226
            Y Head 1 29.090
            Z Head 1 -17.022
      Navigation antenna to the transducer 2
            X Head 2 0.000
            Y Head 2 0.000
            Z Head 2 0.000

      Roll offset of transducer number 1 0.000
      Roll offset of transducer number 2 0.000

      Heave Error: 0.050 or 5.000'' of heave amplitude.
      Measurement errors: 0.020
      Motion sensing unit alignment errors
 Gyro:0.000       Pitch:0.000 Roll:0.000
      Gyro measurement error: 0.020
      Roll measurement error: 0.020
      Pitch measurement error: 0.020
      Navigation measurement error: 2.000
      Transducer timing error: 0.000
      Navigation timing error: 0.000
      Gyro timing error: 0.000
      Heave timing error: 0.010
 PitchTimingStdDev:      0.010
      Roll timing error: 0.010
      Sound Velocity speed measurement error: 0.000
      Surface sound speed measurement error: 0.000
      Tide measurement error: 0.000
      Tide zoning error: 0.000
      Speed over ground measurement error: 0.250
      Dynamic loading measurement error: 0.000
      Static draft measurement error: 0.030
      Delta draft measurement error: 0.000
      StDev Comment: 0>„J ˜†J@3†Jp4†J 1†J0˜…J .†J0^„J`}€J°˜†Ja
_____________________________________________________________
Svp Sensor:

      Time Stamp:  2009-087 00:00

 Comments      (null)
 Svp      #1:
 -------------
 Pitch      Offset:     0.000
 Roll      Offset: 0.000
 Azimuth      Offset:   0.000

 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000

 SVP      #2:
 -------------
```

```
 Pitch      Offset:     0.000
 Roll      Offset: 0.000
 Azimuth      Offset:   0.000

 DeltaX:          0.000
 DeltaY:          0.000
 DeltaZ:          0.000
```

```
WaterLine:

      Time Stamp:  2009-087 00:00

 Comments      (null)
 Apply      Yes
 WaterLine      -3.459
```

Total Propagated Error (TPE) Report

NOAA Ship NANCY FOSTER 2006

Caris HIPS 6.0 has an error model that derives from a sounding's source errors the total propagated error (TPE) for that sounding. The sources of the estimates of the various errors vary from manufacturers' specifications, to theoretical values, to field tested empirical observations. The error estimates (one sigma) are entered into the TPE sensor section of an HVF.

Below is a table listing various source errors and their estimate, followed by a detailed discussion describing each error estimate.

Error Source	Error Estimate
Heave % Amplitude	5.0
Heave	0.05
Gyro	0.02
Roll	0.02
Pitch	0.02
Navigation	4.0
Timing Transducer	unknown
Navigation Timing	unknown
Gyro Timing	0.01
Heave Timing	0.01
Pitch Timing	0.01
Roll Timing	0.01
Sound Velocity Measured	0.05
Surface	0.05
Tide Measured	0.05
Tide Zoning	0.3
Offset X	0.02
Offset Y	0.02
Offset Z	0.02
Vessel Speed	0.25
Loading	unknown
Draft	0.03
Delta Draft	unknown

Detailed Discussion of Error Estimates

Heave % Amplitude

Error: 5.0

Definition: *Heave % Amplitude* is an additional heave standard deviation component that is the percentage of the instantaneous heave.

Discussion: See *Heave* discussion below.

Heave

Error: 0.05

Definition: *Heave* is the measurement for standard deviation of the heave data in meters.

Discussion: The POS/MV heave error is given as 0.05 meters + 5% of heave; however, the Caris error model implementation uses *Heave* or *Heave % Amplitude*, whichever is greater (see *Heave* discussion below). Thus a value of 0.06 for *Heave* is used as a compromise

Gyro

Error: 0.02

Definition: *Gyro* is the measurement standard deviation of the heading data in degrees.

Discussion: *Gyro* is based on POS/MV manufacturer specifications

Roll

Error: 0.02

Definition: *Roll* is the measurement standard deviation of the roll data in degrees.

Discussion: *Roll* is based on POS/MV manufacturer specifications.

Pitch

Error: 0.02

Definition: *Gyro* is the measurement standard deviation of the heading data in degrees.

Discussion: *Pitch* is based on POS/MV manufacturer specifications.

Navigation

Error: 4.0
Definition: *Navigation* is the standard deviation associated with the measurement of positions for the vessel in meters.
Discussion: *Navigation* is based on POS/MV manufacturer specifications.

Timing Transducer

Error: 0.0
Definition: *Timing Transducer* is the standard deviation of transducer time stamp measurements.
Discussion: *Timing Transducer* is not known and is currently being researched.

Navigation Timing

Error: 0.0
Definition: *Navigation Timing* is the standard deviation of navigation time stamp measurements.
Discussion: *Navigation Timing* is not known and is currently being researched.

Gyro Timing

Error: 0.01
Definition: *Gyro Timing* is the standard deviation of gyro time stamp measurements.
Discussion: *Gyro Timing* is based on POS/MV manufacturer specifications.

Heave Timing

Error: 0.01
Definition: *Heave Timing* is the standard deviation of heave time stamp measurements.
Discussion: *Heave Timing* is based on POS/MV manufacturer specifications.

Pitch Timing

Error: 0.01
Definition: *Pitch Timing* is the standard deviation of pitch time stamp measurements.
Discussion: *Pitch Timing* is based on POS/MV manufacturer specifications.

Roll Timing

Error: 0.01
Definition: *Roll Timing* is the standard deviation of roll time stamp measurements.
Discussion: *Roll Timing* is based on POS/MV manufacturer specifications.

Sound Velocity Measured

Error: 0.05
Definition: *Sound Velocity Measured* is the standard deviation of the measurement of sound velocity readings in meters/second.
Discussion: *Sound Velocity Measured* is based on SEACAT manufacturer specifications.

Surface

Error: 0.05
Definition: *Surface* is the standard deviation of the measurement of surface sound speed readings in meters/second.
Discussion: This value is currently being researched. In the meantime, NOAA Ship NANCY FOSTER will use 0.05, which is what NOAA Ship THOMAS JEFFERSON used for its Simrad SSVS.

Tide Measured

Error: 0.05
Definition: *Tide Measured* is the standard deviation of the measured tide values in meters.
Discussion: *Tide Measured* is based on CO-OPS calculations.

Tide Zoning

Error: 0.3
Definition: *Tide Zoning* is the standard deviation of the tide values associated with zoning in meters.
Discussion: *Tide Zoning* is based on general CO-OPS calculations.

Offset X

Error: 0.02
Definition: *Offset X* is the standard deviation of the measured X offsets of the vessel.
Discussion: *Offset X* is the accuracy limit of whatever survey method was used to survey the vessel.

Offset Y

Error: 0.02
Definition: *Offset Y* is the standard deviation of the measured X offsets of the vessel.
Discussion: *Offset Y* is the accuracy limit of whatever survey method was used to survey the vessel.

Offset Z

Error:	0.02
Definition:	*Offset Z* is the standard deviation of the measured X offsets of the vessel.
Discussion:	*Offset Z* is the accuracy limit of whatever survey method was used to survey the vessel.

Vessel Speed

Error:	0.25
Definition:	*Vessel Speed* is the standard deviation for the vessel speed measurements in meters/second.
Discussion:	*Vessel Speed* requires further research. In the meantime, NANCY FOSTER is using what THOMAS JEFERSON

Loading

Error:	0
Definition:	*Loading* is the measurement standard deviation of the vertical changes during the survey because of fuel consumption, etc. *Loading* corresponds to the Caris waterline measurement error.
Discussion:	*Loading* is not currently used. Further investigation is required.

Draft

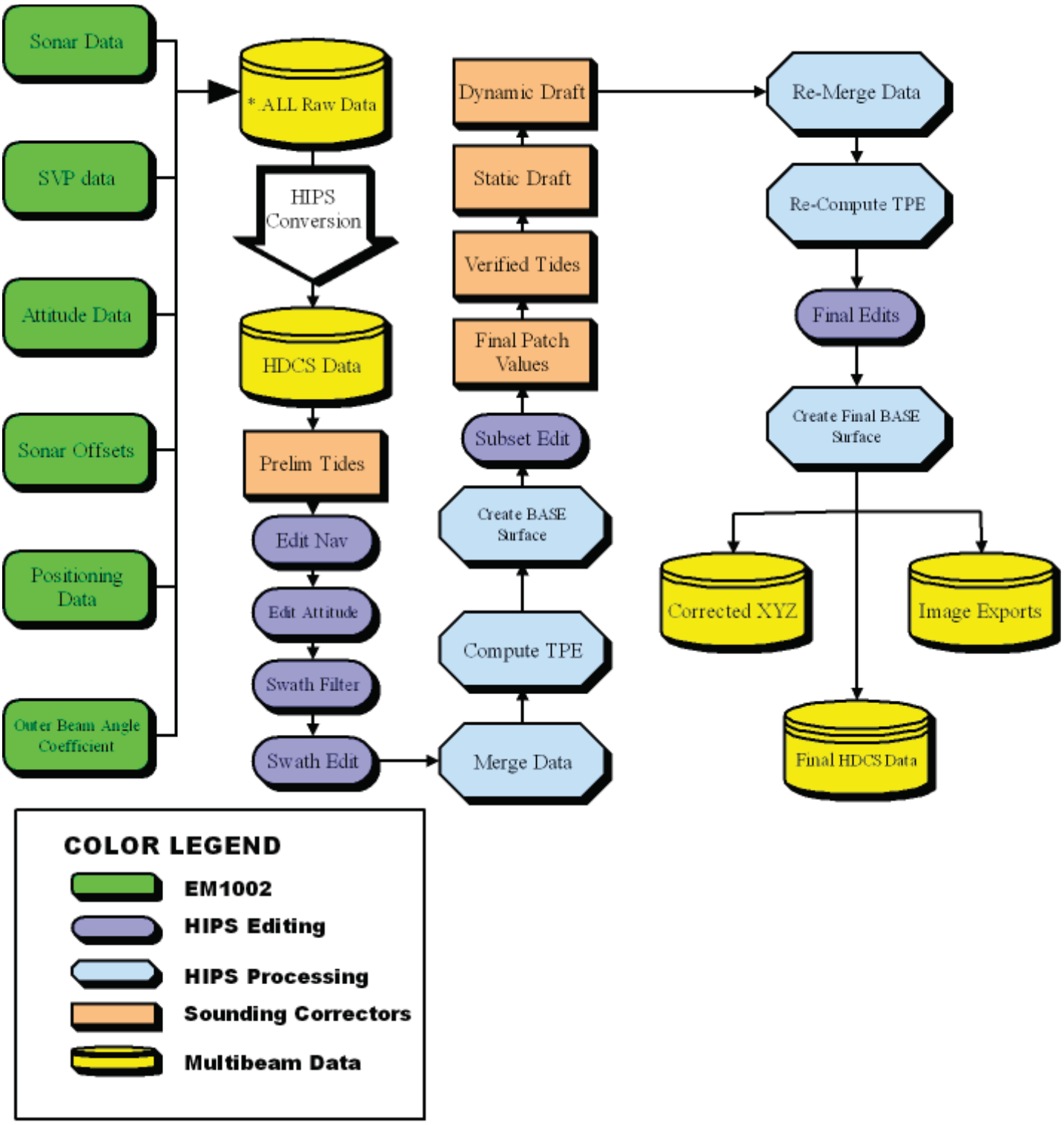
Error:	0.03
Definition:	*Draft* is the standard deviation of the vessel draft measurements in meters.
Discussion:	*Draft* is the accuracy limit of the draft measuring method.

Delta Draft

Error:	0
Definition:	*Delta Draft* is the standard deviation of the dynamic vessel draft measurements in meters.
Discussion:	*Delta Draft* is not currently used. Further investigation is required.

APPENDIX F:

CARIS Processing Flow Chart


Sonar Data
SVP data
Attitude Data
Sonar Offsets
Positioning Data
Outer Beam Angle Coefficient
* .ALL Raw Data
HIPS Conversion
HDCS Data
Prelim Tides
Edit Nav
Edit Attitude
Swath Filter
Swath Edit
Merge Data
Compute TPE
Create BASE Surface
Subset Edit
Final Patch Values
Verified Tides
Static Draft
Dynamic Draft
Re-Merge Data
Re-Compute TPE
Final Edits
Create Final BASE Surface
Corrected XYZ
Image Exports
Final HDCS Data
COLOR LEGEND
EM1002
HIPS Editing
HIPS Processing
Sounding Correctors
Multibeam Data

APPENDIX G:

NOAA Ship NANCY FOSTER Static Offset Reports

L3 communications
Power & Control Systems Group
PacOrd

2/8/2006

Subj : NOAA SHIP Nancy Foster Survey

Ref: (a) SW225-AO-MMA-010/OP762/ALIGN THEORY, Theory of Combat System Alignment
(b) Table 1 of ITEM NO. 501

Encl: (1) Foundation Leveling Data Sheets

PacOrd personnel accomplished the survey of the equipment listed in table 1 of work item # 501 on board the NOAA SHIP Nancy Foster.

The granite blocks Roll and Pitch planes were set to the ship's gravity plane. The granite block was then used as the reference for all readings requiring a comparison to the ship's gravity plane.

The ship's centerline was transferred up from the keel, to the granite block 0°-180° reference line through an access cut into the hull of the ship. The granite block reference lines were then used as the reference for all readings requiring centerline reference.

The IMU foundation had to be removed, drilled and tapped for the new style IMU and reset.

The 12KHZ Transducer pitch angle exceeds the ±0.25° allowed by four minutes (reading is +0.3166°), a waiver was received from NOAA for this condition.

All other readings are within tolerance.

The final survey data is summarized in enclosure (1).

Byron K. Dunn
CSA Engineer

3161-3 St. Johns Bluff Rd
Jacksonville, Fl 32246
(904) 641-5442 - Phone
(904) 641-9967 - Fax

communications
PacOrd

SERIAL NO. 00656.001.02-03

INSPECTION/DEFICIENCY REPORT

JOB ORDER NO.

VESSEL NAME: NOAA SHIP NANCY FOSTER

DATE SUBMITTED: 7-Feb-06

WORK ITEM NO: 501

PARAGRAPH: para. 7.5

INSPECTION DATE(S): 11/14/05-02/02/06

TITLE OF WORK ITEM: SURVEY

TYPE OF REPORT

NOTICE ☐ IDR/CFR ☒ REQ REPORT ☐ PCP ☐ INFO ONLY ☐ OTHER

BALANCE REPORT

☐ PRINTS/DWG ☐ CFM/CFE ☐ GFM/GFE ☐ CONFLICTING PRINTS/DWGS SUPPLIED

☐ PRINTS/DWGS DO NOT REFLECT EXISTING SHIPBOARD / SITE CONDITIONS; DWG. NO:

incorrect: ☐ SPECIFICATIONS ☐ COMPARTMENT ☐ LOCATION REFERENCED SYSTEM:

PROBLEM/CONDITION:

Contractor accomplished Alignment Survey.
See attached results.

RECOMMEND: ☐ ISSUE A CHANGE ORDER ☒ ACCEPT REQUIRED REPORT ☐ ACCEPT PCP ☐ ACCEPT INFO ☒ SEE ATTACHED

Recommend Supervisor accept required report.

LEAD SHOP/AFFECTED TRADES	SIGNATURE OF ORIGINATOR	PRINT NAME	DATE
PacOrd	Byron K Dunn	Byron K. Dunn	7-Feb-06

PROGRAM MANAGER/PROJECT SUPERINTENDENT DIRECTIONS

THE ABOVE RECOMMENDATIONS NEED TO BE CONTRACTUALLY INVOKED WITHIN DAYS OF ## TO LIMIT PRODUCTION IMPACT

☐ THIS REPORT EFFECTS CRITICAL PATH ☐ CHARGED TO BASIC ☐ CHANGE TO BE ISSUED ☐ AUTHORIZED TO PROCEED

CUSTOMER /SUPSHIP FINDINGS, RECOMMENDATIONS AND/OR APPROVAL

SIGNATURE	PRINT NAME	DATE

ENCLOSURE 1

L3 communications
Power & Control Systems Group
PacOrd

PacOrd
Jacksonville Division
3161-3 St. Johns Bluff
Jacksonville, FL 32246
Phone:(904) 641-5442
Fax: (904) 641-9967

SYSTEM	All readings are in centimeters Horiz X	Horiz Y		Vert Z		All readings are in Degrees Heading Degrees		Pitch Degrees		Roll Degrees	
Granite Block	0.0	0.0		0.0		0.0000	±0.1°	-0.0022	±0.0025°	0.0014	±0.0025°
IMU Foundation	73.7	0.1	±0.5cm	4.3	±0.5cm	0.0573	±0.1°	0.0061	±0.01°	0.0092	±0.01°
IMU To Surface	73.7	0.1	±0.5cm	-12.5	±0.5cm	0.0573	±0.1°	0.0061	±0.01°	0.0092	±0.01°
AFT POS/MV Antenna #2	430.9	-473.7	±0.5cm	-1628.2	±0.5cm	N/A		N/A		N/A	
FWD POS/MV Antenna #1	657.1	-474.0	±0.5cm	-1630.8	±0.5cm	N/A		N/A		N/A	
POS/MV Antenna rel. to each other	226.2	-0.3	±0.5cm	N/A	-	N/A	-	N/A	-	N/A	-
Center of Roll and Pitch	-1229.5	0.0	±5cm	-196.5	±5cm	NA	-	NA	-	NA	-
Ship' Draft Marks Aft Stbd	-3138.5	609.6	±5cm	-289.4	±2cm	NA	-	NA	-	NA	-
Ship' Draft Marks Aft Port	-3138.5	-609.6	±5cm	-289.4	±2cm	NA	-	NA	-	NA	-
Ship' Draft Marks Fwd Stbd	1071.7	350.5	±5cm	-350.4	±2cm	NA	-	NA	-	NA	-
Ship' Draft Marks Fwd Port	1071.7	-350.5	±5cm	-350.4	±2cm	NA	-	NA	-	NA	-
Port Gyro	216.5	0.0	±5cm	-1254.8	±2cm	0.0017	±0.25°	NA	-	NA	-
Stbd Gyro	216.5	43.2	±5cm	-1254.8	±2cm	0.0047	±0.25°	NA	-	NA	-
EM 1002 Multibeam Foundation (Bottom)	81.1	185.6	±1cm	153.7	±1cm	0.0286	±0.1°	0.0500	±0.025°	-0.0139	±0.025°
EM 1002 Multibeam	81.1	185.6	±1cm	167.6	±1cm	0.0286	±0.1°	0.0500	±0.1°	-0.0139	±0.1°
ADCP	-665.5	-157.8	±5cm	154.6	±2cm	45.0750	±0.25°	-0.0750	±0.25°	0.0167	±0.25°
AFT Deck Bench Mark Port	-3783.7	-527.1	±0.5cm	-386.1	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
AFT Deck Bench Mark Stbd	-3783.7	527.1	±0.5cm	-386.1	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
AFT Deck Alignment Cube	-3594.5	581.7	±0.5cm	-471.2	±0.5cm	0.0000	±0.1°	0.0555	±0.01°	-0.0083	±0.01°
Moon Pool BM	-2197.7	121.9	±0.5cm	-385.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Flying Bridge Port BM	469.9	-559.4	±0.5cm	-1419.9	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Flying Bridge Stbd BM	469.2	561.4	±0.5cm	-1418.6	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Flying Bridge Alignment Cube	648.3	2.5	±0.5cm	-1431.2	±0.5cm	0.0000	±0.1°	0.0333	±0.01°	-0.0333	±0.01°
Dry Lab Fwd Bench Mark	-462.6	313.5	±0.5cm	-589.0	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Dry Lab Aft Bench Mark	-993.2	313.5	±0.5cm	-589.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°
Dry Lab Alignment Cube	-639.3	102.9	±0.5cm	-588.7	±0.5cm	0.0000	±0.1°	0.0500	±0.01°	0.0083	±0.01°
Computer Lab Fwd Bench Mark	-600.4	-380.9	±0.5cm	-596.7	±0.5cm	0.0667	±0.1°	NA	±0.05°	NA	±0.05°
Computer Lab Aft Bench Mark	-1070.2	-380.8	±0.5cm	-597.8	±0.5cm	0.0667	±0.1°	NA	±0.05°	NA	±0.05°
Computer Lab Alignment Cube	-837.9	-162.2	±0.5cm	-569.7	±0.5cm	0.0000	±0.1°	0.0042	±0.01°	0.0167	±0.01°
IMU AFT Bench Mark	-146.9	16.6	±0.5cm	-19.7	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°

IMU FWD Bench Mark	339.0	17.4	±0.5cm	-19.5	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
IMU Alignment Cube	161.1	169.2	±0.5cm	-4.4	±0.5cm	0.0000	±0.1°	-0.0111	±0.01°	-0.0528	±0.01°	
ADCP AFT Bench Mark	-1169.8	-26.7	±0.5cm	-38.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
ADCP FWD Bench Mark	-148.7	-26.7	±0.5cm	-38.4	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
ADCP Alignment Cube	-668.5	-208.0	±0.5cm	18.4	±0.5cm	0.0000	±0.1°	0.0389	±0.01°	0.0444	±0.01°	
Gyro Bench Mark Fwd	216.5	22.4	±0.5cm	-1164.5	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
Gyro Bench Mark Aft	-98.5	22.4	±0.5cm	-1156.9	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
Keel Bench Mark Fwd	318.6	1.9	±0.5cm	108.3	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
Keel Bench Mark Aft	-118.3	1.9	±0.5cm	108.3	±0.5cm	0.0000	±0.1°	NA	±0.05°	NA	±0.05°	
12Khz Stbd	-634.4	-157.8	±5cm	154.6	±2cm	N/A	-	0.3167	±0.25°	-0.1167	±0.25°	
200KHZ Transducer	-236.7	-90.2	±5cm	108.3	±2cm	N/A	-	0.0917	±0.25°	-0.0333	±0.25°	
Moon Pool Adapter	-2248.7	121.3	±5cm	111.8	±2cm	N/A	-	-0.0250	±0.25°	0.1500	±0.25°	

X dimension readings forward of Granite Block = positive, aft of Granite Block =negative

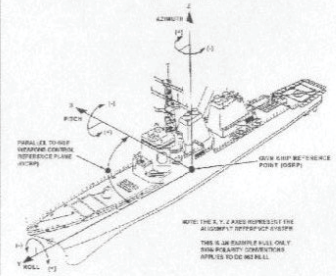
Y dimension readings starboard of Granite Block = positive, port of Granite Block =negative

Z dimension readings lower than Granite Block = positive, higher than Granite Block =negative

Port Down = Positive

Bow Down = Positive

Figure 3-53. Sign Polarity Convention



U.S. Department of Commerce

National Oceanic & Atmospheric Administration

National Ocean Service

National Geodetic Survey

Field Operations Branch

NOAA Ship – Nancy Foster

IMU Component Spatial Relationship Survey

Field Report

Kevin Jordan

March, 2009

NOAA Ship – Nancy Foster
IMU Survey

PURPOSE

The intention of this survey was to accurately position an Inertial Measuring Unit (IMU) that was to be installed onboard the Nancy Foster Coastal Research Vessel.

