Data Acquisition & Processing Report

Type of Survey: Benthic Habitat and Hydrographic Project

No. NF-07-06-USVI-HAB

April 14, 2007 - April 24, 2007

Localities

Abrir La Sierra Bank

Bajo De Cico

Isla De Mona

2007

<u>Chief Scientist</u>

Timothy A. Battista

<u>Lead Hydrograher</u>

Mike L. Stecher

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NF-07-06-USVI-HAB

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Western Coast of Puerto Rico

NOAA Ship NANCY FOSTER

Chief Scientist

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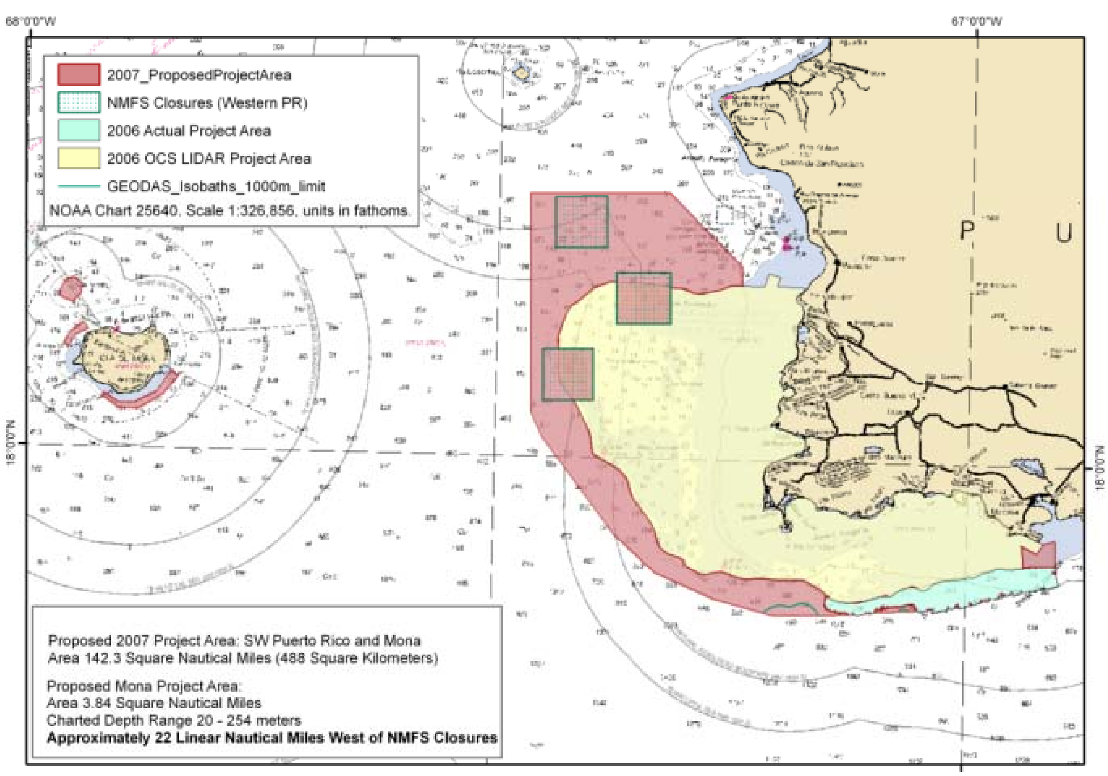
I. Background

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 conducted the fourth year of an ongoing scientific research mission on board the NOAA ship NANCY FOSTER from April 14 to April 24, 2007. 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 1000 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 was assisted by the use of a moderate-depth drop camera. The vehicle has video and frame camera capability to depths of 300 meters and was used for point sampling within areas mapped during the mission.

II. Area

The mission explored and mapped moderate depth bathymetry with the NANCY FOSTER's Simrad EM1002 & Reson 8124 multibeam systems for natural resource management and seafloor characterization. Priority areas for 2007 included three areas offshore of western Puerto Rico and the Isla De Mona. Due to time limitations only Abrir La Sierra Bank, Bajo De Cico and southern Isla De Mona were surveyed.



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 8124 multibeam system in Puerto Rico on April 12, 2007 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 is 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 of the EM1002. CCMA and the Atlantic Hydrographic Branch performed the annual EM1002 multibeam patch test during the NANCY FOSTER'S pre-season sea trials on February 13, 2007 (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 aquiring 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 55°.

A Reson 8124 multibeam echosounder and sound velocity probe was mobilized for this cruise to map the shallow water habitats of Abrir La Sierra in water depths of less than 75 meters. The system was mounted from the moon pool flange of the NANCY FOSTER. An additional extension cable was fabricated to allow the data transmission from the transducer head to the acquisition station located in the dry lab. The 8124 is a 200 kHz system that measures water depths across a 120° swath, consisting of 80 individual 1.75° x 1.5° beams. The sonar was set to a maximum ping rate of 40 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 (7Hz) or less dominated the majority of survey. The TVG gain setting was enabled with the auto gain set to 1. The transmit pulse width was set to 200 microseconds. 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. There were no filters applied to the sonar during acquisition. The 8124 swath width averaged about 3.5 times water depth. Unfortunately the entire swath width had to be used to maximize sonar coverage. The sonar data (snippets and bathy) was collected via ethernet with Triton Imaging's ISIS Sonar and set up with the precise timing method described in NOAA's Field Procedures Manual V2.1. Versions of all hardware and software used for this survey can be found in Appendix B.

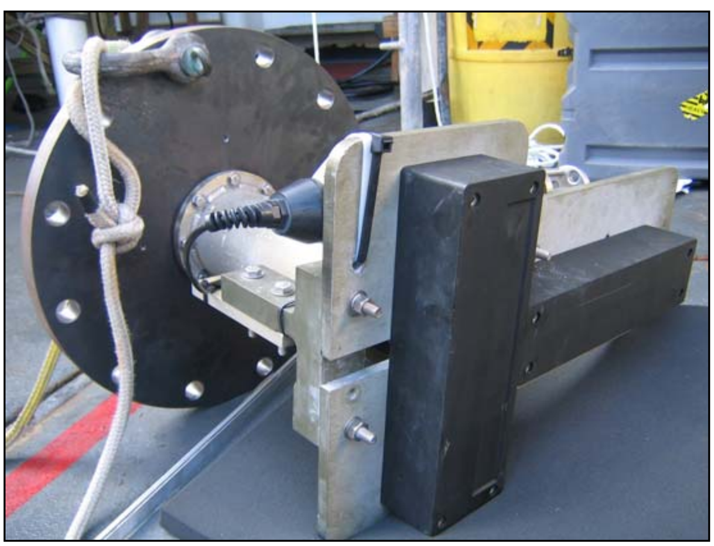


Fig 3: 8124 transducer w/moon pool flange mount

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 ± 0.02°. Heave measurements supplied by POS maintain an accuracy of 5% of the measured vertical displacement or ± 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.

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 10 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 ISIS acquisition system and the Reson 8124 sonar. The ethernet connection to the ISIS provided all the positioning and attitude data via Group 102, 111 and 113. The serial data connection was split to provide an NMEA UTC time string to both the ISIS and Reson 8124, synchronizing the two 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 (Odom DigiBar Pro) 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. An auxiliary SBE-19 was used for calibration verification and could be deployed in the event of a primary system failure. 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 SEA-BIRD 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 PU to create "datagrams". The datagrams combine the positioning, attitude, sound velocity and sounding data. The data was logged in the .ALL format.

Triton Imaging's ISIS SONAR V7.1.428.53 was used to collect the Reson data. The system combined the position, attitude and sounding data to create files in the .XTF format.

Coastal Oceanographics Hypack Max V6.2A provided the navigation information to the helms display and was used to create line plans for the surveyed 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 the Hypack PC to create holiday line plans and delineate drop cam transect locations.

IV. Quality Control

The HIPS Conversion Wizard uses the .ALL and .XTF 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 R352_8124.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 Transmercator Zone 19, Northern Hemisphere (NAD83 UTM19N). All the acquired data was converted and preliminary processed in the field.

Preliminary data processing consisted of: Application of zoned preliminary tides, navigation editing, attitude editing, swath data 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 and sonar. 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 was 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 of features from adjacent lines as well as feature alignment also confirmed sensor offsets. BASE surfaces were created to identify systematic errors or artifacts within the data set and to create holiday line plans. The Bathymetry Associated with Statistical Error (BASE) surfaces created from the merged and TPE calculated soundings are georeferenced 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 surfaces 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 depths, mean depths, 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 drop cam transects. The contract Lead Hydrographer completed final processing of the datasets after the completion of field operations. Refer to Appendix F for a multibeam processing flow chart.