PROJECT DETAILS

This survey was conducted on March 10, 2009 at the Old Naval Shipyard in Charleston, South Carolina while the ship was docked. The weather was clear and sunny on the day of the survey. Reconnaissance was conducted, but there were no centerline marks found as described. Control for this survey was based on alignment cubes recovered and a coordinate report for a survey submitted February 2, 2006 by L3 Communications.

INSTRUMENTATION

The TOPCON GPT 3000 Series Total Station was used to make all measurements.

A SECO 25 mm Mini Prism System with a 30mm offset was used as target sighting and distance measurements.

SOFTWARE AND DATA COLLECTION

ADL Ver. 1.3.4 was used for data collection

ForeSight DXM Ver. 3.2.2 was used for post processing.

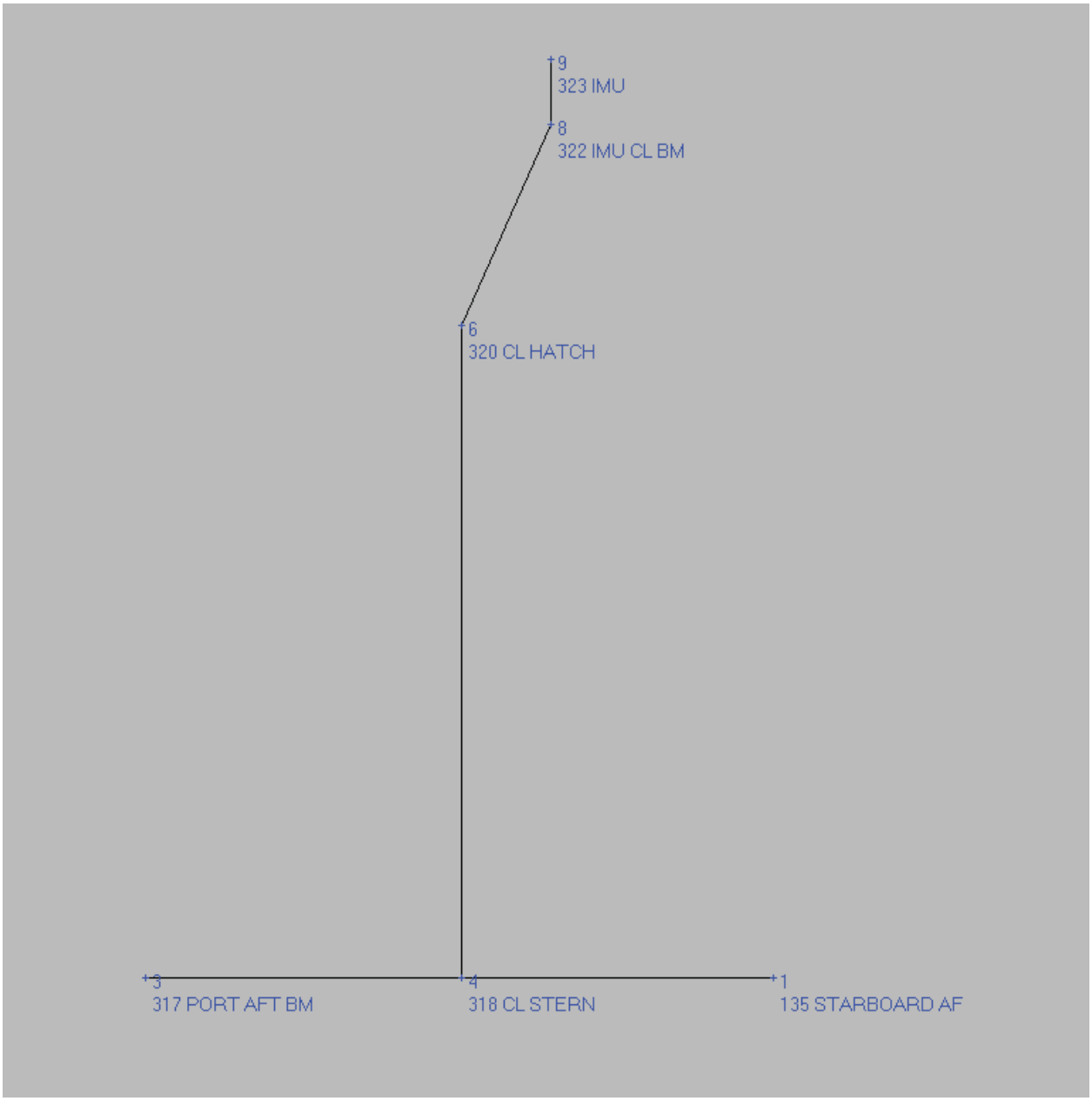
PERSONNEL

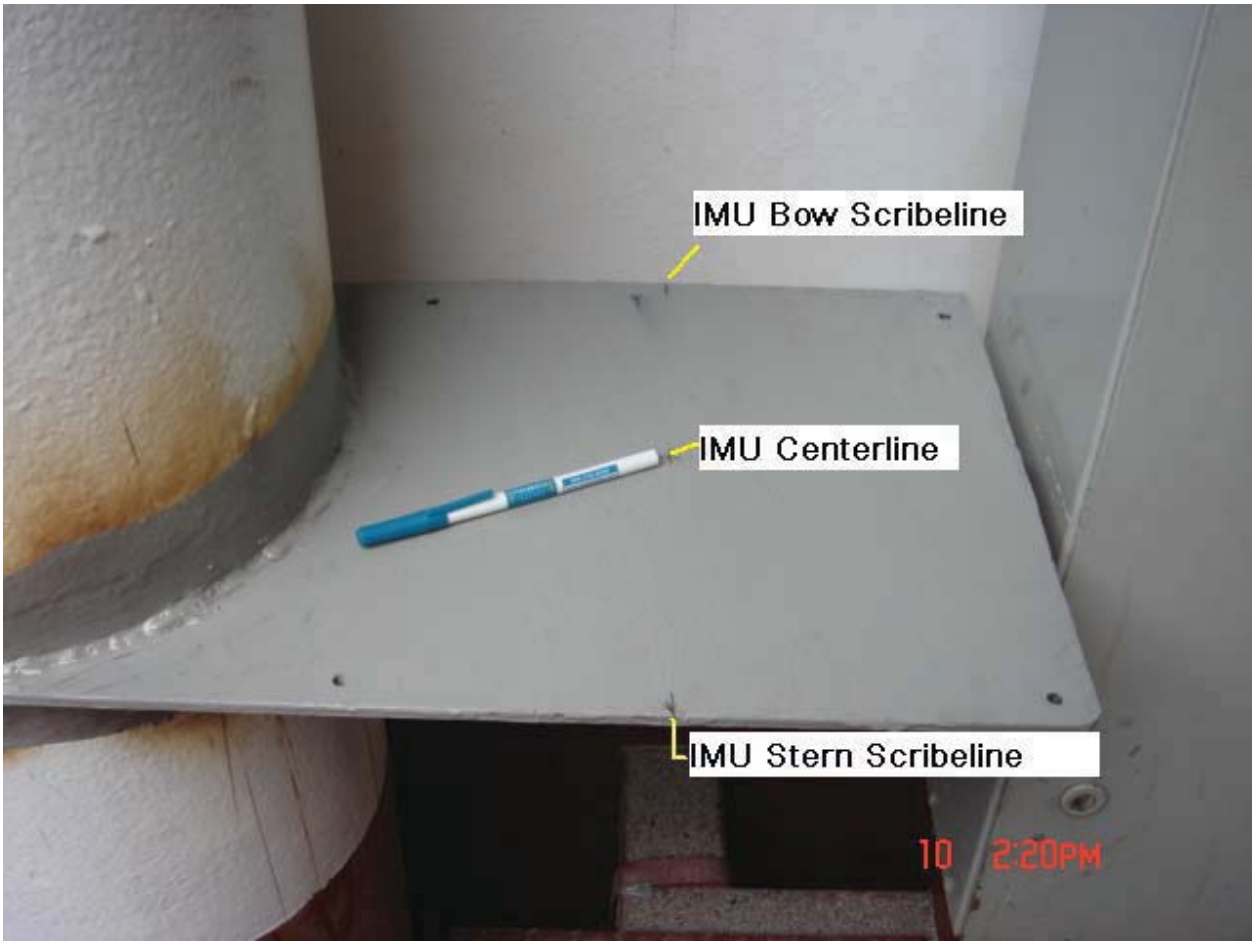
Perky Falconer NOAA/NOS/NGS/Field Operations Branch 757-441-5460

Kevin Jordan NOAA/NOS/NGS/Field Operations Branch 757-441-5461

DESCRIPTION	NORTHING*	EASTING*	ELEVATION*
IMU CL	-22.525 m	1.555 m	1.308 m
IMU BOW SCRIBELINE	-22.512 m	1.555 m	1.308 m
IMU STERN SCRIBELINE	-22.690 m	1.555 m	1.308 m

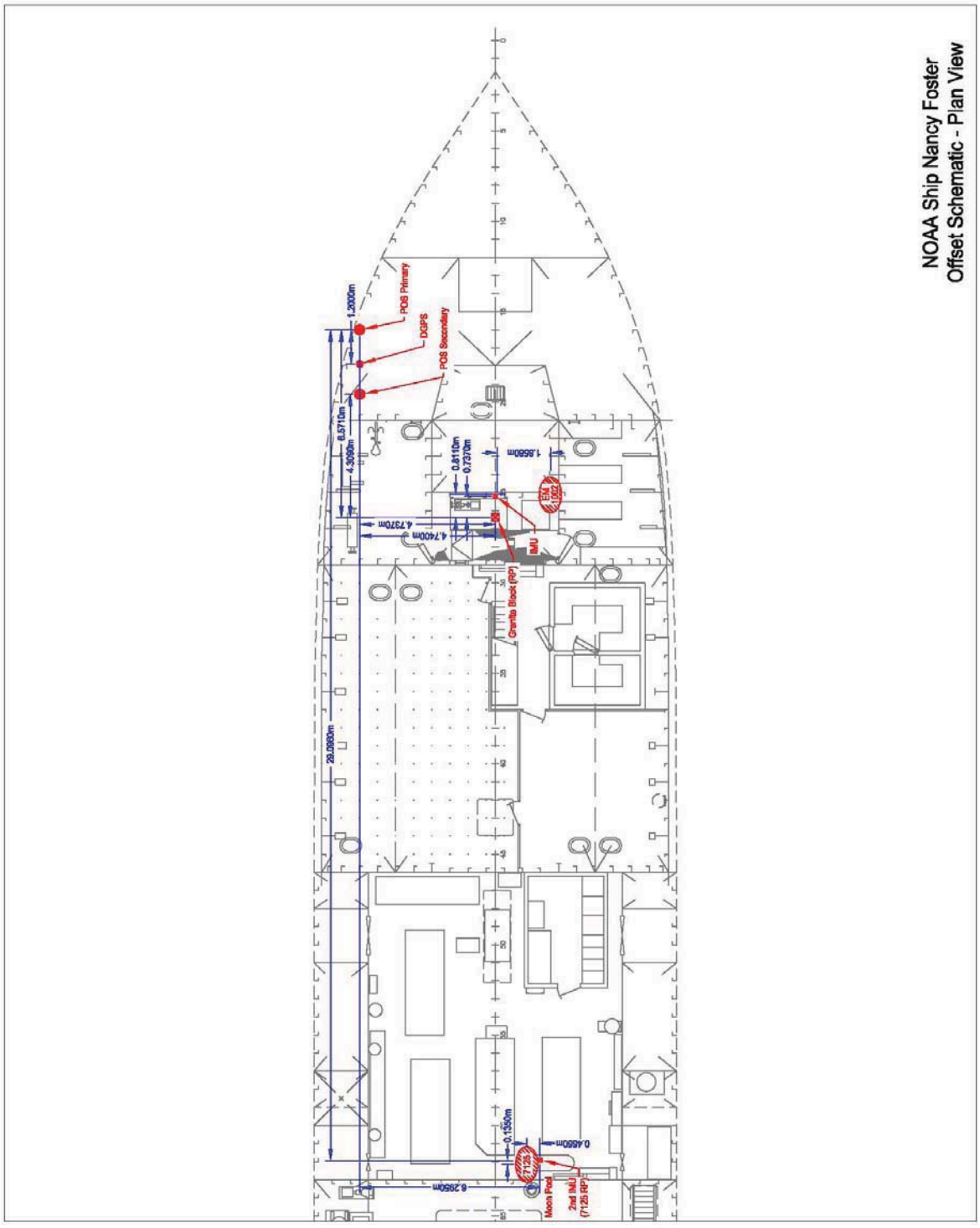
*all positions and elevations are referenced from the ship's granite block with a value of 0.000m northing, 0.000m easting, and 0.000m elevation.

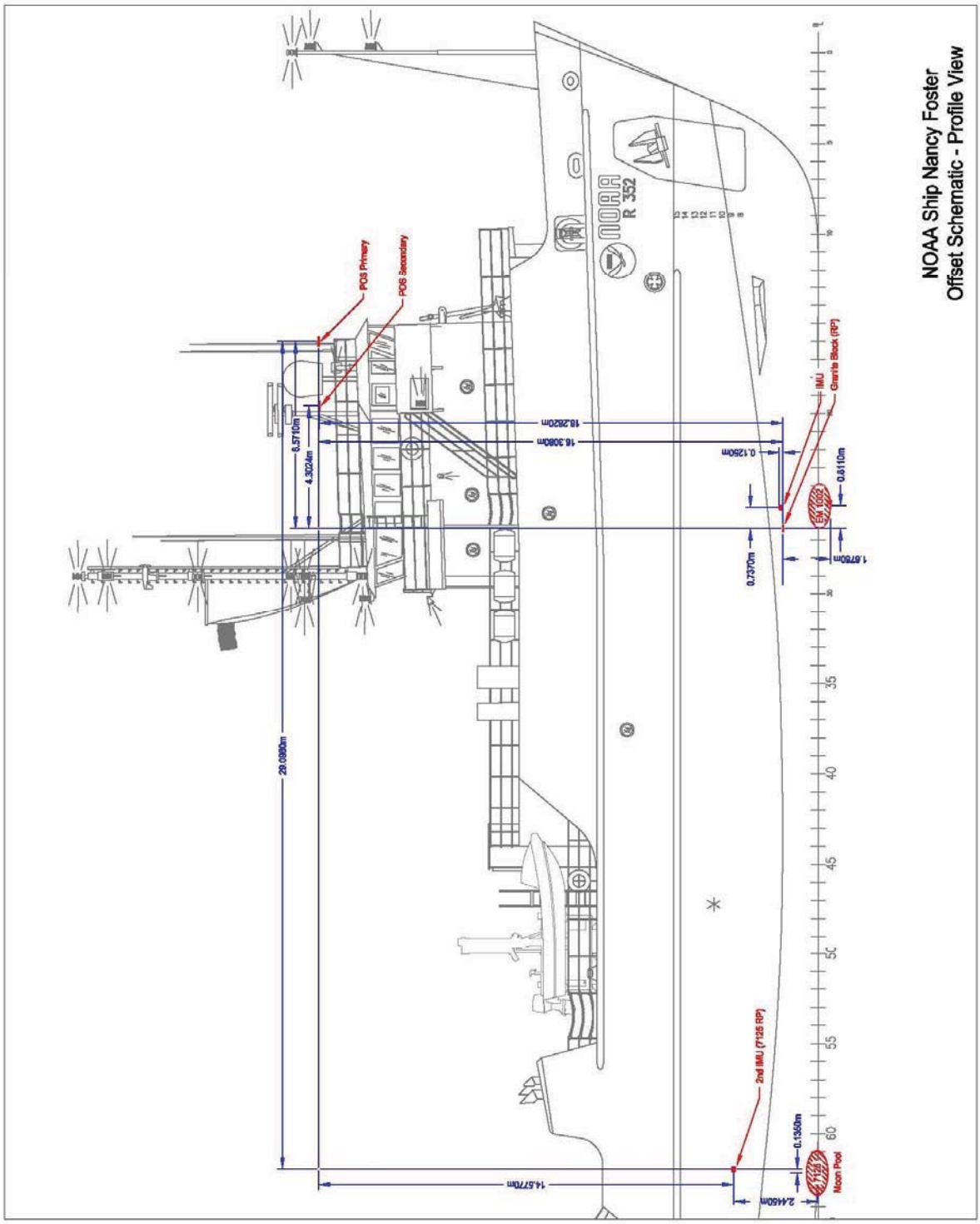



IMU Bow Scribeline
IMU Centerline
IMU Stern Scribeline
10 2:20PM

APPENDIX H:

NOAA Ship NANCY FOSTER Offset Diagrams


NOAA Ship Nancy Foster
Offset Schematic - Plan View
POS Primary
DGPS
POS Secondary
1.2000m
0.5710m
4.3090m
0.6110m
0.7370m
1.8580m
4.7370m
4.7400m
IMU
Gremlo Block (RP)
28.0980m
0.1350m
0.4580m
6.2950m
Moon Pool
2nd IMU (7125 RP)


NOAA Ship Nancy Foster
Offset Schematic - Profile View
NOAA
R 352
POS Primary
POS Secondary
IMU
Granite Block (RP)
EM 1002
Moon Pool
2nd IMU (7125 RP)
18.2820m
16.3080m
0.1250m
0.8110m
1.6750m
0.7370m
0.5710m
4.3324m
29.0990m
14.5770m
2.4450m
0.1350m

APPENDIX I:

Multibeam Calibration Procedures & Patch Test Reports

Calibration Date: March 29, 2009

Ship	NOAA Ship Nancy Foster
Vessel	
Echosounder System	Simrad EM1002
Positioning System	POS/MV Model 320 M4
Attitude System	POS/MV Model 320 M4

Calibration type:

Annual	X	Full	X
Installation		Limited/Verification	
System change			
Periodic/QC			
Other:			

The following calibration report documents procedures used to measure and adjust sensor biases and offsets for multibeam echosounder systems. Calibration must be conducted A) prior to CY survey data acquisition B) after installation of echosounder, position and vessel attitude equipment C) after changes to equipment installation or acquisition systems D) whenever the Hydrographer suspects incorrect calibration results. The Hydrographer shall periodically demonstrate that calibration correctors are valid for appropriate vessels and that data quality meets survey requirements. In the event the Hydrographer determines these correctors are no longer valid, or any part of the echosounder system configuration is changed or damaged, the Hydrographer must conduct new system calibrations.

Multibeam echosounder calibrations must be designed carefully and individually in consideration of systems, vessel, location, environmental conditions and survey requirements. The calibration procedure should determine or verify system offsets and calibration correctors (residual system biases) for draft (static and dynamic), horizontal position control (DGPS), navigation timing error, heading, roll, and pitch. Standard calibration patch test procedures are described in *Field Procedures for the Calibration of Multibeam Echo-sounding Systems*, by André Godin (Documented in Chapter 17 of the Caris HIPS/SIPS 5.3 User Manual, 2003). Additional information is provided in *POS/MV Model 320 Ver 3 System Manual* (10/2003), Appendix F, Patch Test, and the NOAA Field Procedures Manual (FPM, 2003). **The patch test method only corrects very basic alignment biases**. These procedures are used to measure static navigation timing error, transducer pitch offset, transducer roll offset, and transducer azimuth offset (yaw). Dynamic and reference frame biases can be investigated using a reference surface.

Pre-calibration Survey Information

Reference Frame Survey

(IMU, sensor, GPS antenna offsets and rotation with respect to vessel reference frame)

Vessel reference frame defined with respect to:

[ ] IMU [X] Reference Position

Reference to IMU Lever Arm

X(m)	Y(m)	Z(m)
0.737	0.001	-0.125

IMU frame w.r.t vessel reference frame

X(deg)	Y(deg)	Z(deg)
-0.009	-0.006	-0.057

Reference to Sensor Lever Arm

X(m)	Y(m)	Z(m)
0.0	0.0	0.0

[X] Measurements verified for this calibration.

Reference Centerline Survey report

[X] Drawing and table attached.

[X] Drawing and table included with project report/DAPR: NF-09-04-USVI DAPR

Position/Motion Sensor Calibration (for POS/MV model 320 M4)

Calibration date: Feb 7, 2006

Reference to primary GPS Lever Arm

X(m)	Y(m)	Z(m)
6.571	-4.740	-16.308

Heave Settings: Bandwidth 18.00 Damping Period .707

Reference to Center of Rotation Lever Arm

X(m)	Y(m)	Z(m)
-12.295	0.000	-1.965

Firmware version 4.22 was used for the entire survey.

Static Draft Survey

(Vessel waterline with respect to RP)

Survey date: March 28, 2009

Prior to conducting the patch test and survey, initial confidence checks were performed to ensure an accurate measurement of water depths. While the Nancy Foster was tied up at Isla De Vieques the survey team initially observed the static draft of the starboard PROJ draft marks at +/-3.66m (12.0 ft.). The EM1002 transducer offset from the RP (0,0,0) is a fixed distance of 1.676m, which is entered into the installation parameters in the EM1002 controller software, Merlin V.5.2v2. The waterline to the RP is the elevation required to compensate for draft.

RP to EM1002 offset - WL = Elevation from WL to RP

1.68m - 3.66m = -1.98

Static Draft Correction -1.98 (meters)

Dynamic Draft Survey

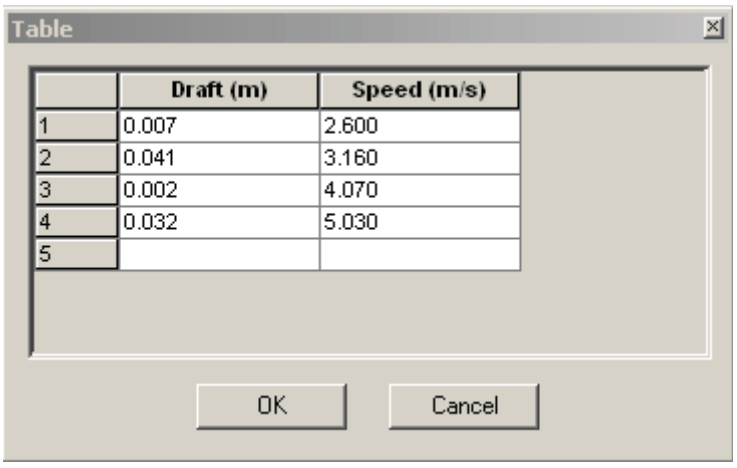
(Vessel waterline with respect to vessel reference frame and vessel speed)

The dynamic draft survey was performed during the Sea Acceptance Test (SAT) offshore of Charleston, South Carolina in March of 2006. Representatives from the NOAA Aviation and Marine Operations (NMAO) performed the survey and evaluated the results. The dynamic draft was determined using the reference surface method as per the NOS Field Procedures Manual. Results of the dynamic draft survey are entered into the CARIS vessel configuration file, R352_MB.hvf

Tabular Summery of Dynamic Draft Results

RPM	Area A		Area B		Area C		Average Speed		Average Δ Draft	
	Speed	*Δ Draft*	*Speed*	*Δ Draft*	*Speed*	*Δ Draft*	*Ave.*	*σ*	*Ave.*	*σ*
0	1.832	0.000	1.327	0.000	0.912	0.000	**1.357**	0.461	**0.000**	0.000
790	6.598	0.026	4.260	-0.026	4.346	0.022	**5.068**	1.326	**0.007**	0.029
1000	6.104	0.088	6.089	-0.078	6.261	0.115	**6.151**	0.095	**0.041**	0.105
1300	7.866	-0.015	7.896	-0.012	8.010	0.034	**7.924**	0.076	**0.002**	0.027
1600	9.816	0.031	9.696	0.063	9.855	0.004	**9.789**	0.083	**0.032**	0.030

Dynamic Draft Table, R352_MB.hvf

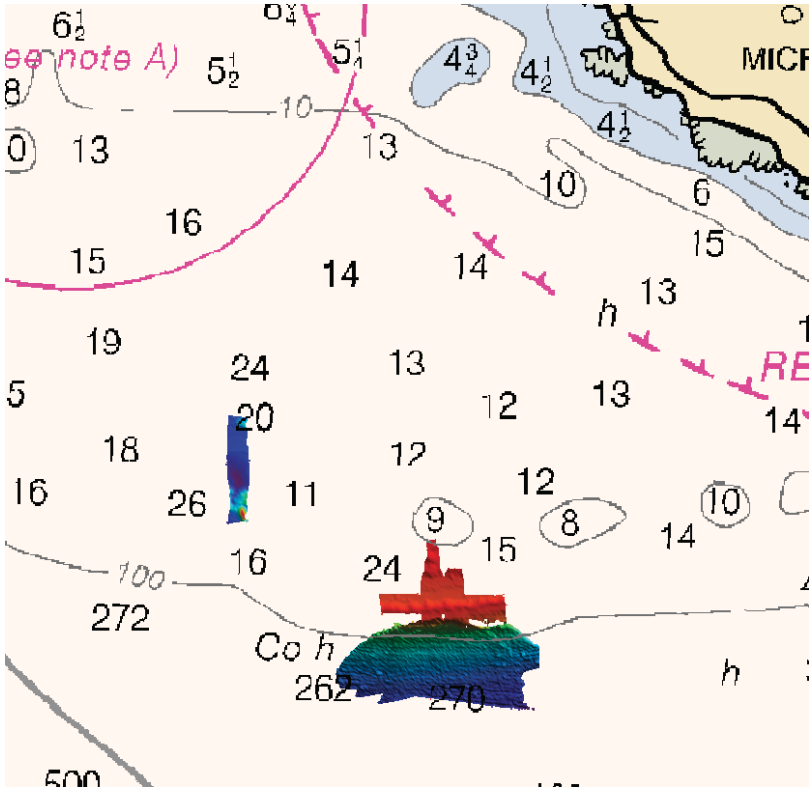


Calibration Survey Information

An annual patch test was performed during the NF-09-01-USVI cruise. Biases were estimated by running a series of calibration lines, as described in the NOS Hydrographic Specifications and Deliverables, April 2009 Edition (HSSD). The patch test calibration quantified residual biases between the POS/MV V4's Inertial Measurement Unit and the EM1002 multibeam transducer alignment. The patch test also identified time latency within the positioning and acquisition system. All values in Merlin and in the CARIS vessel configuration file were changed to zero before the patch test was collected.

An area offshore of South Western Isla De Vieques was chosen for the patch test procedure. The area identified provided the steep and smooth slope with little change in across track depth to accurately assess the latency, pitch and yaw biases for the Nancy Foster's EM1002 multibeam system. Two planned survey lines were oriented perpendicular to slope, parallel and spaced apart to ensure overlap of outer beams for the yaw calibration. A check line was also run perpendicular, along the crest of the seafloor ridge,to verify the determined patch values. A sound velocity cast was performed prior to conducting the patch test in the immediate vicinity. A total of seven lines were surveyed. Vessel speeds were consistent for the pitch and yaw transects at approximately 5 knots. Vessel speeds were increased to approximately 8 knots for the second latency line of the patch test.

A relatively flat area approximately 1.5km to the North West was chosen for the roll calibration. One planned survey line was collected in reciprocal directions at approximately 5 knots.



The hydrographer performed the biases calculations in the order described in the HSSD using CARIS HIPS's calibration tool. The patch test results were proven with seafloor alignment from opposing swaths throughout the data set. The CARIS vessel configuration file R352_MB.hvf was updated with the values obtained from the patch test and used for the duration of the NF-09-01-USVI cruise and for post-processing.

Calibration Lines

Line	Direction	Speed	Bias Measured
0012_20090329_024759_raw	**E-W**	**5**	**Check Line**
0011_20090329_022634_raw	**S**	**5**	**P2,Y2**
0009_20090329_020719_raw	**N**	**8**	**L2**
0007_20090329_015016_raw	**S**	**5**	**Y1**
0005_20090329_013540_raw	**N**	**5**	**P1,L1**
0003_20090329_004855_raw	**N**	**5**	**R1**
0004_20090329_010942_raw	**S**	**5**	**R2**

Sound Velocity Correction

Measure water sound velocity (SV) prior to survey operations in the immediate vicinity of the calibration site. Conduct SV observations as often as necessary to monitor changing conditions and acquire a SV observation at the conclusion of calibration proceedings. If SV measurements are measured at the transducer face, monitor surface SV for changes and record surface SV with profile measurements.

Sound Velocity Measurements

Cast	Time	Depth(m)	LAT	LONG
DN088_1	00:30	500	18 02.85N	65 36.11W
DN088_2	06:15	700	18 03.26N	65 31.65W

Tide Correction

Predicted tides applied.

Approximate distance of gauge from calibration site: Variable

Water level corrections applied:

- [X] Predicted
- [ ] Preliminary
- [X] Zoned
- [ ] Verified

Data Acquisition and Processing Guidelines

Initially, calibration measurement offsets were set to zero in the vessel configuration files. Static and dynamic draft offsets, inertial measurement unit (IMU) lever arm offsets, and vessel reference frame offsets were entered in appropriate software applications prior to bias analysis. Performed minimal cleaning to eliminate gross flyers from sounding data.

Navigation Timing Error (NTE)

Measure NTE correction through examination of a profile of the center beams from lines run in the same direction at maximum and minimum vessel speeds. NTE is best observed in shallow water.

Transducer Pitch Offset (TPO)

Apply NTE correction. Measure TPO correction through examination of a profile of the center beams from lines run up and down a bounded slope or across a conspicuous feature. Acquire data on lines oriented in opposite directions, at the same vessel speed. TPO is best observed in deep water.

Transducer Roll Offset (TRO)

Apply NTE and TPO corrections. Measure the TRO correction through examination of roll on the outer beams across parallel overlapping lines. TRO is best observed over flat terrain in deep water.

Transducer Azimuth Offset (TAO or yaw)

Apply NTE, TPO and TRO corrections. Measure TAO correction through examination of a conspicuous topographic feature observed on the outer beams of lines run in the same direction.

Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
Mike Stecher	0.0	0.14	-0.7	-0.08

Corrections calculated in: CARIS HIPS

[X] Caris [ ] ISIS

[ ] Other _____

Caris Vessel Configuration File

Name: R352_MB.hvf

Version: 6.1 SP 2

New ☐ Appended values with time tag [X]

Evaluator: Mike Stecher, Lead Hydrographer

Calibration Date: March 29, 31 and April 2 2009

Ship	NOAA Ship Nancy Foster
Vessel	
Echosounder System	Reson 7125
Positioning System	POS/MV Model 320 M4
Attitude System	POS/MV Model 320 M4

Calibration type:

Annual		Full	X
Installation	X	Limited/Verification	
System change			
Periodic/QC			
Other:			

The following calibration report documents procedures used to measure and adjust sensor biases and offsets for multibeam echosounder systems. Calibration must be conducted A) prior to CY survey data acquisition B) after installation of echosounder, position and vessel attitude equipment C) after changes to equipment installation or acquisition systems D) whenever the Hydrographer suspects incorrect calibration results. The Hydrographer shall periodically demonstrate that calibration correctors are valid for appropriate vessels and that data quality meets survey requirements. In the event the Hydrographer determines these correctors are no longer valid, or any part of the echosounder system configuration is changed or damaged, the Hydrographer must conduct new system calibrations.

Multibeam echosounder calibrations must be designed carefully and individually in consideration of systems, vessel, location, environmental conditions and survey requirements. The calibration procedure should determine or verify system offsets and calibration correctors (residual system biases) for draft (static and dynamic), horizontal position control (DGPS), navigation timing error, heading, roll, and pitch. Standard calibration patch test procedures are described in *Field Procedures for the Calibration of Multibeam Echo-sounding Systems*, by André Godin (Documented in Chapter 17 of the Caris HIPS/SIPS 5.3 User Manual, 2003). Additional information is provided in *POS/MV Model 320 Ver 3 System Manual* (10/2003), Appendix F, Patch Test, and the NOAA Field Procedures Manual (FPM, 2003). **The patch test method only corrects very basic alignment biases**. These procedures are used to measure static navigation timing error, transducer pitch offset, transducer roll offset, and transducer azimuth offset (yaw). Dynamic and reference frame biases can be investigated using a reference surface.

Pre-calibration Survey Information

Reference Frame Survey

(IMU, sensor, GPS antenna offsets and rotation with respect to vessel reference frame)

Vessel reference frame defined with respect to:

[X] IMU [X] Reference Position

Reference to IMU Lever Arm

X(m)	Y(m)	Z(m)
0.0	0.0	0.0

IMU frame w.r.t vessel reference frame

X(deg)	Y(deg)	Z(deg)
0.0	0.0	0.0

Reference to Sensor Lever Arm

X(m)	Y(m)	Z(m)
-.135	-.455	2.445

[X] Measurements verified for this calibration.

Reference Centerline Survey report

[X] Drawing and table attached.

[X] Drawing and table included with project report/DAPR: NF-09-04-USVI DAPR

Position/Motion Sensor Calibration (for POS/MV model 320 M4)

Calibration date: March 10, 2009

Reference to primary GPS Lever Arm

X(m)	Y(m)	Z(m)
29.096	-6.295	-14.577

Heave Settings: Bandwidth 18.00 Damping Period .707

Reference to Center of Rotation Lever Arm

X(m)	Y(m)	Z(m)
10.23	-1.55	-.675

Firmware version 4.22 was used for the entire survey.

Static Draft Survey

(Vessel waterline with respect to RP)

Survey date: March 28, 2009

The 7125 draft was measured at the beginning and end of the cruise by lowering a weighted tape to the top of the sonar mount and measuring the waterline. The initial draft reading for the 7125 at the moon pool was 3.46m.

WL - (Moon pool shaft + acoustic center 7125) = Draft

1.731m - 5.19m =-3.46m

Static Draft Correction -3.46 (meters)

Dynamic Draft Survey

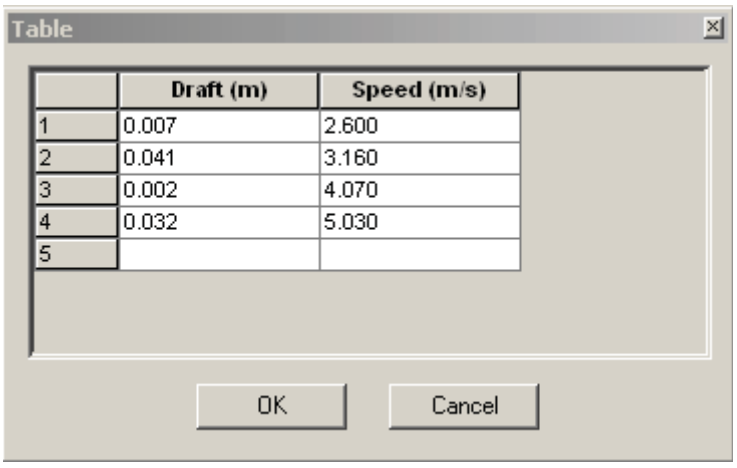
(Vessel waterline with respect to vessel reference frame and vessel speed)

The dynamic draft survey was performed during the Sea Acceptance Test (SAT) offshore of Charleston, South Carolina in March of 2006. Representatives from the NOAA Aviation and Marine Operations (NMAO) performed the survey and evaluated the results. The dynamic draft was determined using the reference surface method as per the NOS Field Procedures Manual. Results of the dynamic draft survey are entered into the CARIS vessel configuration file, NF_7125.hvf

Tabular Summery of Dynamic Draft Results

RPM	Area A		Area B		Area C		Average Speed		Average Δ Draft	
	Speed	*Δ Draft*	*Speed*	*Δ Draft*	*Speed*	*Δ Draft*	*Ave.*	*σ*	*Ave.*	*σ*
0	1.832	0.000	1.327	0.000	0.912	0.000	**1.357**	0.461	**0.000**	0.000
790	6.598	0.026	4.260	-0.026	4.346	0.022	**5.068**	1.326	**0.007**	0.029
1000	6.104	0.088	6.089	-0.078	6.261	0.115	**6.151**	0.095	**0.041**	0.105
1300	7.866	-0.015	7.896	-0.012	8.010	0.034	**7.924**	0.076	**0.002**	0.027
1600	9.816	0.031	9.696	0.063	9.855	0.004	**9.789**	0.083	**0.032**	0.030

Dynamic Draft Table, R352_MB.hvf



Calibration Survey Information

A patch test was performed three times for the 7125. Each time the patch values were not consistent throughout the data. A representative from Reson was onbard for the mobilization, calibration and data acquisition for the cruise. The representative was unable to determine the reasoning for the inconsistencies in patch values. The data was later delivered to Reson B.V. to resolve the issues. Reson determined that the problem was caused by the real time Reson SVP70 sound velocity sensor reporting wrong sound velocity values to the 7-P processor, even though the sound velocity values observed were close to values measured by the SBE-19. Additionally the angle values reported by the 7125 were not right. Instead of the normal 128.1 degree swath width, the 7125 reported a swath width of 131.2 degrees. To address this, Reson applied a 0.2 degrees correction to the outer beams. This was achieved by changing the sound velocity profile at the sonar head by 1 m/s to create an artificial thermo cline during post processing.

Reson performed the biases calculations in PDS2000. The CARIS vessel configuration file NF_7125.hvf was updated with the values obtained from the Reson patch test. These values were used for NF-09-01-USVI post-processing.

Calibration Lines

Line	Direction	Speed	Bias Measured
221636	**W**	**5**	**R1, P1**
222919	**E**	**5**	**R2, P2**
224924	**W**	**5**	**Y1**
230926	**E**	**5**	**Y1**

Sound Velocity Correction

Measure water sound velocity (SV) prior to survey operations in the immediate vicinity of the calibration site. Conduct SV observations as often as necessary to monitor changing conditions and acquire a SV observation at the conclusion of calibration proceedings. If SV measurements are measured at the transducer face, monitor surface SV for changes and record surface SV with profile measurements.

Sound Velocity Measurements

Cast	Time	Depth(m)	LAT	LONG
DN092_4	21:45	37	18 04.12N	65 12.53W

Tide Correction

Predicted tides applied.