Fig 4: Completed 2007 bathymetry coverage, 10m res, Abrir La Sierra, W Puerto Rico

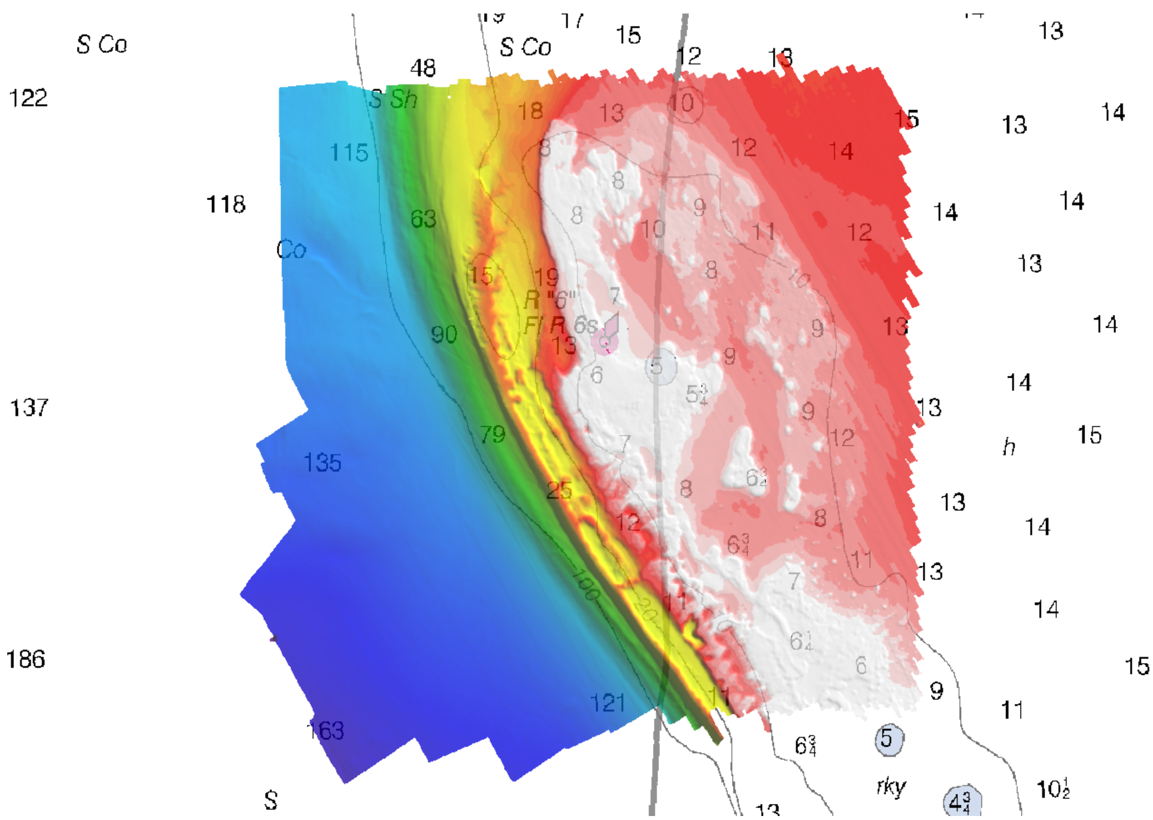


Fig 5: Completed 2007 bathymetry coverage, 10m res, Bajo De Cico, W Puerto Rico

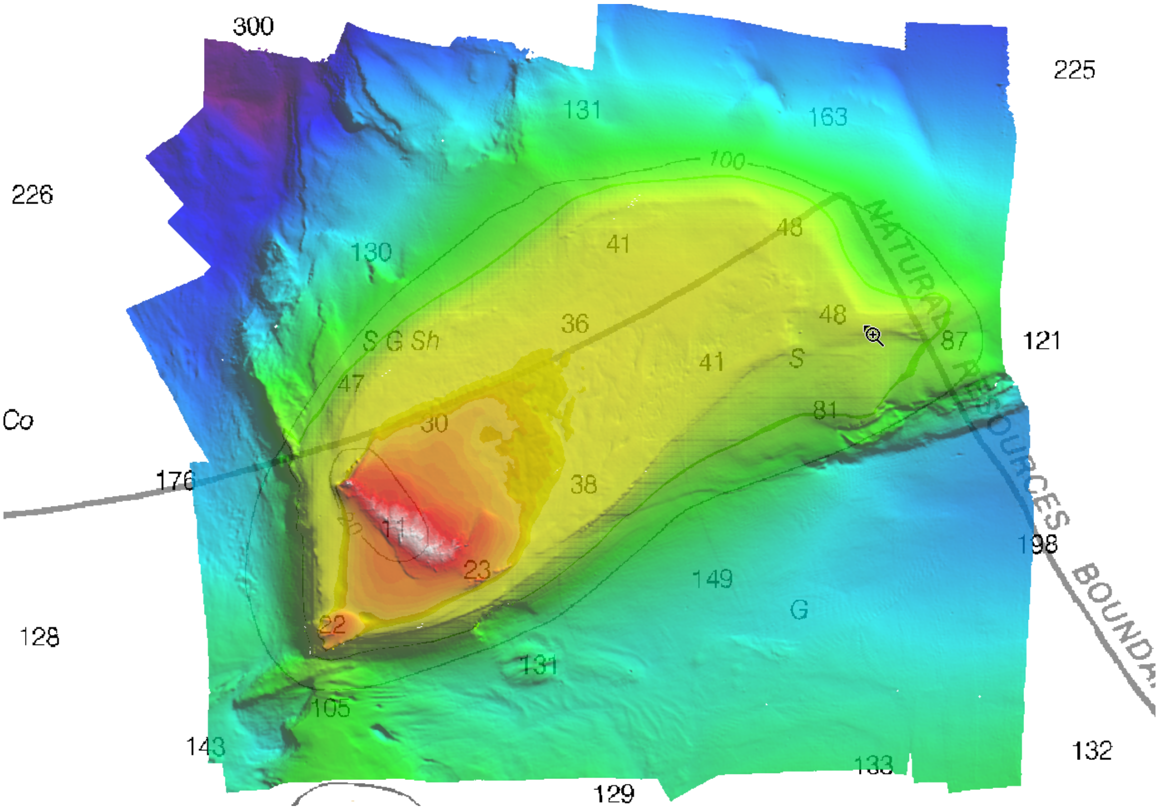


Fig 6: Completed 2007 bathymetry coverage, 10m res, Isla De Mona, W Puerto Rico

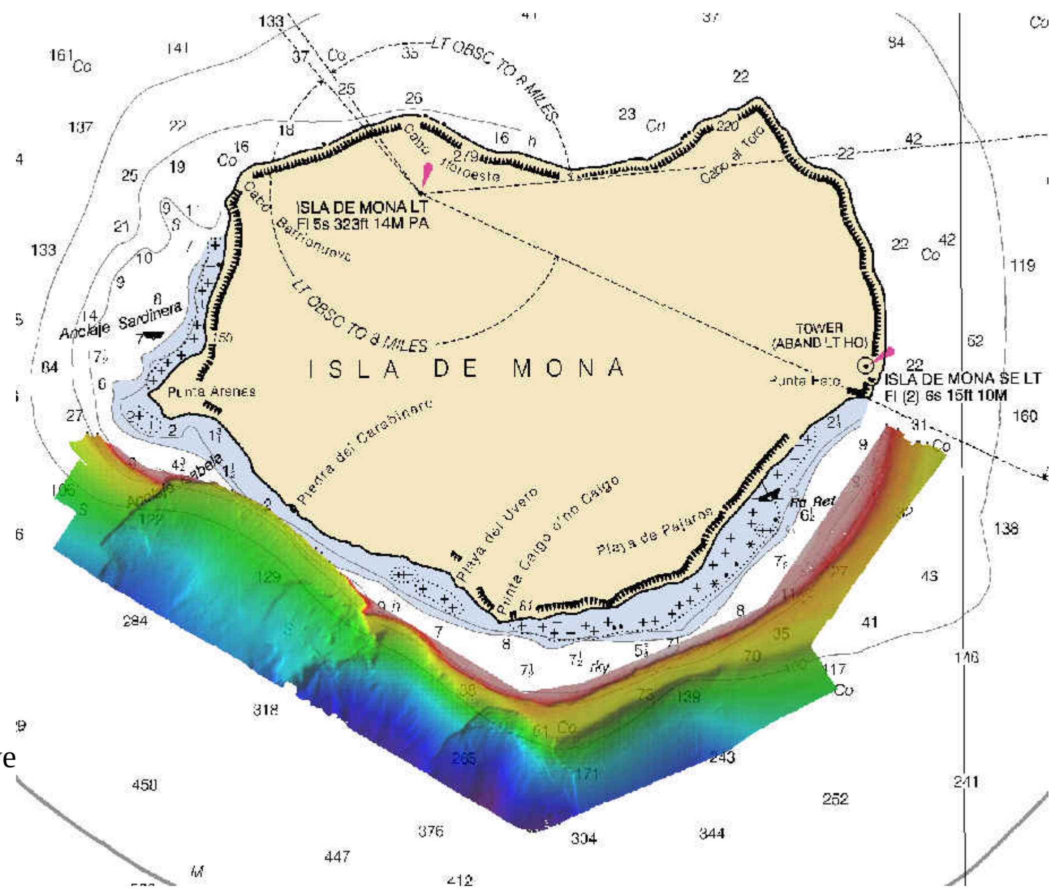


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Table 1: BASE surface resolutions and depth ranges

Resolution	Depth Ranges
3m	0m to 60m
5m	59m to 150m
10m	Deeper than 149m

Multiple BASE surface resolutions were created for each survey area to demonstrate multibeam coverage according to section 5.2.3 in the NOAA Specs and Deliverables. Final exported data from the BASE surfaces included 24bit sun illuminated images of depth and ASCII XYZ text files. A final analysis was performed on the 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 both multibeam echosounders prior to the start of field operations on April 14, 2007 at the USCG Pier facilities in San Juan, Puerto Rico. The purpose of this check was to verify the systems during static conditions by confirming that the digital depths being recorded reflected the actual depths. A sound velocity cast was performed at the site. Two leadlines were performed approximately 7.5 meters to port of each multibeam system. The sonar's acquisition systems were logging data while the leadlines were performed. The CARIS Swath Editor was then used to verify the depth soundings. Soundings were queried approximately 7.5 meters to port of the nadir beam and verified with the leadline values. No instrument correction was necessary because of insufficient evidence of systematic error.