Approximate distance of gauge from calibration site: Variable

Water level corrections applied:

- [X] Predicted
- [ ] Preliminary
- [X] Zoned
- [ ] Verified

Data Acquisition and Processing Guidelines

Initially, calibration measurement offsets were set to zero in the vessel configuration files. Static and dynamic draft offsets, inertial measurement unit (IMU) lever arm offsets, and vessel reference frame offsets were entered in appropriate software applications prior to bias analysis. Performed minimal cleaning to eliminate gross flyers from sounding data.

Navigation Timing Error (NTE)

Measure NTE correction through examination of a profile of the center beams from lines run in the same direction at maximum and minimum vessel speeds. NTE is best observed in shallow water.

Transducer Pitch Offset (TPO)

Apply NTE correction. Measure TPO correction through examination of a profile of the center beams from lines run up and down a bounded slope or across a conspicuous feature. Acquire data on lines oriented in opposite directions, at the same vessel speed. TPO is best observed in deep water.

Transducer Roll Offset (TRO)

Apply NTE and TPO corrections. Measure the TRO correction through examination of roll on the outer beams across parallel overlapping lines. TRO is best observed over flat terrain in deep water.

Transducer Azimuth Offset (TAO or yaw)

Apply NTE, TPO and TRO corrections. Measure TAO correction through examination of a conspicuous topographic feature observed on the outer beams of lines run in the same direction.

Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
Peter De Vries	0.0	-2.18	3.38	-.22

☐ Caris ☐ ISIS

☒ Other PDS 2000

Caris Vessel Configuration File

Name: NF-7125.hvf

Version: 6.1 SP 2

New ☒ Appended values with time ☐ tag

Evaluator: Peter De Vries, Reson B.V.

APPENDIX J:

CO-OPS Tide Requirements, Tide Note and Correspondence

WATER LEVEL INSTRUCTIONS
M-I905-NF-2009 U.S. Virgin Islands and Puerto Rico
(1/8/2009 CFL)

1.0. TIDES AND WATER LEVELS

1.1. Specifications

Tidal data acquisition, data processing, tidal datum computation and final tidal zoning shall be performed utilizing sound engineering and oceanographic practices as specified in National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables (HSSD), dated April 2007, and OCS Field Procedures Manual (FPM), dated March 2007. Specifically reference Chapter 4 of the HSSD and Sections 1.5.8, 1.5.9, 2.4.5, and 3.4.2 of the FPM.

1.2. Vertical Datums

The tidal datums for this project are refere nced to Chart Datum , M ean Lower Low W ater (MLLW) and Mean High Water (MHW). Soun dings are refer enced to MLLW and heights of overhead obstructions (bridges and cables) are referenced to MHW.

The operatin g National Water Level Observation Ne twork (N WLON) stati ons at Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlo tte Amelie, VI (975-1639) will serve as datum control for the survey area including de termination at each subordinate station. Therefore, it is critical that these stations remain in operation during all periods of hydrography.

1.2.1. Water Level Data Acquisition Monitoring

The Commanding Officer (or Team Leader) and the Center for Operational Oceanographic Products and Services (CO-OPS) are jointly responsible for ensuring that valid water level data are collected during periods of hydrography. The Commanding Officer (or Team Leader) is required to monitor the pertinent water level data via the CO-OPS Web site at http://tidesandcurrents.noaa.gov/hydro.shtml, email data transmissions through TIDEBOT, or through regular communications with CO-OPS/Requirements and Development Division (RDD) personnel before and during operations. During traditional non duty hours, the Commanding Officer/Team Leader may contact the Continuous Operational Real-Time Monitoring System (CORMS) watch stander who is available 24 hours/day - 7 days/week for assistance in assessing the status of applicable water level station operation. The CORMS watch stander may be contacted either by phone at 301-713-2540 or by Email: CORMS@noaa.gov. Problems or concerns regarding the acquisition of valid water level data identified by the Commanding Officer/Team Leader shall be communicated with CO-OPS/RDD (Tom Landon, 301-713-2897 ext. 191, Email: Thomas.Landon@noaa.gov on the East Coast) to coordinate the appropriate course of action to be taken such as gauge repair and/or developing contingency plans for hydrographic survey operations. In addition, CO-OPS is required to coordinate with the

Commanding Officer (or Team Leader) before interrupting the acquisition of water level data for any reason during periods of hydrography.

1.2.2. NWLON Water Level Station Operation and Maintenance

The operating water level stations at Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) will also provide water level reducers for this project, reiterating the importance of their operation during all periods of hydrography. See Sections 1.1. and 1.2. concerning responsibilities.

No leveling is required Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) by NOAA Ship Nancy Foster personnel.

CO-OPS/FOD is responsible for the operation and maintenance of all NWLON primary control stations. If a problem is identified at an NWLON primary control station, FOD shall make all reasonable efforts to repair the malfunctioning station. However, CO-OPS may request assistance from the NOAA ship or NRT personnel in the actual repair of the water level station to facilitate a rapid repair. CO-OPS/FOD and the Commanding Officer (or Team Leader) shall maintain the required communications until the repairs to the water level station have been completed.

1.3. Tide Reducer Stations

1.3.1. No subordinate water level stations are required for this project, however, supplemental and/or back-up water level stations may be necessary depending on the complexity of the hydrodynamics and/or the severity of the environmental conditions of the project area. The installation and continuous operation of water level measurement systems (tide gauges) at subordinate station locations is left to the discretion of the Commanding Officer (or Team Leader), subject to the approval of CO-OPS. If the Commanding Officer (or Team Leader) decides to install additional water level stations, then a 30-day minimum of continuous data acquisition is required. For all subordinate stations, data must be collected throughout the entire survey period for which they are applicable, and not less than 30 continuous days. This is necessary to facilitate the computation of an accurate datum reference as per NOS standards.

Tide Component Error Estimation

The estimated tidal error contribution to the total survey error budget in the vicinity of Puerto Rico and the U.S. Virgin Islands is 0.12 meters at the 95% confidence level, and includes the estimated gauge measurement error, tidal datum computation error, and tidal zoning error. Based on this analysis a subordinate station will not be required. It should be noted that the tidal error component can be significantly greater than stated if a substantial meteorological event or condition should occur during time of hydrography.

1.3.2. GOES Satellite Enabled Subordinate Stations

This section is not applicable for this project.

1.3.3. Benchmark Recovery and GPS Requirements

This section is not applicable for this project.

1.3.4. This section is not applicable for this project.

1.4. Discrete Tidal Zoning

1.4.1. The water level station at Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) are the reference stations for preliminary tides for hydrography in the U.S. Virgin Islands. The time and height correctors listed below for applicable zones should be applied to the preliminary data at Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) during the acquisition and preliminary processing phases of this project. Preliminary data may be retrieved in one month increments over the Internet from the CO-OPS Home Page at http://tidesandcurrents.noaa.gov/olddata and then clicking on "Preliminary Water Level". The Commanding Officer (or Team Leader) must notify CO-OPS/RDD personnel immediately of any problems concerning the preliminary tides. Preliminary data are six-minute time series data relative to MLLW in metric units on Greenwich Mean Time. For the time corrections, a negative (-) time correction indicates that the time of tide in that zone is earlier than (before) the preliminary tides at the reference station. A positive (+) time correction indicates that the time of tide in that zone is later than (after) the predicted tides at the reference station. For height corrections, the water level heights **relative to MLLW** at the reference station are multiplied by the range ratio to estimate the water level heights relative to MLLW in the applicable zone.

Zone	Time Corrector(mins)		Range Ratio	Predicted Reference Station	
VIR2	-12	x0.9	6	975-2	235
VIR3	-12	x0.8	8	975-2	235
VIR3B	-12	x1.2		975-1	639
VIR4	-12	x1.0	8	975-1	639
VIR4A	-12	x1.0	8	975-1	639
VIR4B	-6	x1.0	8	975-1	639
VIR5	-12	x1.0	1	975-1	639
VIR6	+6	x1.0	8	975-2	695
VIR7	+12	x1.0	1	975-2	695
VIR20	-12	x1.0	1	975-1	639
VIR21	-6	x1.0	1	975-1	639

1.4.2. Polygon nodes and water level corrections referencing Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) are provided in CARIS® format denoted by a *.zdf extension file name.

NOTE: The tide corrector values referenced to Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639) are provided in the zoning file

"I905NF2009CORP" for this project and are in the fourth set of correctors designated as TS4. Longitude and latitude coordinates are in decimal degrees. Negative (-) longitude is a MapInfo® representation of West longitude

"Preliminary" data for the control water level station, Vieques, PR (975-2695), Culebra, PR (975-2235), and Charlotte Amelie, VI (975-1639), are available in near real-time and verified data will be available on a weekly basis for the previous week. These water level data may be obtained from the CO-OPS web site at http://tidesandcurrents.noaa.gov/olddata . From this site, click on either "Preliminary Water Level" or "Verified Water Level" to obtain preliminary or verified/historical water level data as appropriate.

Please contact the Hydrographic Planning Team at NOS.COOPS.HPT@noaa.gov and the Operational Engineering Team at NOS.COOPS.OET@noaa.gov **before** survey operations begin and **once survey operations are completed** so that the appropriate CO-OPS NWLON (National Water Level Observation Network) water level stations are added to or removed from the CO-OPS Hydro Hotlist (http://tidesandcurrents.noaa.gov/hydro).

1.4.3 Zoning Diagram(s)

Zoning diagrams, created in MapInfo® and Adobe PDF, are provided in digital format to assist with the zoning in section 1.4.1.

1.4.4 Final Zoning

Upon completion of project M-I905-NF-2009, submit a Pydro generated request for smooth tides, with times of hydrography abstract and mid/mif tracklines attached. Forward this request to smooth.tides@noaa.gov . Provide the project number, as well as a sheet number, in the subject line of the email.

CO-OPS will review the times of hydrography, final tracklines, and six-minute water level data from all applicable water level gauges. After review, CO-OPS will send a notice indicating that the tidal zoning scheme sent with the project instructions has been approved for final zoning. If there are any discrepancies, CO-OPS will make the appropriate adjustments and forward a revised tidal zoning scheme to the field group and project manager for final processing.

1.5 TideBot

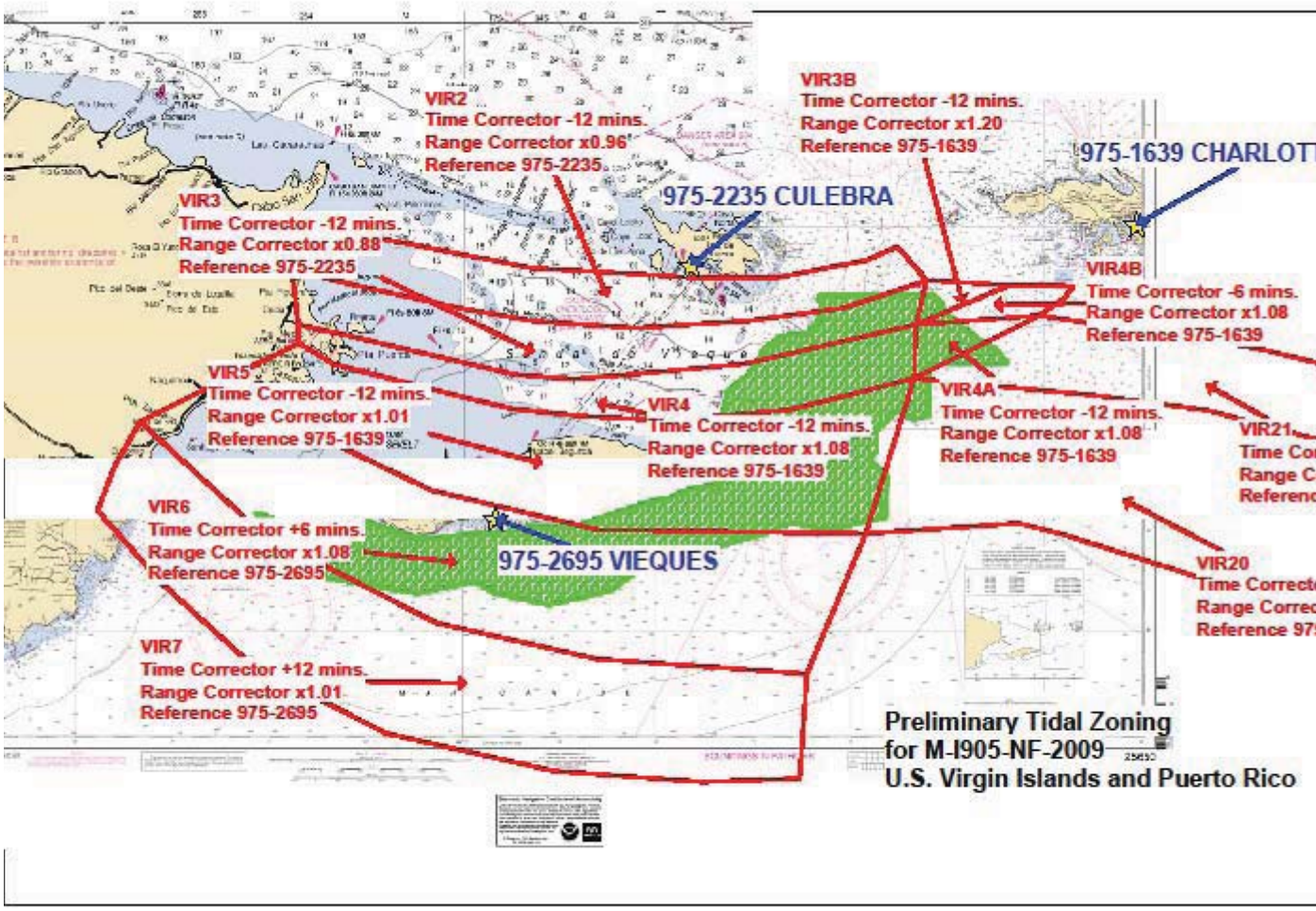
Preliminary and verified six minute water level time series data may be retrieved from the CO-OPS database via TideBot application. TideBot delivers timely preliminary/verified tidal and Great Lakes six minute water level observations via email to users on a scheduled, recurring basis. To access TideBot through an email account, send an email to TideBot@noaa.gov with the word "help" as the subject. An email reply will be sent with instructions on how to subscribe to TideBot for time series data retrieval.

1.6 Water Level Records

Submit water level data, such as leveling records, field reports, and any other relevant data/reports, including the data downloaded onto diskette/CD within 1 week after the end of each month or the end of hydrography to CO-OPS/RDD. Refer to Section 1.1.

1.6.1 Water level records should be forwarded to the following address:

NOA A/National Ocean Service/CO-OPS
Chief, Requirements and Development Division
N/OPS1 - SSMC4, Station 6531
1305 East-West Highway
Silver Spring, MD 20910


VIR2
Time Corrector -12 mins.
Range Corrector x0.96
Reference 975-2235
VIR3B
Time Corrector -12 mins.
Range Corrector x1.20
Reference 975-1639
975-1639 CHARLOTT
975-2235 CULEBRA
VIR3
Time Corrector -12 mins.
Range Corrector x0.88
Reference 975-2235
VIR4B
Time Corrector -6 mins.
Range Corrector x1.08
Reference 975-1639
VIR5
Time Corrector -12 mins.
Range Corrector x1.01
Reference 975-1639
VIR4
Time Corrector -12 mins.
Range Corrector x1.08
Reference 975-1639
VIR4A
Time Corrector -12 mins.
Range Corrector x1.08
Reference 975-1639
VIR21
Time Co
Range C
Referenc
VIR6
Time Corrector +6 mins.
Range Corrector x1.08
Reference 975-2695
975-2695 VIEQUES
VIR20
Time Correct
Range Correc
Reference 97
VIR7
Time Corrector +12 mins.
Range Corrector x1.01
Reference 975-2695
Preliminary Tidal Zoning
for M-I905-NF-2009
U.S. Virgin Islands and Puerto Rico

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOAA Ship NANCY FOSTER (MOA-NF)
439 West York St
Norfolk, VA 23510-1145

May 19, 2009

MEMORANDUM FOR: Chief, Requirements and Development Division, N/OPS1

FROM: Mike Stecher, NOAA Ship NANCY FOSTER (MOA-NF)

SUBJECT: Request for Approved Tides/Water Levels

Please provide the following data:

1. Tide Note
2. Final zoning in MapInfo and .MIX format
3. Six Minute Water Level data (Co-ops web site)

Transmit data to the following:

NOAA/NOS/Atlantic Hydrographic Branch
N/CS33, Building #2
439 West York Street
Norfolk, VA 23510
ATTN: Chief AHB

These data are required for the processing of the following hydrographic survey:

Project No.:	M-I905-NF-09
Registry No.:	H12005
State:	Puerto Rico
Locality:	Caribbean Sea
Sublocality:	5NM SE of Isla De Culebra, PR

Attachments containing:

1) an Abstract of Times of Hydrography,
2) digital MID MIF files of the track lines from Pydro

cc: N/CS33

Generated by Pydro v8.7 (r2666) on Tue May 19 16:37:07 2009 [UTC]

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOAA Ship NANCY FOSTER (MOA-NF)
439 West York St
Norfolk, VA 23510-1145

May 19, 2009

MEMORANDUM FOR: Chief, Requirements and Development Division, N/OPS1

FROM: Mike Stecher, NOAA Ship NANCY FOSTER (MOA-NF)

SUBJECT: Request for Approved Tides/Water Levels

Please provide the following data:

1. Tide Note
2. Final TCARI grid
3. Final zoning in MapInfo and .MIX format
4. Six Minute Water Level data (Co-ops web site)

Transmit data to the following:

NOAA/NOS/Atlantic Hydrographic Branch
N/CS33, Building #2
439 West York Street
Norfolk, VA 23510
ATTN: Chief AHB

These data are required for the processing of the following hydrographic survey:

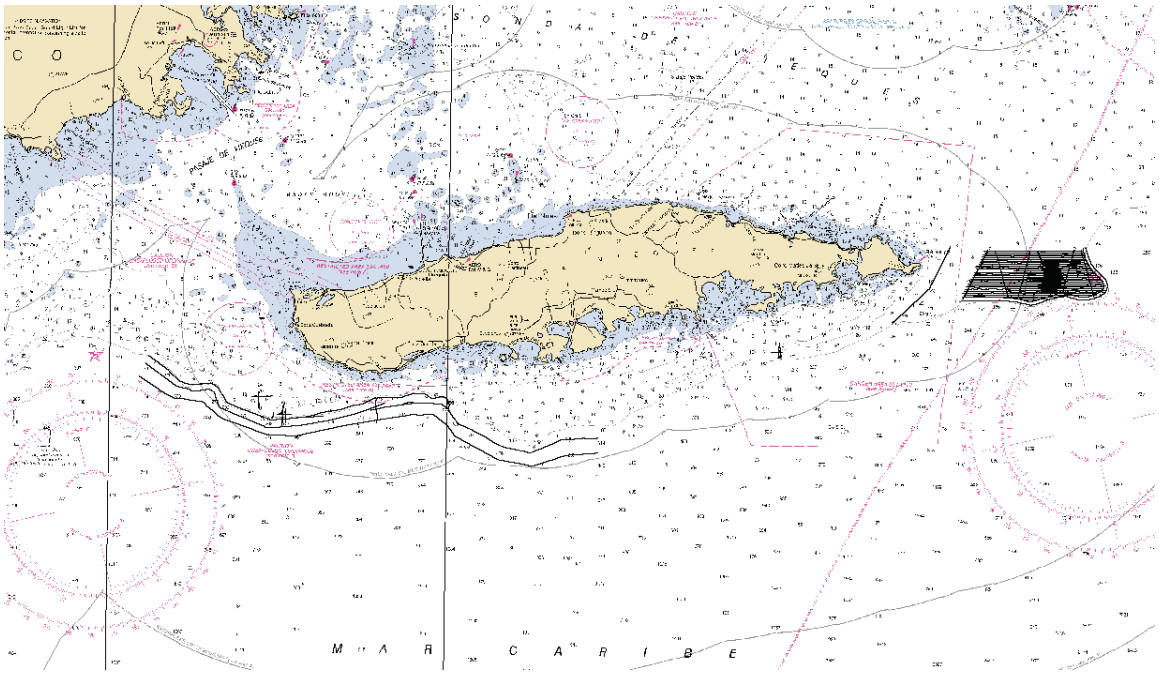
Project No.:	M-I905-NF-09
Registry No.:	H12006
State:	Puerto Rico
Locality:	Caribbean Sea
Sublocality:	SE coast of Isla De Vieques, PR

Attachments containing:

1) an Abstract of Times of Hydrography,
2) digital MID MIF files of the track lines from Pydro

cc: N/CS33

Generated by Pydro v8.7 (r2666) on Tue May 19 16:10:35 2009 [UTC]


C O
PASAJE DE VIEQUES
M A R C A R I B E

UNITED STATES DEPARMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Silver Spring, Maryland 20910

TIDE NOTE FOR HYDROGRAPHIC SURVEY

DATE : June 5, 2009

HYDROGRAPHIC BRANCH: Atlantic
HYDROGRAPHIC PROJECT: M-I905-NF-2009
HYDROGRAPHIC SHEET: H12005

LOCALITY: 5 NM SE of Isla De Culebra, PR
TIME PERIOD: March 28 - April 3, 2009

TIDE STATION USED: 975-1639 Charlotte Amalie
Lat. 18° 20.2′ N Long. 64° 55.2' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 0.227 meters

TIDE STATION USED: 975-2695 Vieques
Lat. 18° 05.6' N Long. 65° 28.3' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 0.216 meters

REMARKS: RECOMMENDED ZONING

Preliminary zoning is accepted as the final zoning for project M-I905-NF-2009.

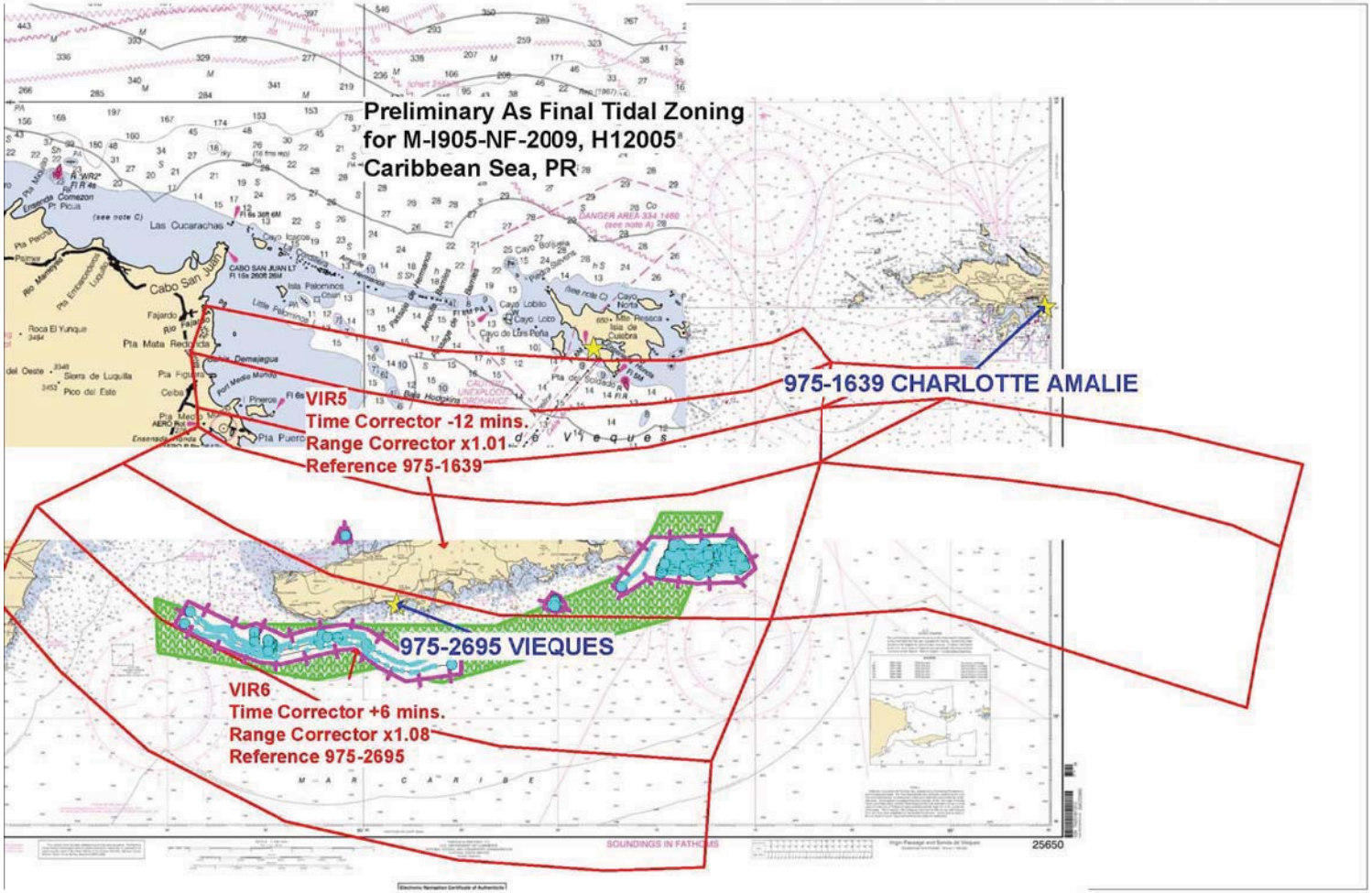
Please use the zoning file "I905NF2009CORP" submitted with the project instructions for M-I905-NF-2009. Zones VIR5 and VIR6 are the applicable zones for H12005.

Note 1: Provided time series data are tabulated in metric units (meters), relative to MLLW and on Greenwich Mean Time on the 1983-2001 National Tidal Datum Epoch (NTDE).

Peter J. Stone

Digitally signed by Peter J. Stone
DN: cn=Peter J. Stone, o=CO-OPS, ou=NOAA/NOS, email=peter.stone@noaa.gov, c=US
Date: 2009.06.08 11:59:47 -04'00'

CHIEF, OCEANOGRAPHIC DIVISION


Preliminary As Final Tidal Zoning
for M-I905-NF-2009, H12005
Caribbean Sea, PR
975-1639 CHARLOTTE AMALIE
VIR5
Time Corrector -12 mins.
Range Corrector x1.01
Reference 975-1639
975-2695 VIEQUES
VIR6
Time Corrector +6 mins.
Range Corrector x1.08
Reference 975-2695
Cabo San Juan
Las Cucarachas
Isla de Culebra
M A R C A R I B E
SOUNDINGS IN FATHOMS
25650

UNITED STATES DEPARMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Silver Spring, Maryland 20910

TIDE NOTE FOR HYDROGRAPHIC SURVEY

DATE : June 5, 2009

HYDROGRAPHIC BRANCH: Atlantic
HYDROGRAPHIC PROJECT: M-I905-NF-2009
HYDROGRAPHIC SHEET: H12006

LOCALITY: SE Coast of Isla de Vieques, PR
TIME PERIOD: March 28 - April 3, 2009

TIDE STATION USED: 975-1639 Charlotte Amalie
Lat. 18° 20.2′ N Long. 64° 55.2' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 0.227 meters

TIDE STATION USED: 975-2695 Vieques
Lat. 18° 05.6' N Long. 65° 28.3' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 0.216 meters

REMARKS: RECOMMENDED ZONING

Preliminary zoning is accepted as the final zoning for project M-I905-NF-2009.

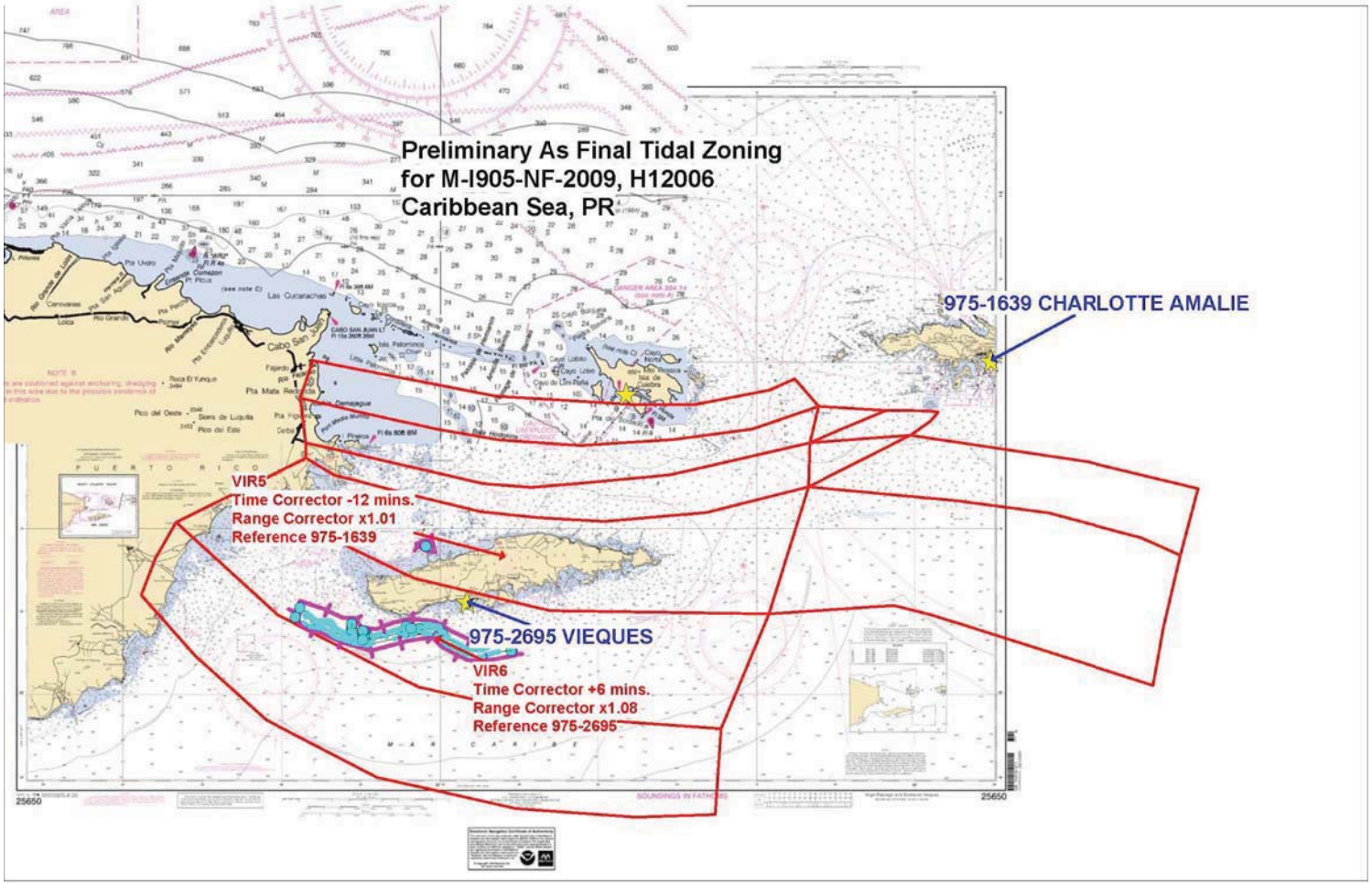
Please use the zoning file "I905NF2009CORP" submitted with the project instructions for M-I905-NF-2009. Zones VIR5 and VIR6 are the applicable zones for H12006.

Note 1: Provided time series data are tabulated in metric units (meters), relative to MLLW and on Greenwich Mean Time on the 1983-2001 National Tidal Datum Epoch (NTDE).

Peter J. Stone

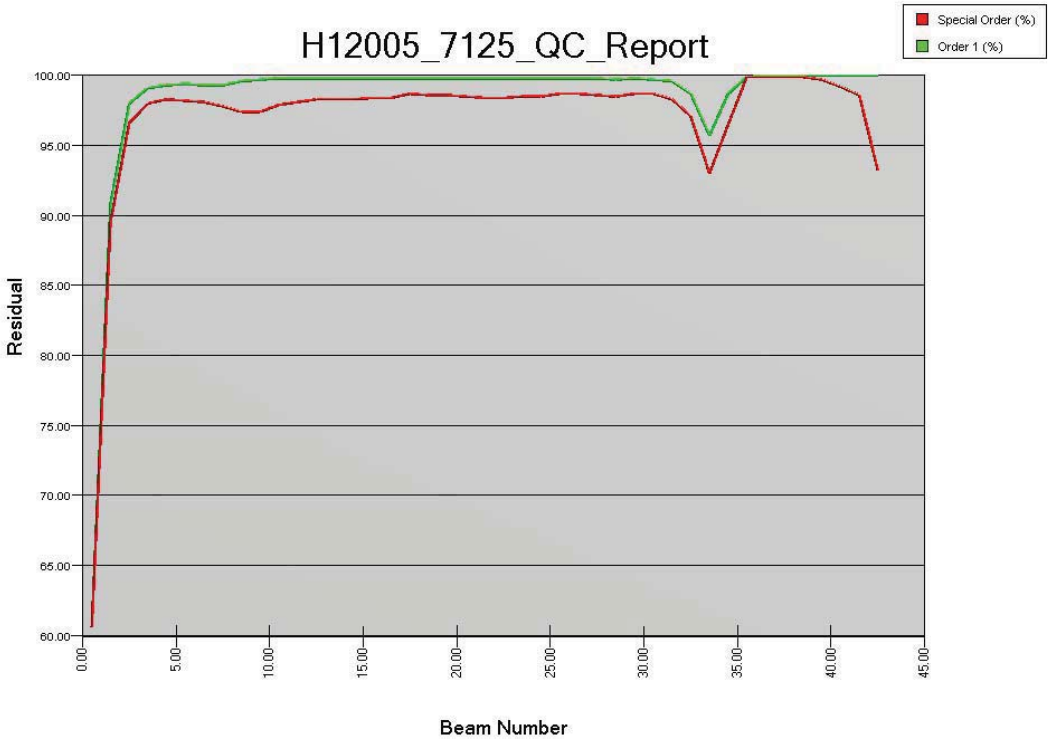
Digitally signed by Peter J. Stone
DN: cn=Peter J. Stone, o=CO-OPS, ou=NOAA/NOS, email=peter.stone@noaa.gov, c=US
Date: 2009.06.08 12:00:21 -04'00'

CHIEF, OCEANOGRAPHIC DIVISION


Preliminary As Final Tidal Zoning
for M-I905-NF-2009, H12006
Caribbean Sea, PR
975-1639 CHARLOTTE AMALIE
VIR5
Time Corrector -12 mins.
Range Corrector x1.01
Reference 975-1639
975-2695 VIEQUES
VIR6
Time Corrector +6 mins.
Range Corrector x1.08
Reference 975-2695

APPENDIX K:

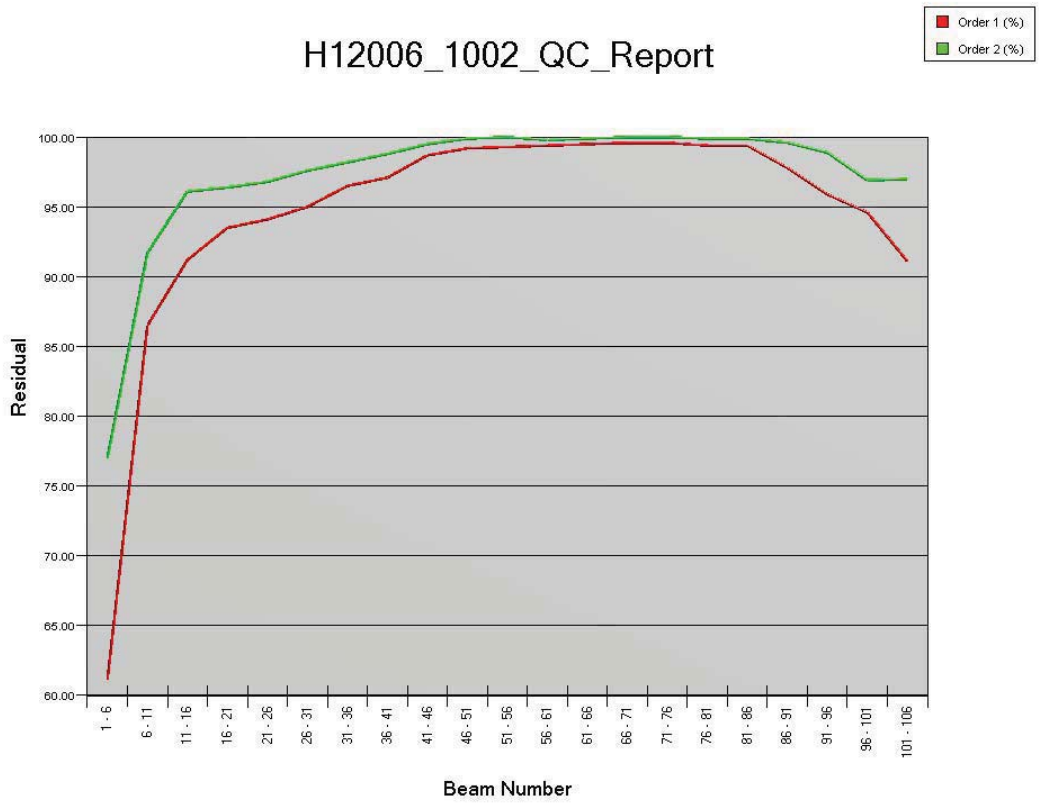
CARIS Quality Control Reports



BASE Surface QC Report ~~H12005~~ ***W00213***

Date and Time: 10/8/2009 1:36:22 PM
Surface: C:\CARIS\HIPS\61\Fieldsheets\M-I905-NF-09\H12005\H12005_2m.hns
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 4,940,928
Number of nodes populated: 4,938,695 (99.9548060607238%)
Number of holidays detected: 0
IHO S-44 Special Order:
    Range: 0.0 to 20.0
    No depths within the specified range
S-44 Order 1:
    Range: 20.0 to 100.0
    Number of nodes considered: 3,962,643
    Number of nodes within: 3,866,157 **(97.565%)**



BASE Surface QC Report ~~H12006~~ *W00214*

Date and Time: 10/8/2009 4:07:39 PM
Surface: C:\CARIS\HIPS\61\Fieldsheets\M-I905-NF-09\M_I905_NF_09_EM1002_Vieques_Ledge\H12006\H12006_8m.hns
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 552,069
Number of nodes populated: 551,857 (99.9615990030232%)
Number of holidays detected: 0

S-44 Order 1:

Range: 20.0 to 100.0
Number of nodes considered: 10,615
Number of nodes within: 685 (**6.453%**)
Residual mean: 5.67673534491979

S-44 Order 2:

Range: 100.0 to 5000.0
Number of nodes considered: 541,242
Number of nodes within: 494,577 (**91.378%**)
Residual mean: -6.02852516565061

APPENDIX L:

Reson Letter of Explanation

RESON, Inc.
100 Lopez Road
Goleta, CA 93117

October 13, 2009

Vieques, Puerto Rico – NOAA Science Cruise – April 2009

In late March, 2009, RESON offered and delivered to the NOAA ship "Nancy Foster" a SeaBat 7125-B Multibeam Echosounder System (MBES) for use during the science cruise to map the offshore areas of Vieques, Puerto Rico. Although this sonar model represents the very latest industry accepted system (at that date, there were 9 such systems in production within the NOAA fleet alone), RESON had mistakenly delivered an early generation topside Sonar Interface Unit (SIU). The demo SIU included a first generation motherboard, processors and early model network and video cards. Due to the schedule, there was no opportunity to rectify this by replacement of a proper topside SIU.

Due to the substandard MBES SIU numerous issues where encountered during the cruise prompting the RESON representative to attempt a solution during the limited trip duration.

These issues included:

- Display time-lag of seafloor in sonar wedge (video card not sufficient for system config)
- Network data flow resulting in a changed integration plan (slow network card)
- Slowed ping rate and/or dropped pings (PC load too great)

All of the above issues were likely to have resulted in inconsistent patch test calibration results and/or apparent sound velocity (beam steering) errors of the initial and final processed data.

During and after the cruise a NOAA representative encountered problems when processing the data. Evidence of mismatch between overlapping swaths was evident during the preliminary data processing and due to the limited window of opportunity, it was decided to continue the collection of the data and attempt to affect a solution afterwards. The data appeared to have erroneous offsets or sound velocity data, however, (prior to the survey) lever arm offsets were determined by NGS using conventional methods and verified independently using the lever arm offset calculation algorithm that is part of the Applanix POS MV 320 v.4. Although the majority of the mismatch in the raw data was removed by RESON staff in the Netherlands via non-standard post processing techniques, the source and actual error is currently still unknown.

Below are notes from RESON/Netherlands staff who worked to minimize the effects of the unknown problem.