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, moon pool (8124) 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. These offsets were entered into the MERLIN acquisition software, POS/MV software and into the vessel configuration files for both the EM1002 and the 8124 in the appropriate areas. The offsets used for the sonar 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 correction recorded on April 14, 2007 was 12.1ft while tied up at the USCG Pier facilities in San Juan, Puerto Rico. Subtracting the initial draft value of 12.1 from the fixed offset (1.68m) for the Reference Point to the EM1002 gives the final draft reading of -2.01m, 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 24th) was also approximately 12.1ft.

The 8124 draft was measured at the beginning and end of the cruise. The initial draft reading (RP to WL) for the 8124 at the moon pool was 2.18m. A total draft change of .07m was observed for the cruise duration and entered into the vessel configuration file R352_8124.hvf as a daily change of 0.007m.

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 fully documented in Appendix I, the NF-07-06 Multibeam Calibration Procedures & Patch Test Report. There are two reports, one for each sonar system used for this cruise. 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). Preliminary 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 0.14 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 Transmercator Zone 19, Northern Hemisphere (NAD83 UTM19N). Differential GPS (DGPS) corrected positions were supplied to both the POS/MV and HYPACK systems. Both systems have 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 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

A position check between two independent DGPS systems was observed and recorded with HYPACK on April 24, 2007 while docked at the USCG Pier, San Juan Puerto Rico. The Trimble DMS 132 was logged as raw DGPS positions with no offsets applied. The POS/MV DGPS data was logged with the offsets positioning the vessel at the Reference Point (RP). Both systems DGPS data were collected for at least one minute. The distance measured between the two averaged DGPS positions was approximately 7.15m. The distance calculated from the PacOrd survey was 7.15m. The consistent positioning between the two systems falls well within DGPS positioning standards. Static offsets were applied from the RP to EM1002 in Merlin, and from the RP to the moon pool in the vessel configuration file.

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, Magueyes Island PR (945-9110), Mona Island PR (975-9938) and Aguadilla PR (975-9412) 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 acquisition. Verified smooth tides 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 time and height corrected with the I911NF2007CORP.zdf file that was provided by CO-OPS.

Statement of accuracy and compliance with HSSDM

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

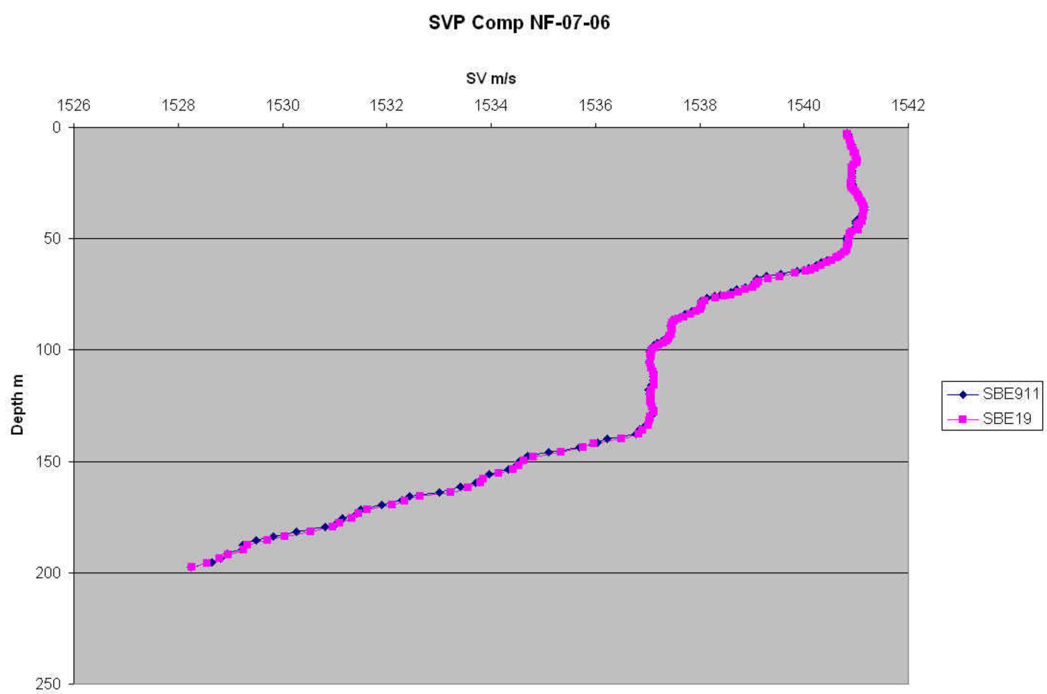
Assessment of sensors

Ancillary sensors

Sound velocity profiles were acquired using the NANCY FOSTER'S SeaBird Electronics SBE911 Conductivity, Temperature, and Depth (CTD) profiler (S/N 9P32146-0731). A secondary SBE 19 (S/N 192523-0355) was used for shallow casts and also to verify the calibration coefficients of the SBE911. Raw CTD data was processed using NOAA's Velocwin V8.85 software, which generated the sound velocity profiles required for real-time corrections and post processing. 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. There are occasional (<1m) sound velocity artifacts in the Reson data. These artifacts probably could have been removed from the data set if the entire 120° swath of the system wasn't needed for coverage. The primary CTD was checked against the backup unit prior to the commencement of survey operations and was in agreement. Each unit had been calibrated prior to use for this survey; refer to Appendix D for the SBE calibration reports.

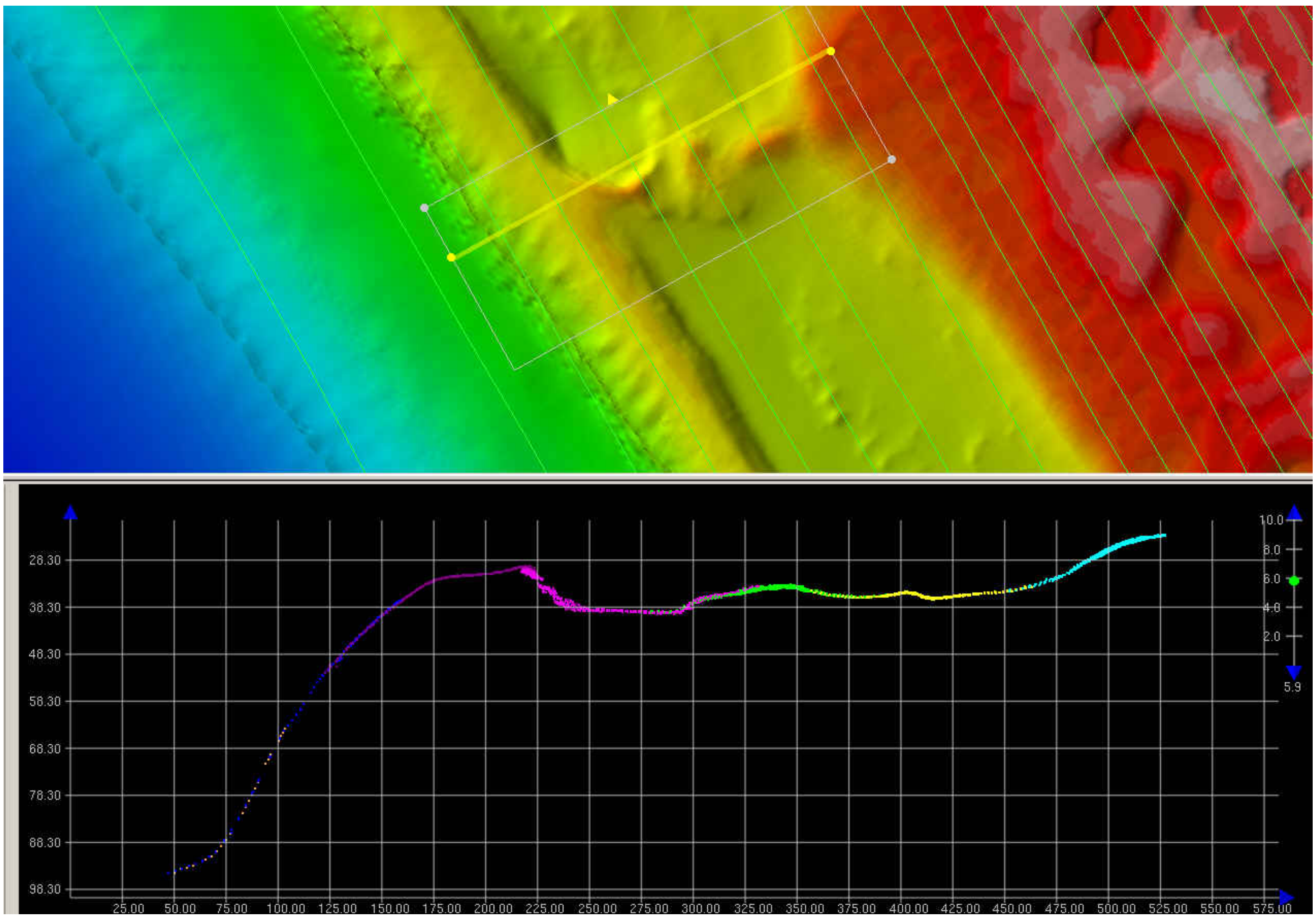
Fig 7: SVP Comparison



Assessment of Patch Test and Results

The Hydrographer believes that the values of the latency, pitch, roll and gyro offsets 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 8: Feature mapped with the EM1002 & 8124 multibeam systems



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 in CARIS.

Table 2: CARIS Dynamic Draft Table

Table

	Draft (m)	Speed (m/s)
1	0.007	2.600
2	0.041	3.160
3	0.002	4.070
4	0.032	5.030
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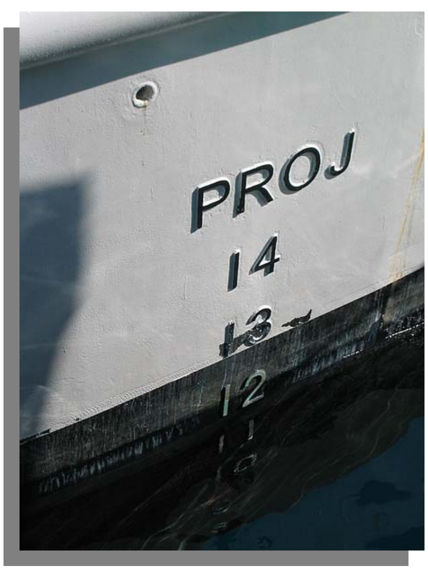


Fig 9: Projection Draft markings

Static draft (waterline) observations were made for both systems the day of departure under full load, and at the end of the cruise in Puerto Rico. Subtracting the RP from the projection draft markings on the starboard side of the NANCY FOSTER gave the draft to be used in the MERLIN software (-2.01m). No significant amount of change in PROJ (EM1002) draft was observed for this cruise. A total loss of .072m was observed during the cruise at the moon pool. This value was divided into the 10 days of underway time (0.007m/day) and entered into the R352_8124.hvf vessel configuration file. The initial draft values were verified with lead line observations while tied up at the USCG pier in San Juan. The Lead Hydrographer feels that the dynamic and static draft corrections are adequate for this survey.

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. For the NF-07-06 cruise the Lead Hydrographer and Ed Owens (NMAO) referred to the moon pool bench marks surveyed in by PacOrd and created the R352_8124 vessel configuration file for the Reson. 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 one form of calibration prior to commencement of survey operations. The multibeam sonars and offsets were calibrated with a leadline and position check while docked at the USCG Pier in San Jaun. This data was digitally recorded to verify that the proper offsets and draft corrections were being applied to the multibeam data. The offsets to these systems were accurately measured during the PacOrd offset survey and verified by the Lead Hydrographer as well as other participating hydrographers. The position checked well within DGPS position standards of +/-10meters. The CTD was calibrated against the backup unit and both received calibrations by the manufacturer within the previous year. The calibration for all systems including mounting angle offsets for the sonar system (Patch Test), occurred during the SAT trials, and were confirmed again with the documented NF-03-06 and NF-07-06 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 8124 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 55° cutoff angles, port and starboard for the EM1002. A 10% overlap with 60° (total swath), port and starboard line spacing plan was used for the 8124 for surveying the shelf areas to maximize coverage. 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 3m for the shelf regions and 10m 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. During final evaluation of the 3m BASE surfaces during post processing, several small areas of holidays were identified in the shelf regions from insignificant overlap from neighboring swaths.

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 of Abrir La Sierra Bank. The Field Operations Officer (FOO) of the NOAA ship THOMAS JEFFERSON, which also operates an EM1002 echosounder, 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 heavy seas. 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 the Abrir, Bajo and Mona regions. The CARIS generated Quality Control Report compares the crosslines for each project against the 5m Depth BASE surface. The graphs in *Appendix K* are a cumulative representation of the IHO compliance of all the crosslines run for 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 new CARIS utility 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. Both Bajo De Cico and Abrir La Sierra met or exceeded IHO compliance for IHO order 1 for depths shoaler than 100m, and IHO order 2 for depths deeper than 100m (95% confidence level). For Isla De Mona 83% of soundings shoaler than 100m met IHO order 1 standards, and 100% for IHO 2 standards.

VII. Summary Of Submitted Data:

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

<u>Data</u>

- Raw multibeam sonar sounding files in ALL 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 2003.

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 & 8124 Parameters

Reson 8124 Menu Settings Cruise# NF-07-06

Main
MaxRate: 40.0 p/s TxPulse: 200 us GainMode: TVG AutoGain: 1

Filters
None

Ocean
Spread: 30 log dB Absorb: 50 dB/km Velocity: Real-time from DigiBar Pro SVP

Modes
Format: RI0 Sidescan: Full-New Snippets: Flatbottom PitchStab: Off RollStab: Off

Config
Uplink: Coax1 Output: Ethernet ProfilBd: 115200 TimeBd: 115200 ContrlBd: 115200 MotionBd: 9600 VelctyBd: 9600 UDP Base:5000 Oriented: ProjAft HeadSync: OneHead

EM1002 installation parameters NOAA SHIP NANCY FOSTER Cruise# NF-07-06

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. = -2.01

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-07-06

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-07-06				HARDWARE
Equipment type	Manufacturer	Model	Serial #	Firmware
Transducer	Kongsberg/Simrad	EM1002	288	N/A
Transducer	RESON	8124	3802057	N/A
Transceiver Unit	RESON	81-P	34906	N/A
Transceiver Unit	Kongsberg/Simrad	EM1002	303	N/A
Inertial GPS PCS	Applanix	POS/MV 320 V4	2249	3.2
IMU	Applanix	LN 200	447	N/A
DGPS	Trimble	DSM 132	224096283	3.0
Acquisition	Sun MicroSystems	Solaris 8	TT32220431	N/A
SVP	ODOM	DigiBar Pro	98013-082007	1.11
SVP	SBE	SBE 911	9P32146-0731	N/A
SVP	SBE	SBE 19	O285	N/A

Hydrographic Systems Inventory Cruise# NF-07-06			SOFTWARE
Equipment type	Manufacturer	Model	Software Version
Inertial GPS PCS	Applanix	POS/MV 320 V4	3.2
Navigation	Coastal Oceanographics	N/A	4.3A
Acquisition	Triton Imaging	ISIS Sonar	7.1.428.53
Acquisition	Kongsberg/Simrad	MERLIN	5.2 V2
Processing	NOAA	Velocwin	8.85
Processing	CARIS	HIPS & SIPS	6.1 SP1 HF 1-4

APPENDIX C:

POS/MV 320 V4 Configuration Report

Input/Output Ports Set-up

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=10 Hz 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

APPENDIX D:

SBE Calibration Reports

SBE 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:	44947	**Date of Report:**	12/28/2006
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: 12/28/2006 **Drift since last cal:** -.00010 **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.

SBE 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:	44947	**Date of Report:**	12/14/2006
Model Number	SBE 04C	**Serial Number:**	042767

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: 12/14/2006 **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 N.E., Bellevue, Washington, 98005 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0731
CALIBRATION DATE: 20-Dec-06

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 89936

DIGIQUARTZ COEFFICIENTS:

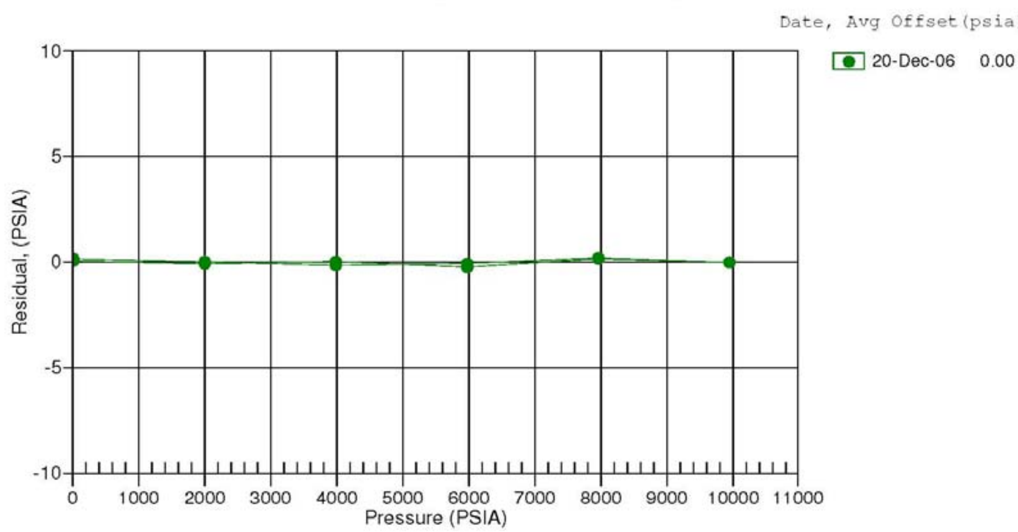
```
C1 =   -4.767972e+004
C2 =   -5.006157e-001
C3 =    1.084620e-002
D1 =    3.613800e-002
D2 =    0.000000e+000
T1 =    3.031386e+001
T2 =   -5.277072e-004
T3 =    3.790810e-006
T4 =    6.671000e-010
T5 =    0.000000e+000
```