> To the original PDS2000 logfiles are no offsets, no sound velocity profiles and no mounting angles applied. As for multibeam filters, only the beam quality (quality 3) and the nadir angle (60° to port and starboard) were used.
>
> The offset from the IMU to the sonar was used (in PDS2000 convention):
>
> | | | | |
> |---|---|---|---|
> | 400 KHz | X = -0.455 | Y = -0.135 | Z = -2.445 |
> | 200 KHZ | X = -0.17 | Y = -0.135 | Z = -2.445 |
>
> A multibeam calibration (patch test) was performed with the data set form 2nd April from 2216hrs to 0004hrs (3rd April). For this dataset the sound velocity profile file *DN092_4-0204_2216* was applied and the offset of the 400 KHz was added to the PDS2000 logfiles.
>
> The result of the multibeam calibration was:
>
> - Latency: Not calculated.

- Roll: -0.22 (PU+) using files 2216 and 2229
- Pitch: -2.18 (BU+) using files 2216 and 2229
- Yaw: 3.38 (BS+) using files 2249 and 2309

The result of this multibeam calibration is applied to all PDS2000 logfiles. It should be noted that the calculated yaw value is thought to be excessive.

All the data was processed with the 400 KHz offsets, the applicable sound velocity profiles and the calculated mounting angles. It appears that several lines were sailed with a range setting in the sonar set to shallow resulting in unusable outer beam data. These files were manually edited to remove the outer beams.

After applying the offset, mounting angles and sound velocity profiles a smiling seafloor is still recognizable. The impression is that the smiling is caused by a pointing problem of the sonar.
This pointing problem can be caused by the sound velocity sensor reporting wrong sound velocity values; however the local sound velocity value was close to the sound velocity value as measured with the sound velocity profile sensor
.
Another reason for the persistent smiling seafloor could be that the angle value reported by the MBES is not correct. Further investigation in this direction revealed that the SeaBat 7125 used during the Puerto Rico Science Cruise reported a full swath width of 131.2 degrees. This value is 3.1 degrees greater than the normal 128.1 degrees swath.

As a means of correcting these incorrect reported pointing angles a calculated 0.2 degrees correction on the outer beams was applied. This was achieved by modifying the values of the sound velocity profile. For example, to the first sound velocity value in the profile, 1 m/s was added to create an artificial thermo cline.

The solution appears to have reduced, in some locations, and eliminated, in other locations, the smiling seafloor. Therefore, it is unsure whether the processing efforts to reduce the effects of the errant data were the proper ones implemented or if the error was due to another cause. Although thermal vents have been shown to have caused similar issues and could explain the regional nature of the mismatch this is likely not the case as profile data was collected directly over three patch test calibration areas and yet the problem remained quite prominent.

RESON would like to extend an apology to NOAA for the ill-performing multibeam Sonar Interface Unit which has certainly caused grief for the crews onboard the survey vessel and for the NOAA representative responsible for processing the bathymetry data. We very much hope that our efforts after the cruise were sufficient in arriving upon a solution and that the data is deemed useable. Should any further question arise, please do not hesitate to contact us: Michael.Mutschler@reson.com and Support@reson.com

APPENDIX M:

NF-09-01-USVI Cruise Instructions

CRUISE INSTRUCTIONS: NOAA SHIP NANCY FOSTER

Cruise Title: **Characterization of seafloor habitats of Vieques Puerto Rico**

Cruise Number NF-09-01-USVI

Period of Cruise:
DEP: 3/21/09
ARR: 4/3/09

Area of Operation: Vieques, Puerto Rico (See Figure 1)

1.0 Scientific Objectives:

The Center for Coastal Monitoring and Assessment (CCMA) will be conducting the sixth year of an ongoing scientific research mission onboard the NOAA ship Nancy Foster funded by NOAA's Coral Reef Conservation Program. The purpose of the cruise will be to collect swath bathymetry and acoustical backscatter, as well as fishery acoustics data in high priority areas surrounding Vieques Island. Scientists will collect high resolution multibeam and acoustic fisheries data in mid-water depths approximately 10 to 100 meters so as to continue to characterize seafloor habitats within all U.S. States, Territories, and Commonwealths. The objective of this project is to collect a multibeam bathymetry dataset with 100% seafloor ensonification, along with multibeam backscatter suitable for seafloor characterization. Multibeam data will be collected to conform to IHO Order 1 (<100m) and Order 2 (>100m) accuracy standards. The strategies developed for each survey area will take into account the minimum depths, general bathymetry, and time allotment. The delineation and identification of seafloor habitats will be assisted by the use of a moderate-depth ROV and drop camera. The vehicle has video and frame camera capability to depths of 300 meters and will be used to point sampling within areas mapped during this mission.

2.0 Schedule of Operations:

2.1 Daily Schedule:

Actual survey and ground truthing locations will be made available to the Operations Officer during the daily operations meeting. The following are estimates of locations.
* Passive fisheries acoustics via the Kongsberg ES120-7C will occur during all shifts (MBES Survey and Groundtruthing).

19 March (Thursday): Nancy Foster arrives in San Juan, Puerto Rico
Survey NF: Survey install team arrives.
GT: Ground Truthing (GT) install team arrives.

20 March (Friday):
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning. Install Reson 7125 and ES120-C (time TBD) to the moon pool using ship divers. Conduct dockside calibration tests.
GT: Ground Truthing (GT) install team configures remaining camera gear and conducts USBL, POS/MV, GPS integration with Hypack; and installs hydrophone pole.
All: Team scientists meeting to prepare for VIP/Education Day.

21 March (Saturday):
VIP Boarding: (0830) to transit with ship to Vieques.
Transit/VIP Event: (0930-1730) Ship transit from San Juan to El Rompeolas (Mosquito Pier) to conduct Education Day Event (touch and go). Conduct VIP MBES, fish acoustic demonstration en route with ROV deployment mid-route (~ 1 hr) with the exact location TBD.
Education Event/Open House: (1600-1700) Run education day events.
Transit/Survey NF: (1730-2400) Ship transit from Mosquito Pier to project area to begin MBES survey.

22 March (Sunday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

23 March (Monday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

24 March (Tuesday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

25 March (Wednesday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

26 March (Thursday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

27 March (Friday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

28 March (Saturday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

29 March (Sunday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

30 March (Monday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

31 March (Tuesday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

1 April (Tuesday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

2 April (Wednesday):
Survey NF: (2400-0800) MBES Vieques Project Area.
GT: (0800-1600) Conduct ground truthing of Vieques Project Area.
Survey NF: (1600-2400) MBES Vieques Project Area.

3 April (Thursday):
Survey NF: (2400-0800) MBES Vieques Project Area.
Transit: (0800-1300) Transit to San Juan USCGS

2.2 Watches:

Vessel operations will typically be a ~ 24 hour workday. A "give and take" operation cycle will be instituted during these workdays via consultation between the Chief Scientist and Commanding Officer in order to balance crew complement with demands of day-night operations. One crew member will be required on deck to work the winch for the ROV and CTD casts.

In Science Party, the Field Party Chief is responsible for organization of operations and data, respectively.

3.0 Map of Operations:

(See Figures 1 and 5)

4.0 Description of Operations:

Multibeam Operations:

Survey Schedule/Personnel:

The EM1002 will be utilized for deepwater multibeam surveying and the Reson 7125 for shallow-water surveying. Installation of the Seabat 7125 will occur in San Juan. The 7125 is being configured to mount to the moon pool flange.

Patch Test:

The patch test will be performed before surveying operations commence. The patch test calibration will quantify any residual biases from the alignment between the motion sensor, gyro and the multi-beam transducer. The patch test also quantifies the time lag

(latency) between the tim e positioning data is received, an d the tim e the com puted position re aches th e ac quisition sy stem. To ensure qua lity resu lts f rom the patch tes t procedure it is necessary to have a relatively calm sea state, collection of clean data and a helmsman that can stay online during the procedure. S tatic transducer draft, se ttlement and squat corrections, sound veloc ity corrections, and preliminary tide corrections will be applied to the data prior to bias determination. The general patch test procedure requires multibeam data co llection along a series of transects as described in Figure 3. Alternatively, yaw bias can al so be determ ined by survey ing two lin es on each s ide of a submerged object in relatively shallow water (Fig. 4). Patch test results will be calculated with CARIS's v6.1 calibration program in the following orde r: Latency, pitch, roll and yaw.

An area in the vicinity of Vieques will be been identified to provide the steep and smooth slope with little change in across track depth to accurately assess the latency, pitch and yaw biases for the NF. Two planned survey lines (1&2) oriented perpendicular to slope are parallel and spaced apart to ensure abundant overlap of outer beams. O

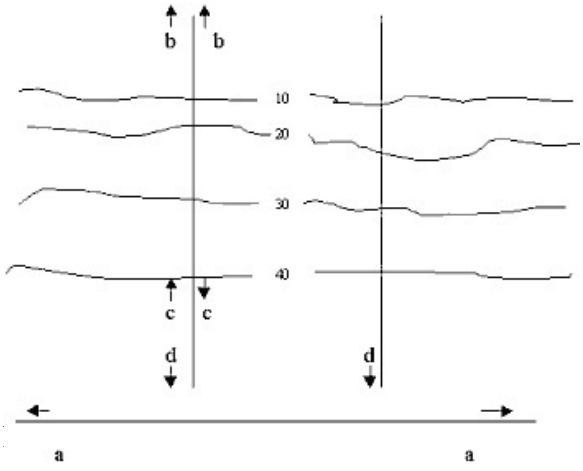


Figure 3: a = Roll, b = Latency, c = Pitch, d =Yaw

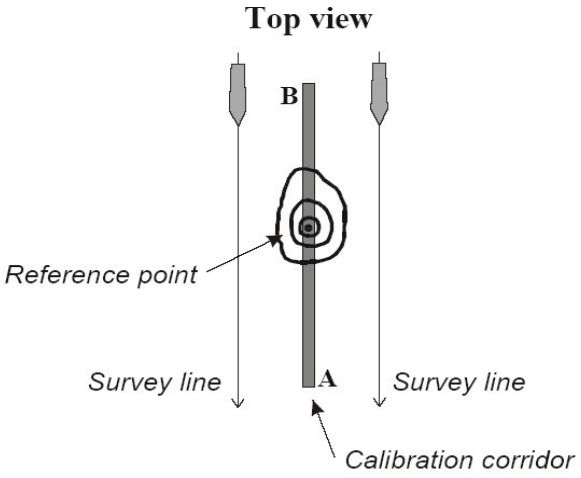


Figure 4: Yaw bias test performed on submerged object

tenc
l be

disturbances have cleared and will not impact data quality. Additional lines can be included and the schedule is preliminary.

Data Acquisition Methodology:

Due to the shoal depths along Puerto Rico, a line spac ing of 55 m eters is required to provide suf ficient cove rage. Reducing the an ticipated cov erage a rea will be r equired. The line plan is g enerally o rientated para llel with the co ntours to maxim ize swath coverage and improve acoustic returns. The line plan has taken into account water depths, swath width f ilters and overlap re quirements (Table 2). Restrict ing the swath lim it ensures th e data will m eet IHO standards, and m ake the data clean ing process more efficient. A ll deep surv ey areas will be accep ting sounding s 55 ° from nadir, port and starboard, with 10% sw ath overlap. Areas sho aler than 55 m eters will accept 60 ° port and starboard with a 10% overlap. Survey ing operations in the shallow water should

ideally be perform ed during daylight hours at higher tides to m aximize swath widths, and for vessel safety reasons. Surveying during calm waters and steady piloting of the vessel will improve data quality . T his is a pr eliminary lin e plan and f ield ad justments may be required.

The EM1002 data packets will be logged in Si mrad Merlin navigation program to create real time coverage maps to ensure coverage. During line turns data will be transferred to CARIS processing stations where prelim inary zoned tides, swath f ilters and SVP cast corrections will b e applied. The preliminary data will be used to create preliminary sun-illuminated Base surfaces for QA/QC analysis and then exported in to geo tiff for mat. These geo tif fs will be s uperimposed on top of the cha rts in Hypack f or additional line planning and navigation purposes.

Data Quality Assurance/Quality Control Methodology:

To ensure that the da ta collec ted m eets IHO Level 1 & 2 standards severa l quality assurance/quality control m easures will be implemented. The velocity of sound through the water colum n will be deriv ed from conductiv ity, tem perature, and depth measurements (CTD casts) coll ected no m ore than 4 hours apar t. A CTD cast will be will be tak en prio r to the commencem ent of daily m ultibeam oper ations. Sp atial variability will be tak en into acco unt as well as tem poral variab ility when determ ining cast locations. These location s will be reco rded and each cast will be com pared to th e previous to identif y any signif icant changes in the water colum n. Turns will be lim ited and vessel speed will be adjusted to ensure th at no less than 3.2 beam foot prints, center-to-center, f all within 3 m, or a dis tance e qual to 10 percent of the depth, whichever is greater, in the along track direction. Syst em c onfidence checks prior to, and during, multibeam operations will b e con ducted. Th ese in clude position che cks, le ad lin es and bar checks. Cross line s totaling 5% of main scheme will also be collected across each of the survey areas. Comparison of single beam, priors' and multibeam data will be used as an independent verification of the survey.

Ground Truthing Operations:

Benthic habitats in moderate depth water (>10m and <300m) Vieques Island will be visually-characterized using a ROV and drop camera system. This data will be collected to train and validate an automated benthic habitat characterization technique which uses fine-scale (<5 m) multibeam data. The topside control system will be operated from the Wet Lab. The ROV will be deployed using the J-frame. A hydrophone pole will be mounted/deployed over the port side forward of the J frame. The pole can be easily retrieved before transiting to a new location.

The sampling approach will be operated to conduct transects. The selection of ROV transects will largely be determined by assessing the results of the backscatter and bathymetry mapping occurring on preceding survey shifts. Ground truth sampling will be conducted using a modified stratified random sampling approach. Stratified "Regions" of homogeneous acoustical distinction will be identified for deployment based on visual and analytical assessment of the multibeam data. A number of samples station (2-5) will be randomly identified within the "region". The geodetic coordinates will be provided to the bridge as well as targeted in Hypack for display on

the bridge. Once the ship is on station, the USBL hydrophone pole will be rotated into position, and the drop camera powered up for deployment. Deployment of the ROV at the deepest depths (280m) will require the most time on station. Time estimates: 1) 15 minutes to deploy the ROV to the seafloor, 2) 2 hour transects, and 3) 20 minutes for retrieval. The scientists anticipate sampling between 3 to 4 transects per day for an 8 hour daylight shift. A ship deck hand will be required during recovery and deployment, but can otherwise be operated by the scientists.

Fishery Acoustics Operations:
A Kongsberg ES120-7C 120 kHZ split beam ec hosounder will be used to estimate fish abundance in high priorit y areas bein g survey ed. Active fisher y acoustics will be conducted concurrently with mutlibeam and ground-truthing ac tivities. Survey line plans will be acquired at strategic ti mes to optim ize collection of fish size and distribution to estim ate diurnal m igration patterns and habitat utilization patterns. Data collection at Mona Island will specifically focus on collecting data to character ize spawning aggrega tion, which has a high probability of occurrence during the days of activity. Target depths for spawning occur from 20 to 40 meters water depth.

5.0 Requirements and Equipment:

5.1 Vessel Provided:

1) Hand held radios for communication between bridge and deck.
2) EM 1002 shipboard multibeam, CARIS Processing station, Hypack, Velociwin, Alternate Applanix IMU for use with Reson 7125.
3) CTD's 100m and1000 m depth rating.

5.2 Program Provided:

Equipment
1) Underwater video + camera equipment + tow bodies (Phantom 2 ROV)
2) USBL Underwater tracking system and hydrophone pole
3) 6 USB 250GB Maxtor 5000XT hard-drives (CCMA).
4) Five high end laptops and two flat screen monitors.
5) CARIS, ArcGIS, ISIS
6) Reson 7125 multibeam and acquisition system.
7) Kongsberg ES120-6C 120 kHz transducer/receiver, and topside control

6.0 Scientific Personnel:

6.1 Chief Scientist Authority
The Chief Scientist has the authorit y to revise or alter the technical portions of the instructions provided that, after consultation with the Commanding Officer, it is ascertained that the proposed changes will not: 1) jeopardize the safety of the personnel on the ship, 2) exceed the time all otted for the pr oject, 3) result i n undue additional expense, or 4) alter th e general intent of the Project Instruction.

6.2 Scientific Personnel List:
Chief Scientist: Tim Battista

Lead Hydrographer: Mike Stetcher
Lead Communications/Outreach: Alicia Clarke

Scientist:	Organization:	FA	GT	Multibeam	Date
Tim Battista	NOAA		X		3/19-4/3
Mike Stetcher	Contractor			X	3/19-4/3
Ed Owens	NOAA			X	3/19-4/3
Bryan Costa	NOAA		V	C	3/20-4/3
Charlie Menza	NOAA		X		3/20-4/3
Zach H echt-Leavitt	NOAA		X	X	3/20-4/3
Lance Horn	NURC		X		3/19-4/3
Glenn Taylor	NURC		X		3/19-4/3
Chris Taylor	NOAA	X			3/19-4/3
Mike Mutchler	Reson			X	3/19-3/25
Tyler Smith	UVI		X		3/25-4/3
Alicia Clark	NOAA				3/20-3/28
Mark Monaco	NOAA				3/20-3/28
Bob Hairston-Porter	Charleston			X	3/20-4/3
Steven Long	Charleston			X	3/20-3/28
Christy Fadel	Charleston			X	3/20-3/28
Paulo Maurin	NOAA				3/28-4/3

TASK TEAMS

Education/Outreach
Clarke, Maurin

Fishery Acoustics
Taylor

Ground Truthing
Battista, Menza, Hecht-Leavitt, Horn, Taylor, Smith

Multibeam
1) **NF Team A (1600-2400): Stetcher**, Hecht-Leavitt, Long/Fadel, Foster Survey Tech.
2) **NF Team B (2400-0800): Owens**, Foster Survey Tech, Hairston-Porter, Costa.

Person in **bold** is field party chief – responsible f or prepping rest of team . Multibeam tea m members will rotate positions throughout the cruise.

Identification: All scientific personnel planning t o board the ship should have in their possession at the time of boarding, a proper photo identification card (agency ID, drivers license, etc.).

7.0 Miscellaneous Activities:
Education/VIP/Media day to occur on March 21 en route to Vieques and while in Vieques.

Clearance needs to be obtained to conduct a "touch and go" in Vieques at El Romepolas (Mosquito Pier) from the USCG, Vieques Municpality, and Puerto Rico Maritime Transportation Authority. Pier coordinates are 65° 30' 53.605" W, 18° 9' 2.009" N

7.1 Bridge Activities:
It is requested that a copy of the ship's *Deck Log - Weather Observation Sheet NOAA 77-13d* for and digital SCS data for the entire cruise be provided to the Chief Scientist upon departure of the science party or transmitted within 2 weeks thereafter.

8.0 Modification of Cruise Instructions:
Additional operations and ancillary projects, not covered under the main project, may be performed on a "not to interfere" basis. The Chief Scientist is responsible for determining the priority of the additional work, provided that any changes are discussed with the Commanding Officer and do not constitute a risk to the safety of the ship or personnel and do not significantly change the schedule for this cruise. If the requirements for the additional work place significantly different requirements on the ship, amendments to the Cruise Instructions must be prepared and approved.

9.0 Ancillary Tasks:
Ship's personnel conduct ancillary tasks. Instructions for ancillary tasks routinely assigned to Marine Operations Center ships are contained in *Marine Operations Center Directive 1803.00, Ancillary Tasks for NOAA Vessels*.

10.0 Hazardous Materials:
An inventory list and a *Material Safety Data Sheet* for each hazardous material will accompany hazardous material brought on board NANCY FOSTER by scientific parties. This information should be provided to the Commanding Officer. On departure from the ship, scientific parties will provide an inventory of hazardous material to the Commanding Officer showing that all hazardous material brought on board have been properly used up or removed in suitable waste containers. No anticipated hazardous materials is anticipated to be brought onboard.

The *Material Safety Data Sheet* is normally available from the manufacturer of the hazardous product. Procedures followed for use of chemicals will be those outlined in the *Chemical Hygiene Plan for Chemical Labs* aboard NOAA ships. The Science Party will provide a small spill containment kit appropriate for these chemicals.

11.0 Navigation:
Survey and ROV operations will be operated using DGPS. Navigation information via Hypack software will be fed to the Bridge monitor from the Wet and Dry labs via cable.