AD590M, AD590B, SLOPE AND OFFSET:

```
AD590M =    1.30208e-002
AD590B =   -9.65521e+000
Slope =     0.99992
Offset =    0.0040 (dbars)
```

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.670	33002.40	18.2	14.812	14.818	0.148
2001.989	33681.90	18.3	2002.145	2002.000	0.011
3988.837	34345.80	18.3	3988.981	3988.687	-0.150
5975.755	34995.30	18.4	5976.124	5975.679	-0.076
7962.833	35631.20	18.4	7963.626	7963.031	0.198
9950.256	36254.10	18.5	9950.980	9950.235	-0.021
7962.675	35631.20	18.6	7963.423	7962.828	0.153
5975.574	34995.30	18.7	5975.773	5975.328	-0.246
3988.429	34345.90	18.7	3988.746	3988.452	0.023
2001.377	33681.90	18.8	2001.435	2001.291	-0.086
14.662	33002.70	19.0	14.704	14.710	0.048

Residual = corrected instrument pressure - reference pressure



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: 09-Jan-07

SBE19 PRESSURE CALIBRATION DATA
300 psia S/N 133245 TCV: -140

QUADRATIC COEFFICIENTS:

PA0 = 1.497946e+002
PA1 = -3.901670e-002
PA2 = 2.667097e-008

STRAIGHT LINE FIT:

M = -3.901248e-002
B = 1.499449e+002

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.62	3474.0	14.57	-0.02	14.42	-0.07
59.90	2309.0	59.85	-0.02	59.87	-0.01
119.89	771.0	119.73	-0.05	119.87	-0.01
179.89	-768.0	179.78	-0.04	179.91	0.00
239.88	-2303.0	239.79	-0.03	239.79	-0.03
299.87	-3836.0	299.86	-0.00	299.60	-0.09
239.86	-2307.0	239.95	0.03	239.95	0.03
179.88	-776.0	180.09	0.07	180.22	0.11
119.89	766.0	119.92	0.01	120.06	0.06
59.93	2304.0	60.04	0.04	60.06	0.04
14.61	3472.0	14.65	0.01	14.49	-0.04

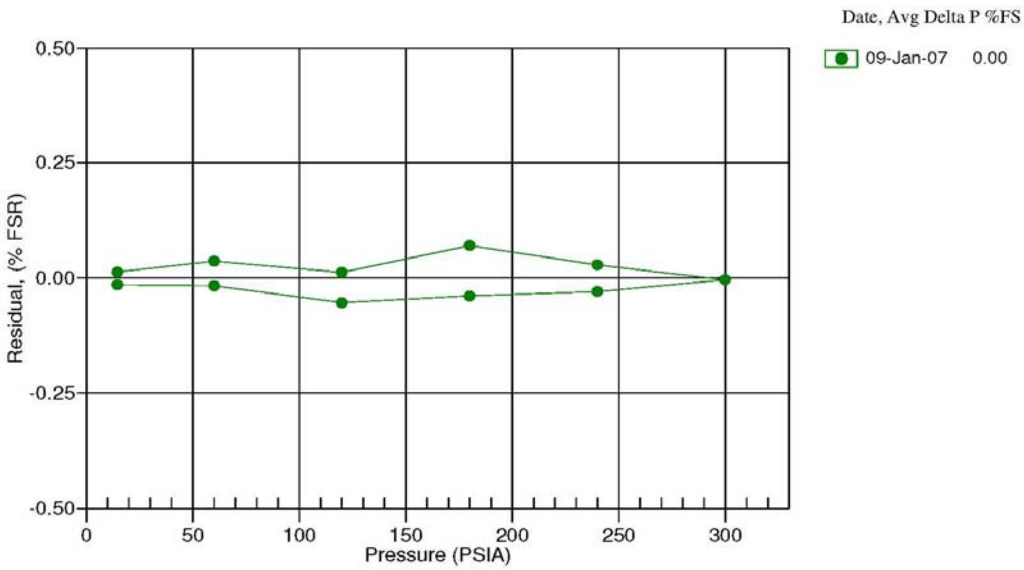
Straight Line Fit:

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 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:	44947	**Date of Report:**	12/20/2006
Model Number	SBE 03Plus	**Serial Number:**	03P4175

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: 12/20/2006 **Drift since last cal:** -.00140 Degrees Celsius/year

Comments:

'CALIBRATION AFTER REPAIR' ☐ Performed ☑ Not Performed

Date: Drift since Last cal: Degrees Celsius/year

Comments:

SBE 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:	44947	**Date of Report:**	12/28/2006
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: 12/28/2006 **Drift since last cal:** +.00056 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

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: 0.690
Roll Offset: -0.110
Azimuth Offset: -1.700

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:

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 0.074
Y Head 1 1.855
Z Head 1 1.801
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 5.760
Y Head 1 6.596
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: 0.060 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: 4.000
Transducer timing error: 0.000
Navigation timing error: 0.100
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: `éƒJ Ï…J`õ…JPõ…J°ð…J €…J@í…J°k€JàZ€J€Ó…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: 0.811
DeltaY: 1.856
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: 2006-064 00:00

Comments
Apply No
WaterLine 0.000

Vessel Name: R352_8124.hvf

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2007-103 00:00

Transduer #1:

Pitch Offset: -0.520
Roll Offset: -0.100
Azimuth Offset: 4.000

DeltaX: 1.219
DeltaY: -22.477
DeltaZ: 1.588

Manufacturer:
Model: sb8124
Serial Number:

Navigation Sensor:

Time Stamp: 2007-103 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: 2007-103 00:00

Comments
Latency 0.000

Heave Sensor:

Time Stamp: 2007-103 00:00

Comments
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: 2007-103 00:00

Comments
Apply Yes
Latency 0.000
Pitch offset: 0.000

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

Roll Sensor:

Time Stamp: 2007-103 00:00

Comments (null)
Apply Yes
Latency 0.000
Roll offset: 0.003

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

Draft Sensor:

Time Stamp: 2007-103 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: 2007-103 00:00

Comments
Offsets

Motion sensing unit to the transducer 1
X Head 1 1.219
Y Head 1 -23.214
Z Head 1 1.713
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 5.959
Y Head 1 -28.548
Z Head 1 17.879
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: 0.060 or 5.000'' of heave amplitude.
Measurement errors: 0.000
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: 4.000
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: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.000
Dynamic loading measurement error: 0.000
Static draft measurement error: 0.000
Delta draft measurement error: 0.000
StDev Comment: `éƒJ Ï…J`õ…JPõ…J°ð…J €…J@í…J°k€JàZ€J€Ó…Ja

Svp Sensor:

Time Stamp: 2007-103 00:00

Comments
Svp #1:

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

DeltaX: 1.219
DeltaY: -22.477
DeltaZ: 1.588

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: 2007-103 00:00

Comments (null)

Apply Yes
WaterLine -2.180

Time Stamp: 2007-104 00:00

Comments
Apply No
WaterLine -2.173

Time Stamp: 2007-105 00:00

Comments
Apply No
WaterLine -2.166

Time Stamp: 2007-106 00:01

Comments
Apply No
WaterLine -2.159

Time Stamp: 2007-107 00:00

Comments
Apply No
WaterLine -2.152

Time Stamp: 2007-108 00:00

Comments
Apply No
WaterLine -2.145

Time Stamp: 2007-109 00:00

Comments
Apply No
WaterLine -2.138

Time Stamp: 2007-110 00:00

Comments
Apply No
WaterLine -2.131

Time Stamp: 2007-111 00:00

Comments
Apply No
WaterLine -2.124

Time Stamp: 2007-112 00:00

Comments
Apply No
WaterLine -2.117

Time Stamp: 2007-113 00:00

Comments
Apply No
WaterLine -2.110

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	0.5
Surface	0.5
Tide Measured	0.012
Tide Zoning	0.0 & .03
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.

<u>Sound Velocity Measured</u>

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.

<u>Surface</u>

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.

<u>Tide Measured</u>

Error: .01

Definition: *Tide Measured* is the standard deviation of the measured tide values in meters.

Discussion: *Tide Measured* is based on CO-OPS calculations.

<u>Tide Zoning</u>

Error: .14

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.

<u>Offset X</u>

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.

<u>Offset Y</u>

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 used in 2005.

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

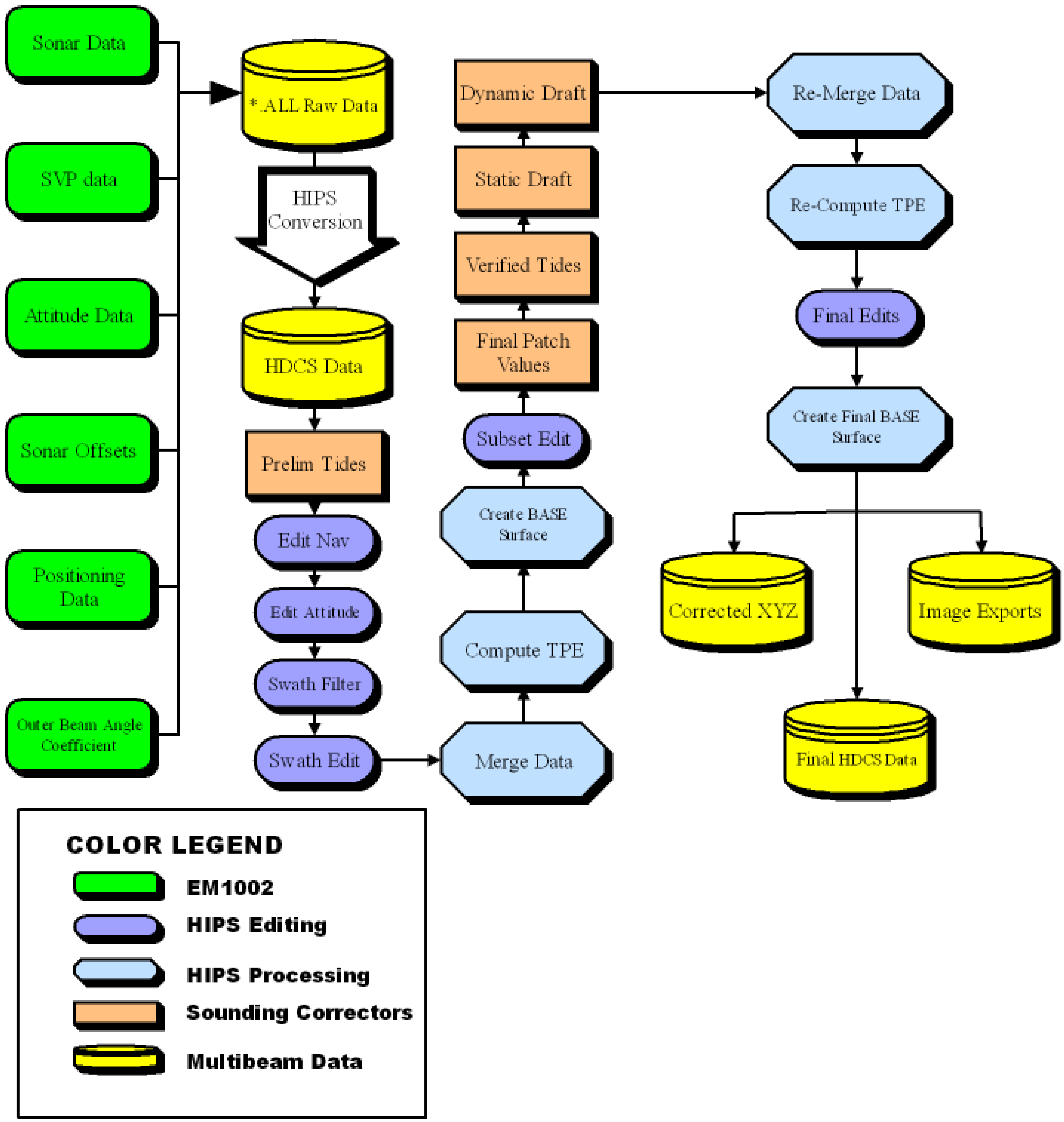
Error: 0

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 Report

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

INSPECTION/DEFICIENCY REPORT

SERIAL NO. 00656.001.02-03	
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
BALANCE REPORT

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

☐ 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					All readings are in Degrees					
	Horiz			Vert		Heading		Pitch		Roll	
	X	Y		Z		Degrees		Degrees		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 Top 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°	

Port Down = Positive

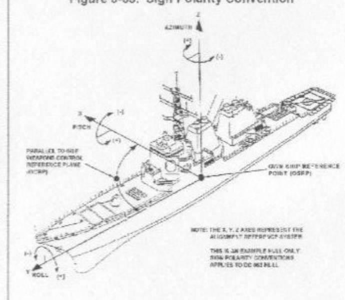
Bow Down = Positive

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

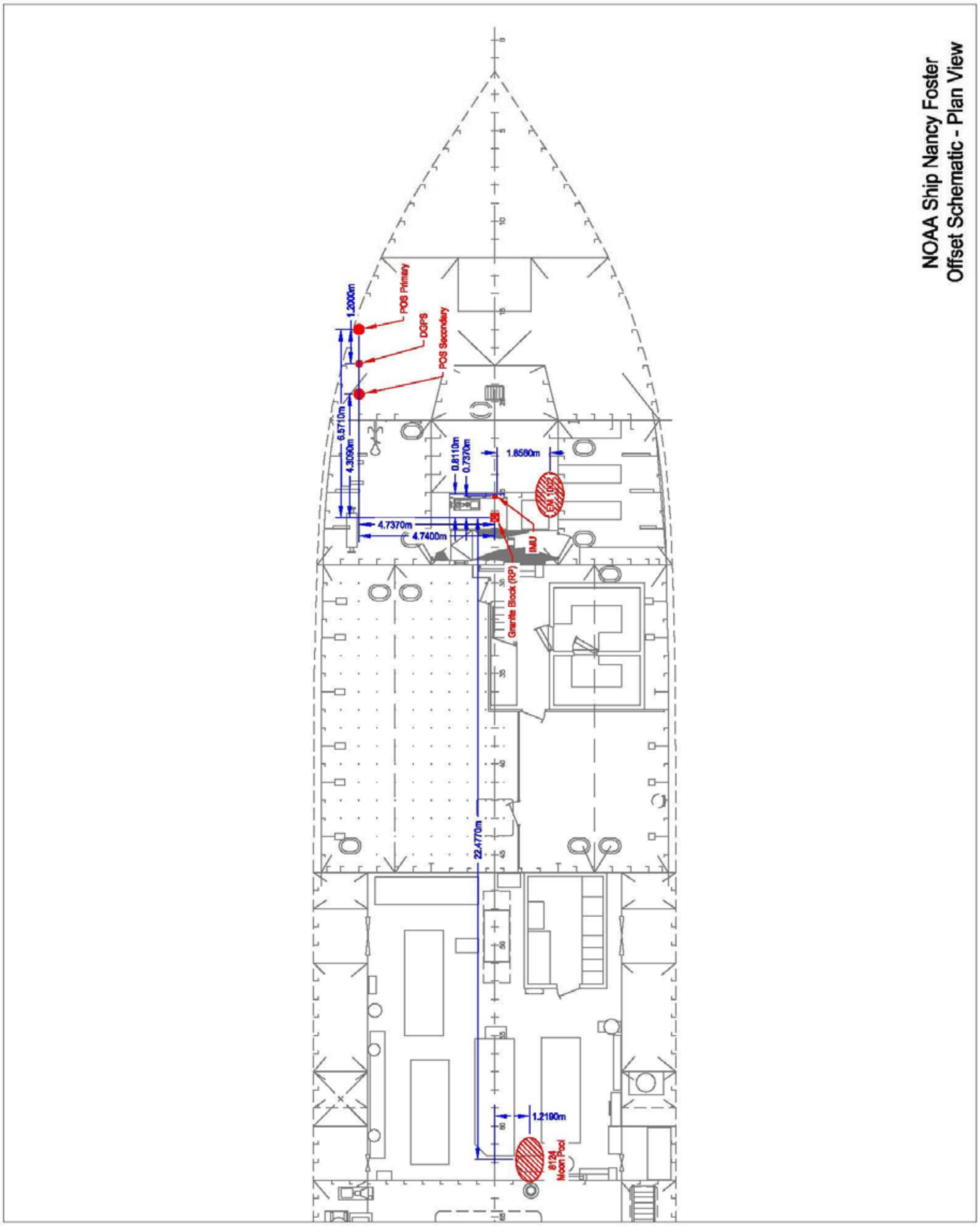
Z dimension readings lower than Granite Block = positive, higher than Granite Block =negative