12.0 Communications:
A progress report on operations prepared by the Chief Scientist may be relayed to the program office. Sometimes it is necessary for the Chief Scientist to communicate with another vessel, aircraft, or shore facility. Through various modes of communication, the ship is able to maintain contact with the Marine Operations Center on an as needed basis. These methods will be made available to the Chief Scientist upon request, in order to conduct official business. Due to a new directive from Marine Operations Center, the ship must charge the science party for all calls made on the cell or sky-cell telephone. INMARSAT, Sky Cell and cellular communication costs shall be reimbursed to the ship for telephone calls made by all scientific personnel. Currently, Sky Cell and cellular telephone services are about $0.89 per minute and INMARSAT Mini-M is around

$1.68 per minute for voice. These charges will be assessed against the program after NANCY FOSTER receives the bill. There is generally a three-month delay receiving the bill for review. The Chief Scientist will be required to keep a log of all calls made by the science party. The program will also provide a cell phone to be kept on the bridge.

13.0 Disposition of Data:
The Chief Scientist is responsible for the disposition of data.

14.0 Foreign Nationals
Paul Maurin of NOAA's CRCP program is an Argentinean Foreign National. He is submitting the required paperwork for ship clearance.

15.0 Travel orders
All Federal employee scientists will be issued travel orders for participation in the science cruise. Contractors will travel under terms of their respective contracting organizations.

16.0 Meals and Berthing:
Meals and berthing are required for up to 7 scientists. Meals will be served 3 times daily beginning one hour before scheduled departure, extending throughout the cruise, and ending two hours after the termination of the cruise. Berthing requirements, including number and gender of the science crew, will be provided to the ship by the Chief Scientist. The Chief Scientist and Commanding Officer will work together on a detailed berthing plan to accommodate the gender mix of the scientific party taking into consideration the current make-up of the ship's complement.

All NOAA Scientists will have proper travel orders when assigned to any NOAA ship. The Chief Scientist will ensure that all non NOAA or non Federal scientists aboard also have proper orders. It is the responsibility of the Chief Scientist to ensure that the entire scientific party has a mechanism in place to provide lodging and food and to be reimbursed for these costs in the event that the ship becomes uninhabitable and/or the galley is closed during any part of the scheduled project.

Since the watch schedule is split between day and night, the night watch may often miss daytime meals and will require adequate food and beverages (for example a variety of sandwich items, cheeses, fruit, milk, juices) during what are not typically meal hours. Special dietary requirements for scientific participants will be made available to the ship's command at least seven days prior to the survey.

17.0 Medical Forms:
NOAA Fleet Medical Policy requires all personnel embarking on NOAA vessels to furnish a completed copy of the NOAA Health Services Questionnaire (NHSQ) to the Health Services Office of the Marine Operations Center. This form should be submitted 30 days in advance of sailing, but no later than 7 days in advance of sailing. The Chief Scientist is responsible for the timely submission of NHSQs for scientific personnel to the Health Services Office.

18.0 Post Cruise Reporting Requirements

Within seven days of the completion of the cruise, a Ship Operation Evaluation form is to be completed by the Chief Scientist. The preferred method of transmittal of this form is via email to

OMAO.Customer.Satisfation@noaa.gov If email is not an option, a hard copy may be forwarded to:

Director, NOAA Marine and Aviation Operations
NOAA Office of Marine and Aviation Operations
8403 Colesville Road, Suite 500
Silver Spring, MD 20910

Upon completion of the cruise, a post-cruise meeting will normally be held at 08:30 (unless prior alternate arrangements are made) and attended by the ship's officers, the Chief Scientist and members of the scientific party, the Vessel Coordinator and the Port Captain to review the cruise. Concerns regarding safety, efficiency, and suggestions for improvements for future cruises should be discussed. Minutes of the post-cruise meeting will be distributed to all participants with email to the CO.MOC.Atlantic@noaa.gov and ChiefOps.MOA@noaa.gov

19.0 IT Security: Any computer that will be hooked into the ship's network must comply with the *NMAO Fleet IT Security Policy* prior to establishing a direct connection to the NOAA WAN. Requirements include, but are not limited to:

(1) Installation of the latest virus definition (.DAT) file on all systems and performance of a virus scan on each system.
(2) Installation of the latest critical operating system security patches.
(3) No external public Internet Service Provider (ISP) connections.

Non-NOAA personnel using the ship's computers or connecting their own computers to the ship's network must complete NOAA's IT Security Awareness Course within 3 days of embarking.

17.0 Cruise Instruction Approvals:

The Marine Operations Center and NANCY FOSTER will acknowledge receipt of these instructions.

Submitted by:

Dr. Russell Callender
Center Director,
Center for Coastal Monitoring and Assessment

Date_____

Mr. Timothy A. Battista
Biogeographic Team,
Center for Coastal Monitoring and Assessment

Date _____

Approved by:

Captain Emily Christman, NOAA
Commanding Officer, Marine Operations Center Atlantic

Date_____

Figure 1: Puerto Rico Priority (multibeam and ground truthing areas).

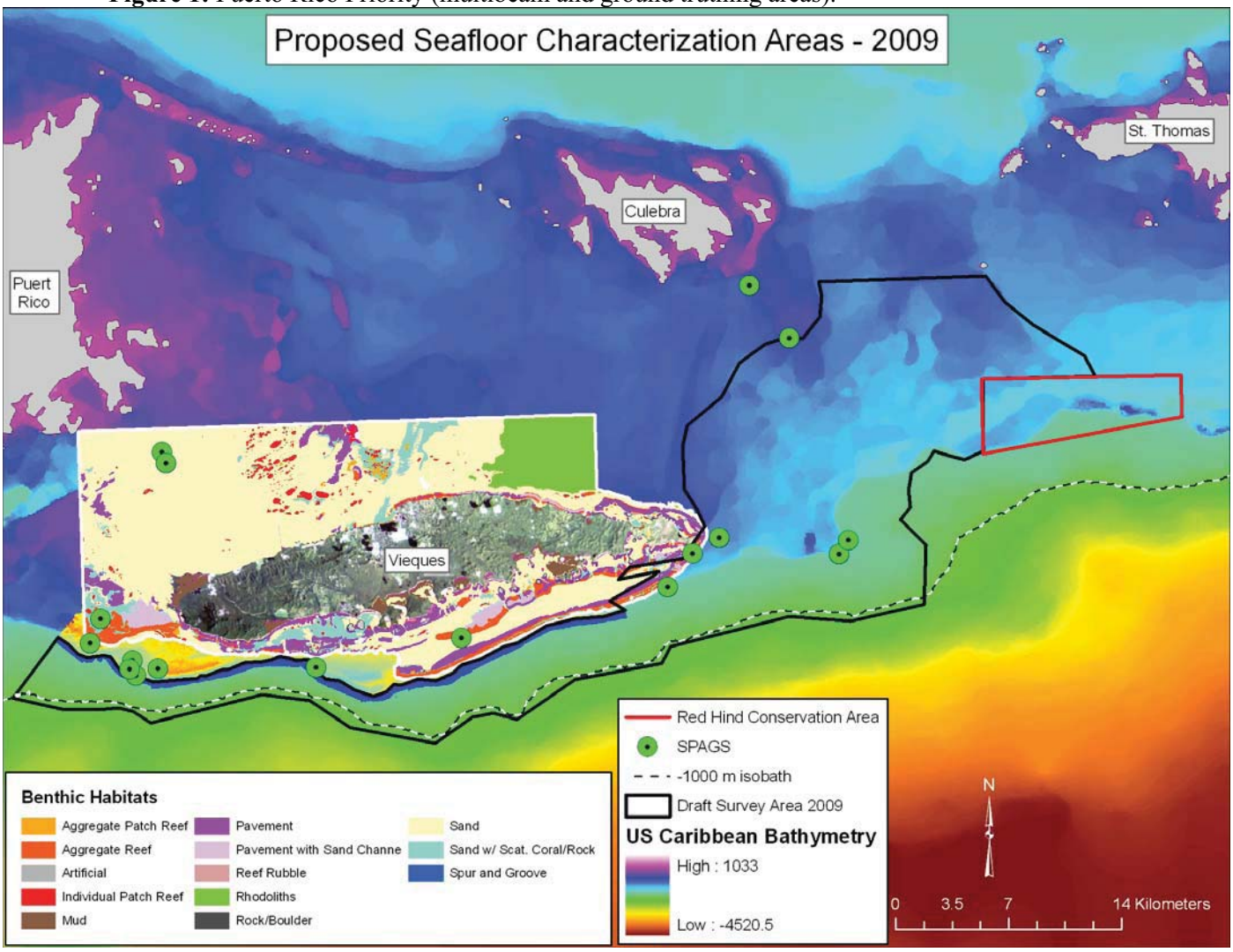


Table 2: Line Spacing Specifications

Depth (Fath)	Depth (M)	Depth (ft)	Swath Angle (Degrees)	Swath Overlap (%)	Line Spacing (M)	Line Spacing (ft)
5	9.1	30.0	55	10	23.5	77.1
10	18.3	60.0	55	10	47.0	154.2
15	27.4	90.0	55	10	70.5	231.4
20	36.6	120.0	55	10	94.0	308.5
25	45.7	150.0	55	10	117.5	385.6
30	54.9	180.0	55	10	141.0	462.7
40	73.2	240.0	55	10	188.0	617.0
50	91.4	300.0	55	10	235.1	771.2
75	137.2	450.0	55	10	352.6	1156.8
100	182.9	600.0	55	10	470.1	1542.4
125	228.6	750.0	55	10	587.7	1928.0
150	274.3	900.0	55	10	705.2	2313.6
175	320.0	1050.0	55	10	822.7	2699.2
200	365.8	1200.0	55	10	940.2	3084.8
250	457.2	1500.0	55	10	1175.3	3856.0
300	548.6	1800.0	55	10	1410.4	4627.2
350	640.1	2100.0	55	10	1645.4	5398.4
400	731.5	2400.0	55	10	1880.5	6169.6
450	823.0	2700.0	55	10	2115.6	6940.8
500	914.4	3000.0	55	10	2350.6	7712.0
550	1005.8	3300.0	55	10	2585.7	8483.2
600	1097.3	3600.0	55	10	2820.7	9254.4
650	1188.7	3900.0	55	10	3055.8	10025.6
700	1280.2	4200.0	55	10	3290.9	10796.8

$L=2\ d \tan (a/2) * (1-s)$

a = Multibeam Swath Angle

d = Water Depth (ft)

s = Swath Sidelap

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

February 5, 2009

MEMORANDUM FOR: Timothy A. Battista
NOAA, National Center for Coastal and Ocean Science

Jeffrey Ferguson
on=Jeffrey Ferguson, o=Office of Coast Survey, ou=Chief, Hydrographic Surveys Division, email=jeffrey.ferguson@noaa.gov, c=US
I am approving this document
2009.02.09 14:00:58 -05'00'

FROM: Jeffrey Ferguson
Chief, Hydrographic Surveys Division

SUBJECT: Hydrographic Survey Project Instructions,
M-I905-NF-09 Puerto Rico Mapping Project

Hydrographic Project Instructions are forwarded for concurrence and issue as a supplemental to the Primary Investigator during the NF-09-01-USVI, Coral Reef Mapping Project aboard the NOAA Research Vessel Nancy Foster. All hydrographic data being considered for submission to the Office of Coast Survey (OCS) for nautical charting purpose's must be acquired, processed, and delivered according to the OCS specifications and requirements stated in the accompanying hydrographic project instructions.

Please email concurrence cover memo to the vessel Commanding Officer and the Chief, Operations Branch, Hydrographic Surveys Division (James.M.Crocker@noaa.gov).

Attachment
cc Commanding Officer, NOAA Ship Nancy Foster
cc Timothy A. Battista, NOAA, National Center for Coastal and Ocean Science
cc CDR Shep Smith, Chief, NOAA, Atlantic Hydrographic Branch

Hydrographic Survey Project Instructions, M-I905-NF-09, Puerto Rico Mapping Project

project number **M-I905-NF-09**	*project name* **Puerto Rico Mapping Project**
field unit(s) assigned to project **Nancy Foster, R 352**	*planned acquisition* **February and March, 2009**
expected delivery to the Atlantic Hydrographic Branch **July 2009**	
Purpose and location This project is being conducted in support of the National Center for Coastal Ocean Science (NCCOS) to provide shallow water bathymetric data of critical benthic habitats in select areas off the east coast of Isla De Vieques, Puerto Rico. Bathymetric data from this project will be collected with a multibeam echosounder and further utilized by the Office of Coast Survey (OCS) to update the nautical charts in this area. An Atlantic Hydrographic Branch (AHB) representative will assist with data acquisition to ensure OCS charting standards are met. **This project will cover approximately 150 nm^2 of Survey Priority Areas 2 and 4 as designated in NOAA Hydrographic Survey Priorities, 2008 edition.**	

Hydrography shall consist of Navigable Area Surveys in accordance with the following support documents. Data from survey is intended to supersede all prior survey data in the common area.
NOS Hydrographic Surveys Specifications and Deliverables Manual (HSSDM), April 2008
NOS Field Procedures Manual for Hydrographic Surveying (FPM), May 2008
• **Hydrographic Survey Technical Directive 2008-5, 2008-9**

PERSONNEL SAFETY AND DATA QUALITY SHALL ALWAYS BE EMPHASIZED OVER DATA QUANTITY! THE HYDROGRAPHER SHALL NEVER SUBJECT BOATS OR PERSONNEL TO UNDUE RISKS AND HAZARDS.

REGISTRY DETAILS AND SURVEY PRIORITIES

All sheets for this project have the general locality of the Caribbean Sea and are in the Common Wealth of Puerto Rico. See attached sheet layout and project sketch dated 12/10/08.

registry number	*sheet letter*	*sublocality*	*scale*	*estimated SNM*	*priority*
H12005	A	5 NM Southeast of Isla De Culebra, PR	1:20,000	83	1st
H12006	B	Southeast Coast of Isla De Vieques, PR	1:20,000	67	2nd

Hydrographic Survey Project Instructions,
M-I905-NF-09, Puerto Rico Mapping Project

REQUIRED COVERAGE TYPES

water depth range or area	*required coverage type(s)*
> 10 meters water depth	Complete MB coverage

TASKS

Acknowledgement	Acknowledge receipt of these instructions and submit any comments or questions via email to: Paul.Turner@noaa.gov			
Aids to Navigation (ATONs)	N/A			
AWOIS Items	• 0 items are assigned for full investigation • 0 items are provided for background information only			
Bottom Samples	N/A			
Chart Comparison	Use the latest editions of NOS nautical charts which are included with the project data from Operations Branch for comparison during this project in accordance with section 4.5 of the FPM and section 8.1.3., D.1 of the HSSDM. Resolve any discrepancies in the field and explain them in the Descriptive Report.			
	Raster			
	Chart Number	*Edition*	*Edition Date*	*Raster (.kap) Date*
	25640	42nd	11-2006	11/18/06
	25650	34th	04-2004	4/17/04
	Electronic			
	ENC Cell Name	*Edition*	*Update Application Date*	*Issue Date*
	US3PR10M	5th	2008-11-17	2008-11-17
	US4PR30M	5th	2008-11-03	2008-11-03
Coast Pilot	Review and make recommendations for changes to the Coast Pilot excerpts provided with the project data. Submit the revised Coast Pilot section or a report stating no changes are recommended, via email to OCS.NDB@NOAA.GOV with a copy to N/CS33. The report should be submitted as soon as possible following field work for the project. Refer to sections 3.5.6 and 5.2.3.2.5. of the FPM for more information.			
Dangers to Navigation (DTONs)	Generate DTON reports in accordance with the HSSDM, section 8.1.2. ***It is of paramount importance that DTONs be reported as soon as possible.***			
Data directory size report	After data acquisition is complete for each survey, send an e-mail indicating the survey/project number, survey platform, raw MBES and/or VBES directory size, and raw SSS directory size to NGDC at hydro.info@noaa.gov with a copy to Shep.Smith@noaa.gov, Chief of the Atlantic Hydrographic Branch.			

Hydrographic Survey Project Instructions,
M-I905-NF-09, Puerto Rico Mapping Project

Historical Properties Coordination	A request for historical properties has been sent to NOAA's Marine Sanctuary Program and the Puerto Rico State Historical Preservation Officer. No known historical features are present in the project area.			
Junctions	N/A			
Progress sketches and statistics sheet	Email zipped monthly progress sketch MapInfo table with workspace (without raster charts) and separate Excel statistics spreadsheet directly to progress.sketches@noaa.gov with a copy to Shep.Smith@noaa.gov, the chief of the Atlantic Hydrographic Branch. The submittal is due within 5 days after the end of each month and will be submitted by an OCS representative.			
Survey outlines	Create a survey outline region in MapInfo, UTM (NAD 83), showing the extent of hydrography as soon as possible after field acquisition is completed on a sheet. Instructions for creating this outline are included with the project data. Email the outline to survey.outlines@noaa.gov			
Tide requirements	Comply with the requirements from COOPS which are included with the project data from Operations Branch. Submit surveys with final approved water levels applied. Contact the Operations Branch if this causes the survey to miss a submission deadline.			
	Zoning method: Discrete			
	operating water level stations	*station ID*	*leveling required?*	*installation required?*
	Vieques, PR	975-2695	No	No
	Culebra, PR	975-2235	No	No
	Charlotte Amelie, VI	975-1639)	No	No
Topography	N/A			

USER EVAULATION

The following primary offices and persons **shall be** contacted at or near the beginning and ending of field operations to discuss survey objectives and accomplishment.