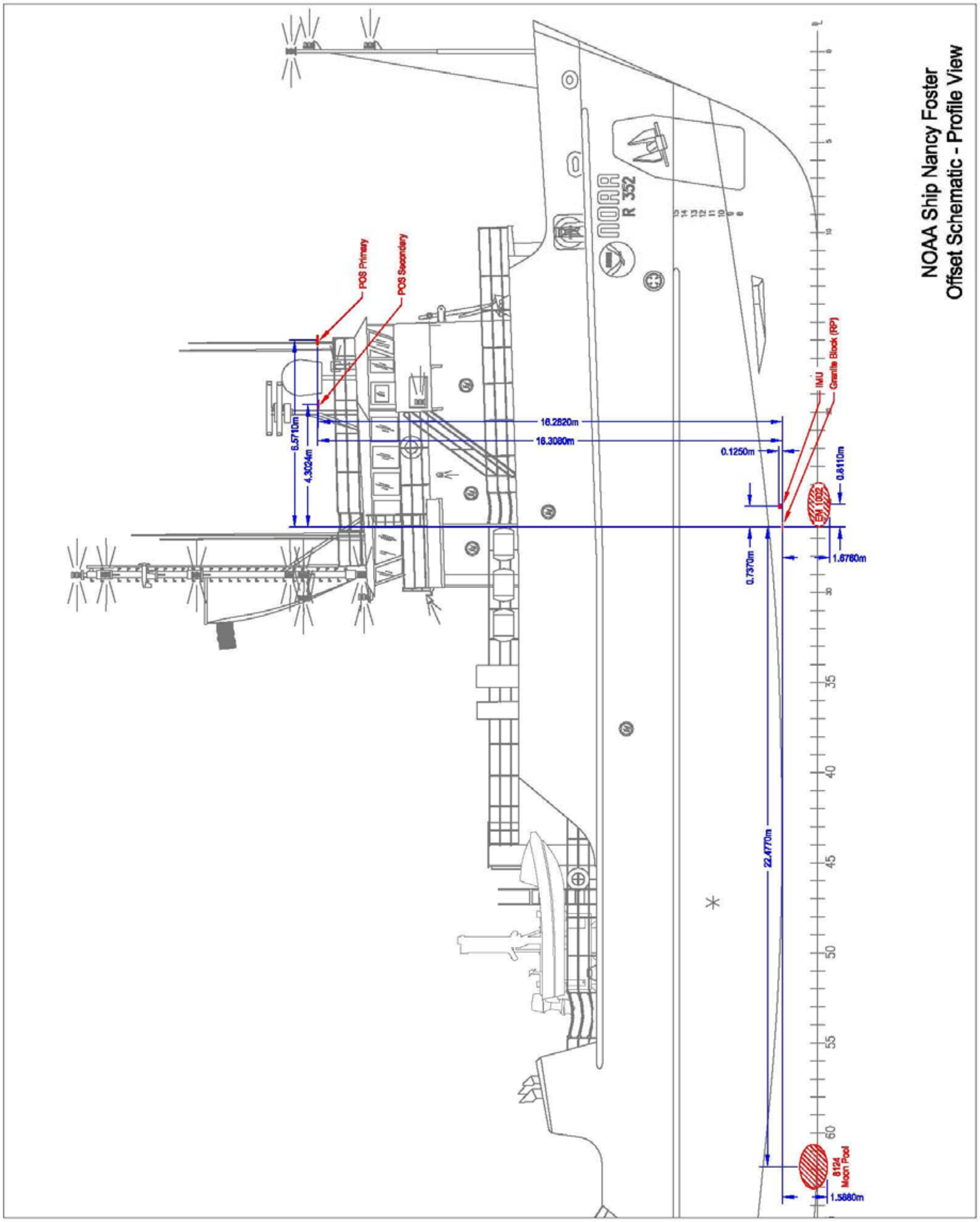
Figure 3-53. Sign Polarity Convention



APPENDIX H:

NOAA Ship NANCY FOSTER Offset Diagram


NOAA Ship Nancy Foster
Offset Schematic - Plan View
POS Primary
DGPS
POS Secondary
1.2000m
6.5710m
4.3090m
0.8110m
0.7370m
1.8580m
4.7370m
4.7400m
EM 1002
IMU
Granite Block (RP)
22.4770m
1.2190m
8124
Moon Pool


NOAA Ship Nancy Foster
Offset Schematic - Profile View
POS Primary
POS Secondary
IMU
Granite Block (RP)
EM 1002
8124 Moon Pool
16.2820m
16.3080m
0.1250m
0.8110m
6.5710m
4.3024m
0.7370m
1.8760m
22.4770m
1.5880m
NOAA
R 352

APPENDIX I:

Multibeam Calibration Procedures & Patch Test Report

Calibration Date: February 13, 2007

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). **<u>The patch test method only corrects very basic alignment biases</u>**. 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-07-06 DAPR

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

Calibration date: February 13,2007

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 3.22 was used for the entire survey.

Static Draft Survey
(Vessel waterline with respect to RP)

Survey date: February, 13 2007

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 to the pier at the USCG Base Charleston, the survey team initially observed the static draft of the starboard PROJ draft marks at +/-3.69m(12.1ft.). 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 - 3.69m = -2.01

Static Draft Correction -2.01 **(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 were 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

Table

	Draft (m)	Speed (m/s)
1	0.007	2.600
2	0.041	3.160
3	0.002	4.070
4	0.032	5.030
5		

OK Cancel

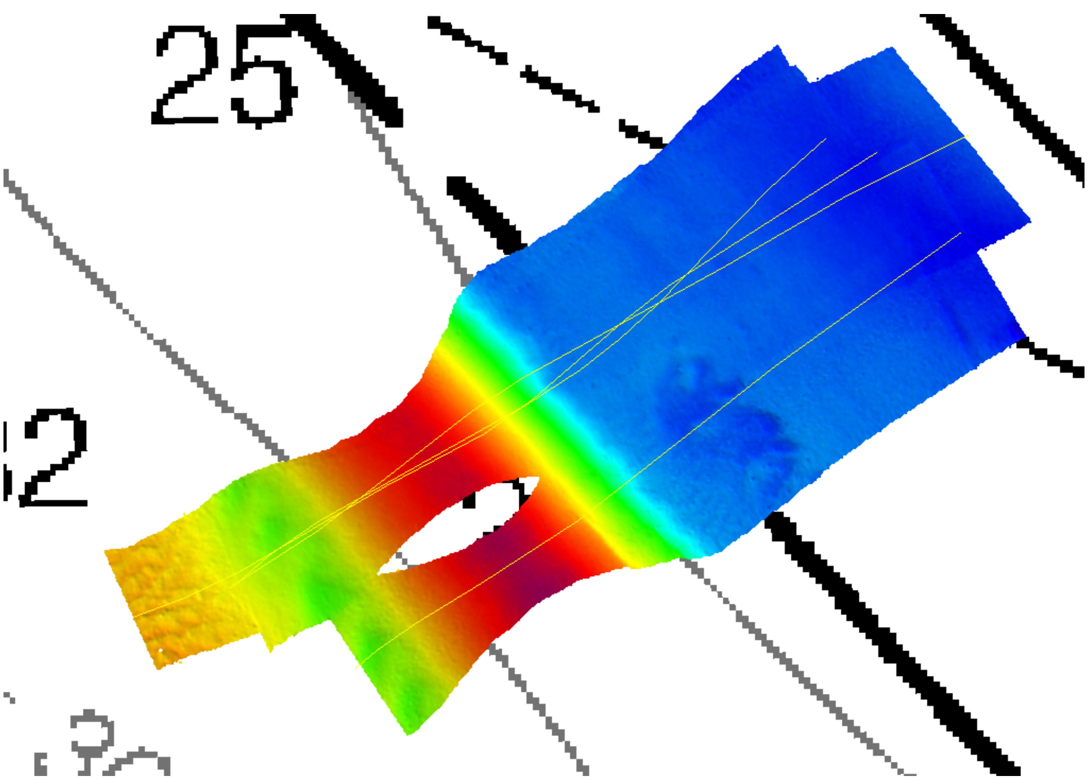
Calibration Survey Information

An annual patch test was performed before the NANCY FOSTER 2007 field operations commenced. Biases were estimated by running a series of calibration lines, as described in the NOS Hydrographic Specifications and Deliverables, March 2003 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.