NOAA Navigation Manager,
Southeast Region
Michael E. Henderson
NMFS Route: F/SE
263 13TH Avenue South
St. Petersburg, FL 33701
Phone: 727-824-5396
Cell: 727-772-3708
E-Mail: Michael.Henderson@noaa.gov

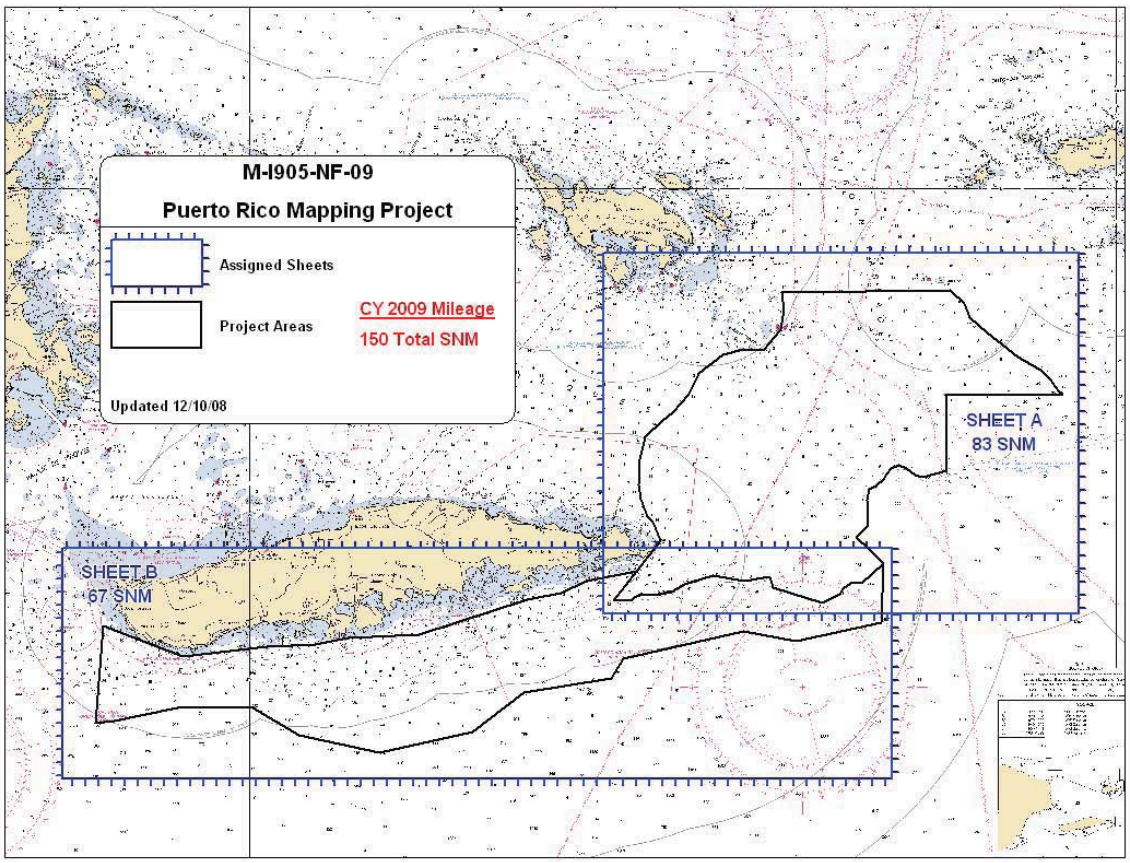
National Center for Coastal and
Ocean Science
Timothy A. Battista
1305 East West Highway
Silver Spring, MD 20910
Phone: 301-713-3028*171
E-Mail: Tim.Battista@noaa.gov

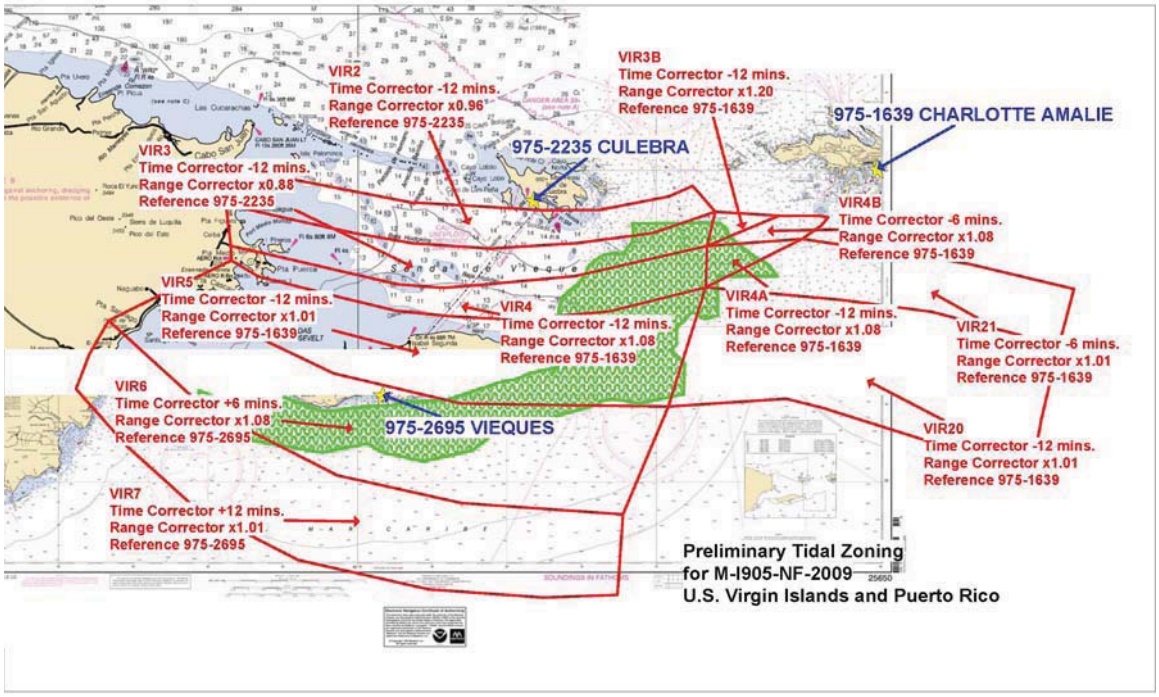
The following secondary contacts are listed **for reference** and are to be contacted at the discretion of the Commanding Officer.

U.S. Coast Guard – District 7
Sector San Juan
Lt Blanca Rosas
#5 La Puntilla
San Juan, PR 00901
Phone: (787) 289-2089
Fax: (787) 729-6618
E-Mail: Blanca.Rosas@uscg.mil

U.S. Army Corps of Engineers,
Jacksonville District
Jerry Scarborough
Coastal/Navigation Branch
U.S. Army Corps of Engineers,
Jacksonville District
P.O. Box 4970
Jacksonville, FL 32232-0019
Phone: 904-232-1600
E-Mail:
Jerry.W.Scarborough@usace.army.mil

State Historic Preservation Officer
(SHPO), Puerto Rico
Mr. Miguel Bonini, SHPO
P.O. Box 9066581
San Juan, PR 00906-6581
Phone: 787-721-3737
Fax: 787-721-3773
E-Mail: mbonini@prshpo.gobierno.pr


M-I905-NF-09
Puerto Rico Mapping Project
Assigned Sheets
Project Areas
CY 2009 Mileage
150 Total SNM
Updated 12/10/08
SHEET A
83 SNM
SHEET B
67 SNM


VIR2
Time Corrector -12 mins.
Range Corrector x0.96
Reference 975-2235
VIR3B
Time Corrector -12 mins.
Range Corrector x1.20
Reference 975-1639
975-1639 CHARLOTTE AMALIE
975-2235 CULEBRA
VIR3
Time Corrector -12 mins.
Range Corrector x0.88
Reference 975-2235
VIR4B
Time Corrector -6 mins.
Range Corrector x1.08
Reference 975-1639
VIR5
Time Corrector -12 mins.
Range Corrector x1.01
Reference 975-1639
VIR4
Time Corrector -12 mins.
Range Corrector x1.08
Reference 975-1639
VIR4A
Time Corrector -12 mins.
Range Corrector x1.08
Reference 975-1639
VIR21
Time Corrector -6 mins.
Range Corrector x1.01
Reference 975-1639
VIR6
Time Corrector +6 mins.
Range Corrector x1.08
Reference 975-2695
975-2695 VIEQUES
VIR20
Time Corrector -12 mins.
Range Corrector x1.01
Reference 975-1639
VIR7
Time Corrector +12 mins.
Range Corrector x1.01
Reference 975-2695
Preliminary Tidal Zoning
for M-I905-NF-2009
U.S. Virgin Islands and Puerto Rico

AHB COMPILATION LOG

General Survey Information	
REGISTRY No.	W00213
PROJECT No.	M_I905_NF_09
FIELD UNIT	NOAA SHIP NANCY FOSTER
DATE OF SURVEY	20090326 - 20090402
LARGEST SCALE CHART	***25650, edition 34, 20101016, 1:100,000***
ADDITIONAL CHARTS	***25640, edition 43, 20101016, 1:326,856***
SOUNDING UNITS	**FATHOMS**
COMPILER	Kolleen McKenzie

Source Grids	**File Name** H:\Compilation\W00213_I905-NF\AHB_ W00213\SAR Final Products\GRIDS
Surfaces	**File Name** H:\Compilation\ W00213_I905-NF\AHB_ W00213\COMPILE\Working
Combined	**W00213_8m_Combined.csar**
Interpolated TIN	\Interpolated TIN\ **W00213_16m_InterpTIN.csar**
Shifted Interpolated TIN	\Shifted Surface\ **W00213_16m_InterpTIN_Shifted.csar**
Final HOBs	**File Name** H:\Compilation\W00213_I905-NF\AHB_W00213\COMPILE\Final_Hobs
Survey Scale Soundings	**W00213_SS_Soundings.hob**
Chart Scale Soundings	**W00213_CS_Soundings.hob**
Contour Layer	**W00213_Contours.hob**
Feature Layer	**W00213_Features.hob**
Meta-Objects Layer	**W00213_MetaObjects.hob**
ENC Retain Soundings	**W00213_ENC_Retain_Soundings.hob**

Meta-Objects Attribution	
Acronym	**Value**
M_COVR	
CATCOV	1 – coverage available
SORDAT	20090402
SORIND	US,US,graph,W00213
M_QUAL	
CATZOC	6 – zone of confidence U (data not assessed)
INFORM	NOAA Ship Nancy Foster
POSACC	10.0 m
SORDAT	20090402
SORIND	US,US,graph,W00213
SUREND	20090402
SURSTA	20090326
DEPARE	
DRVALV 1	11.42115 fm
DRVALV2	189.65279 fm
SORDAT	20090402
SORIND	US,US,graph,W00213

M_CSCL	
CSCALE	
SORDAT	
SORIND	

SPECIFICATIONS:

I. COMBINED SURFACE:
- a. Number of SAR Final Grids: 4
- b. Resolution of Combined (m): 8 m

II. SURVEY SCALE SOUNDINGS (SS):
- a. Attribute Name: Depth
- b. Selection criteria: Radius, Shoal bias
- c. Radius value is: mm at map scale
  - i. Use single-defined radius: 1.00 m
- d. Queried Depth of All Soundings
  - i. Minimum: 20.887 m
  - ii. Maximum: 346.897 m

III. INTERPOLATED TIN SURFACE:
- a. Resolution (m): 16 m
- b. Interpolation method: Natural Neighbor
- c. Shift value: -0.75 fm [*only include applicable shift values*] [*-0.75 feet* (And/Or) *-0.75 fathoms*]

IV. CONTOURS:
- a. Attribute Name: Depth
- b. Use a Depth List: W00213_depth_contours.txt
- c. Output Options: Create contour lines
  - i. Line Object: DEPCNT
  - ii. Value Attribute: VALDCO

V. FEATURES:
- a. Number of Chart Features: 1 [*all features included in H-Cell*]
- b. Number of Non-Chart Features: 0 [*all features submitted by field & not included in H-Cell*]

VI. CHART SURVEY SOUNDINGS (CS):
- a. Number of ENC CS Soundings: 22
- b. Attribute Name: Depth
- c. Selection criteria: Radius, Shoal bias
- d. Radius value is: Distance on the ground (m)
  - i. Use single-defined radius: 1000 m
  - ii. Enable Filter: Interpolated !=1
- e. Number Survey CS Soundings: 25

VII. NOTES:

[*Type text*]

ATLANTIC HYDROGRAPHIC BRANCH
H-CELL REPORT to ACCOMPANY
SURVEY W00213 (2009)

Survey W00213 was originally submitted as "H12005". After submission to the Atlantic Hydrographic Branch (AHB), survey H12005 was found to be in noncompliance with *National Ocean Service Hydrographic Survey Specifications & Deliverables* (NOS HSSD) requirements for basic hydrographic surveys. Survey H12005 was re-registered as Outside Source Data survey W00213.

This H-Cell Report has been written to supplement and/or clarify the original Data Acquisition & Processing Report (DAPR) and pass critical compilation information to the cartographers in the Marine Chart Division.

A. AREA SURVEYED

Isla de Vieques, Puerto Rico

Hydrographic survey W00213 was conducted in accordance with the Project Instructions for **M-I905-NF-09**. Data were collected aboard the NOAA Ship *Nancy Foster* (NF) from March 26 to April 2, 2009.

Project **M-I905-NF-09** was conducted in support of the National Center for Coastal Ocean Science (NCCOS) to provide shallow water bathymetric data of critical benthic habitats in select areas off the coast of Isla de Vieques, Puerto Rico. Bathymetric data from this project was collected with multibeam echosounders and further utilized by the Office of Coast Survey (OCS) to update the nautical charts in this area. Field processing and reports were provided by the contract Lead Hydrographer Mike L. Stecher of Solmar Hydro, Inc.

Refer to the Data Acquisition and Processing Report (DAPR) *M-I905-NF-09_DAPR.pdf* accompanying this survey for detailed documentation of system calibrations, data acquisition, and data processing.

B. DATA ACQUISITION AND PROCESSING

B.2 QUALITY CONTROL

The AHB source depth grids for the survey's nautical chart update were depth thresholded at 1m, 2m, 4m, and 8m resolution BASE surfaces (*.CSAR), and were combined at 8m resolution. The survey scale soundings were created from the combined surface at a single defined radius of 1mm at the largest scale chart that covers the respective survey area (25640 ~ 1:100,000). A TIN was created from the survey scale soundings, from which an interpolated surface of 16m resolution was generated. The chart scale soundings were selected using a single defined radius of 1000m (on the ground) from only the non-interpolated nodes of this surface to preserve

absolute continuity between the charted depths, the survey scale soundings and the original source grid node. The surface model was referenced when selecting the chart scale soundings, to ensure that the selected soundings portray the bathymetry within the common area.

The interpolated TIN surface of 16m resolution was shifted by the NOAA sounding rounding value of -0.75 fathoms. The shifted interpolated TIN was used to generate depth contours in fathoms. The depth contours are forwarded to MCD for reference only. The contours were utilized during chart scale sounding selection and quality assurance efforts at AHB. The depth contours are incorporated into the SS H-Cell product as per 2009 H-Cell Specifications.

The compilation products (Final *.HOB files) for this survey are detailed in the W00213 AHB Compilation Log contained within this document. The Final HOB files include depth areas (DEPARE), depth contours (DEPCNT), soundings (SOUNDG), features (SBDARE), and meta-objects (M_COVR, and M_QUAL).

As dictated by Hydrographic Technical Directive 2008-8, the Final HOB files were combined into two separate H-Cell files in S-57 format. Both S-57 files were exported from CARIS Bathy DataBASE in meters, and then converted from metric units into feet using CARIS HOM ENC 3.3. Quality assurance and topology checks were conducted using CARIS S-57 Composer 2.1 validation tests and DKART Inspector 5.0 validation tests.

The final H-Cell products are two S-57 files, in Lat/Long NAD-83. The contents of these two H-Cell deliverables are listed in the table below:

TABLE 1 - Contents of H-Cell Files

W00213_CS.000			**Scale 1:100,000**
Object Class Types	**Geographic**	**Cartographic**	**Meta**
S-57 Object Acronyms	DEPARE		M_COVR
	SBDARE		M_QUAL
	SOUNDG		
W00213_SS.000			**Scale 1:20,000**
Object Class Types	**Geographic**		
S-57 Object Acronyms	DEPCNT		
	SOUNDG		

B.2.4 Junctions and Prior Surveys

There are no contemporary surveys that junction with W00213. Most present survey depths compare within 10 feet of junctioning survey depths, but in some cases, the depths differ by up to 115 feet. The survey is along a dynamic and steep slope, where small horizontal offsets between soundings can result in significant depth differences (Fig. 1).

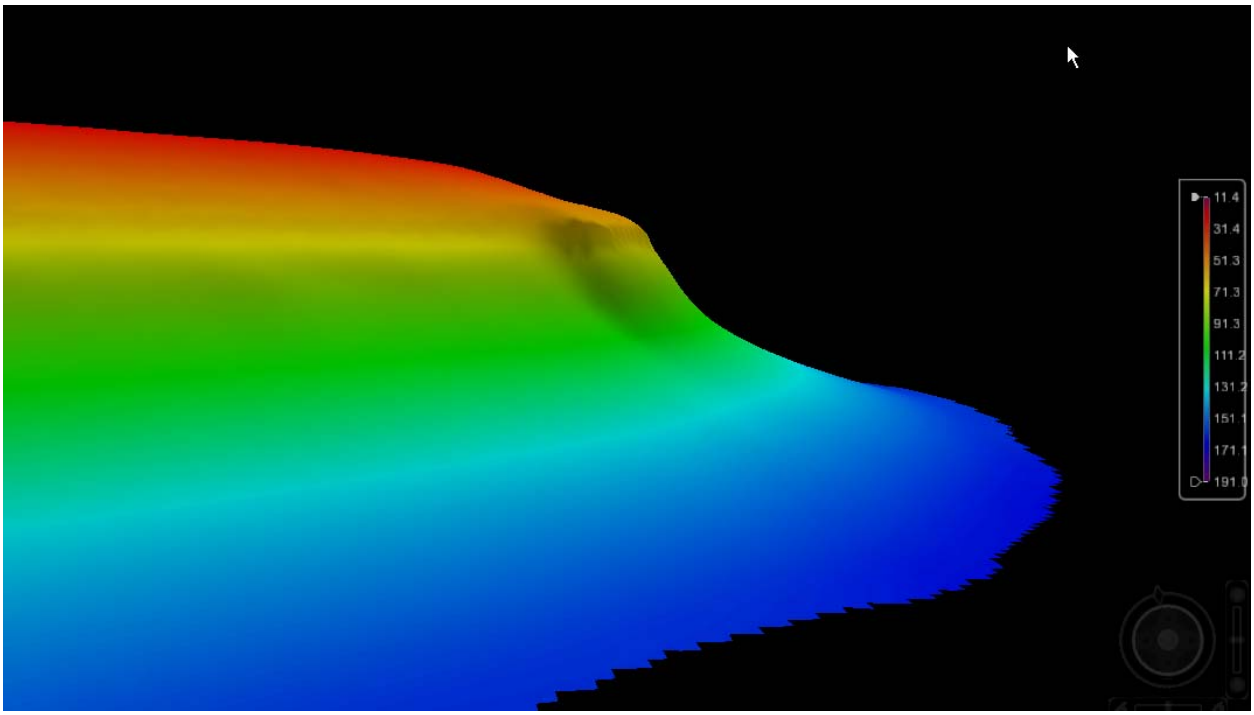


Fig. 1: The bathymetry along the survey junction is characterized by very steep relief.

B.4 DATA PROCESSING

The following software was used to process data at the Atlantic Hydrographic Branch:

CARIS Bathy DataBASE version 2.3/HF16
CARIS Bathy DataBASE version 3.0/HF8
CARIS HIPS and SIPS version 7.0/SP2/HF3
CARIS HIPS and SIPS version 6.1/SP2/HF8
CARIS S-57 Composer version 2.1/HF4
CARIS HOM ENC version 3.3/SP3/HF8
DKART Inspector version 5.0

C. HORIZONTAL AND VERTICAL CONTROL

The hydrographer makes adequate mention of horizontal and vertical control used for this survey in section VI of the DAPR. The sounding datum for this survey is Mean Lower Low Water (MLLW), and the vertical datum is Mean High Water (MHW). Horizontal control used for this survey during data acquisition is based upon the North American Datum of 1983 (NAD83), UTM projection zone 20 North.

D. RESULTS AND RECOMMENDATIONS

D.1 CHART COMPARISON

25650 (34th Edition, Apr/04)
Virgin Passage and Sonda de Vieques
Corrected through NM 10/16/2010
Corrected through LNM 10/12/2010
Scale 1:100,000

25640 (43rd Edition, Nov/08)
Puerto Rico and Virgin Islands
Corrected through NM 10/16/2010
Corrected through LNM 10/12/2010
Scale 1:326,856

ENC COMPARISON

US4PR30M
Virgin Passage and Sonda de Vieques
Edition 5
Application Date 2008/11/03
Issue Date 2009/01/07
Chart 25650

US3PR10M
Puerto Rico and Virgin Islands
Edition 8
Application Date 2010/08/24
Issue Date 2010/08/27
Chart 25640

D.2 ADDITIONAL RESULTS

The charted hydrography originates with prior surveys and requires no further consideration. The hydrographer makes adequate chart comparisons in section B.2 of this report. The hydrographer recommends that any charted features not specifically addressed either in the H-Cell files or this report should be retained as charted.

D.6 MISCELLANEOUS

Chart compilation was completed by Atlantic Hydrographic Branch personnel in Norfolk, Virginia. Compilation data will be forwarded to the Marine Chart Division in Silver Spring, Maryland. See section D.1 of this report for a list of the Raster Charts and Electronic Navigation Charts (ENC) used for compiling the present survey.

D.7 ADEQUACY OF SURVEY

Survey W00213 is considered as Outside Source Data and is not held accountable for OCS survey specifications; the data and deliverables are adequate for chart update. Survey W00213 is adequate to supersede the charted bathymetry within the common area. Any features (including seabed characteristics) not specifically addressed in the H-Cell files should be retained as charted.

APPROVAL SHEET
W00213

Initial Approvals:

The completed survey has been inspected with regard to survey coverage, delineation of depth contours, disposition of critical depths, cartographic symbolization, and verification or disproval of charted data. All revisions and additions made to the H-Cell files during survey processing have been entered in the digital data for this survey. The survey records and digital data comply with National Ocean Service and Office of Coast Survey requirements except where noted in the Descriptive Report and the H-Cell Report.

All final products have undergone a comprehensive review per the Hydrographic Surveys Division Office Processing Manual and are verified to be accurate and complete except where noted.

Kolleen McKenzie

Digitally signed by Kolleen McKenzie
DN: cn=Kolleen McKenzie, o=NOAA, ou=AHB, email=kolleen.mckenzie@noaa.gov, c=US
Date: 2010.12.29 08:48:54 -05'00'

Kolleen McKenzie
ERT Intern
Atlantic Hydrographic Branch

I have reviewed the H-Cell files, accompanying data, and reports. This survey and accompanying Marine Chart Division deliverables meet National Ocean Service requirements and standards for products in support of nautical charting except where noted.

Richard T. Brennan
I am approving this document
2010.12.29 20:17:34 -05'00'

Approved: _____

CDR Richard T. Brennan, NOAA
Chief, Atlantic Hydrographic Branch

Paul Turner
AWOIS & SURF Check
2011.01.03 10:15:02 -05'00'