Calibration Area

Site Description for Latency, Pitch and Yaw Procedures

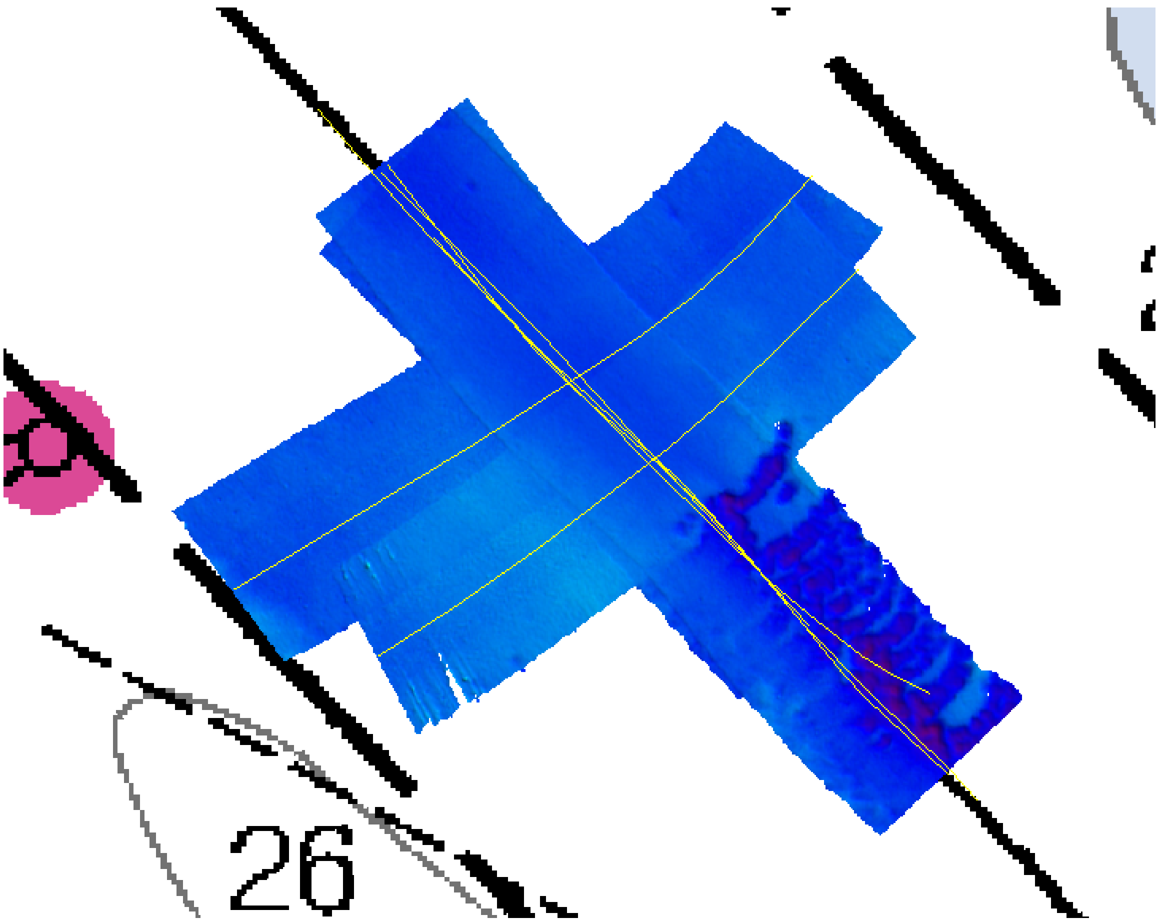
An area within the Mount Pleasant Range at the entrance to Charleston Harbor was chosen for the patch test procedure. The area identified provided the steep and smooth slope with little change in across track depth to accurately assess the latency, pitch and yaw biases for the Nancy Foster's EM1002 multibeam 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 sound velocity cast was performed prior to conducting the patch test in the immediate vicinity. A total of four lines were surveyed. Vessel speeds were consistent for the latency, pitch and yaw transects at approximately 4 knots. Vessel speeds were increased to approximately 7 knots for the second latency line of the patch test.



Site Description for Roll and Outer Beam Angle Offset Procedures

The roll and outer beam angle offset calibration procedures require a flat seafloor. An area area within the Mount Pleasant Range proved to be sufficient enough for calibrations.

The outer beam angle offset calibration procedure is unique to the EM1002 and is required for electronic beam steering for all beam angles larger than 50°. The EM1002 transducer coating has a sound speed that is significantly different from the sound speed of water and varies with temperature. The outer beam angle offset coefficient is found by estimating the beam pointing angle error in degrees by comparing the depths measured in the outer beams to those of the nadir beams. Comparing two perpendicular surveyed lines with CARIS's roll calibration tool, entering the estimated offset value into Merlin, and re-surveying the lines for verification was necessary before the surveying operations commenced.

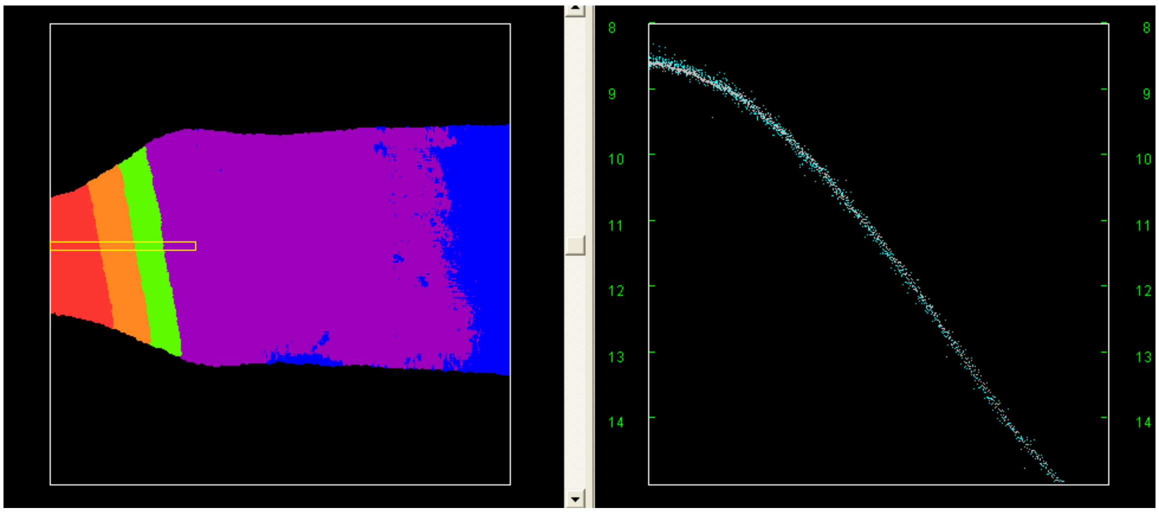


Calibration Survey Information

The hydrographer performed the biases calculations in the order described in the HSSD using CARIS HIPS's calibration tool.

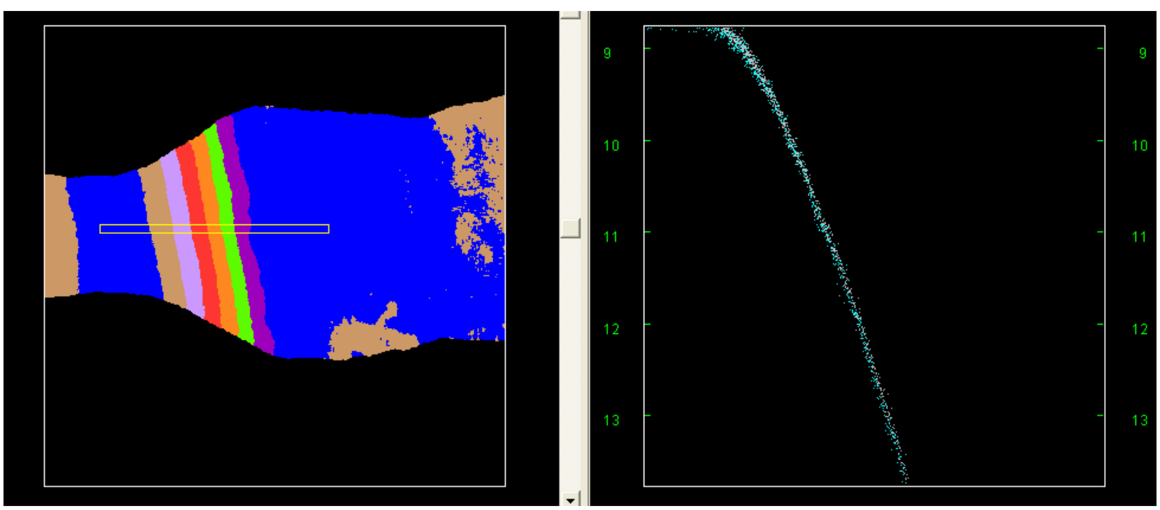
- Latency was calculated first, observing two surveyed lines in the same direction up a slope, at different speeds. Nadir beams were observed with an estimated 0.0 seconds of latency, which is typical of the POS/MV systems.

1) Latency



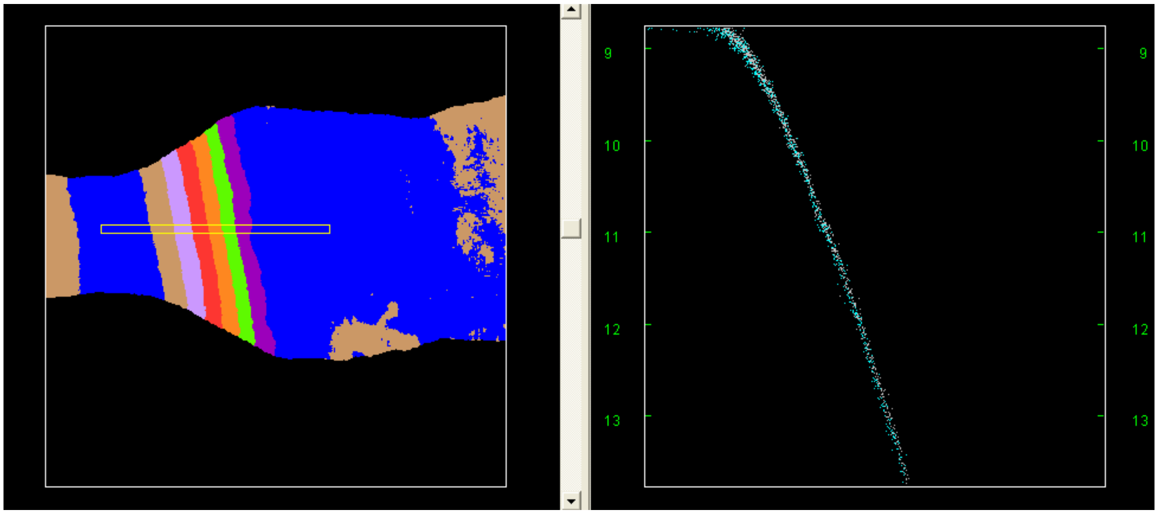
- The pitch offset was calculated next, observing nadir data with two-surveyed lines in opposing directions over a slope.

2) Pre-Pitch Alignment



- A pitch offset alignment of 0.90° was identified and entered into theR352_MB.hvf

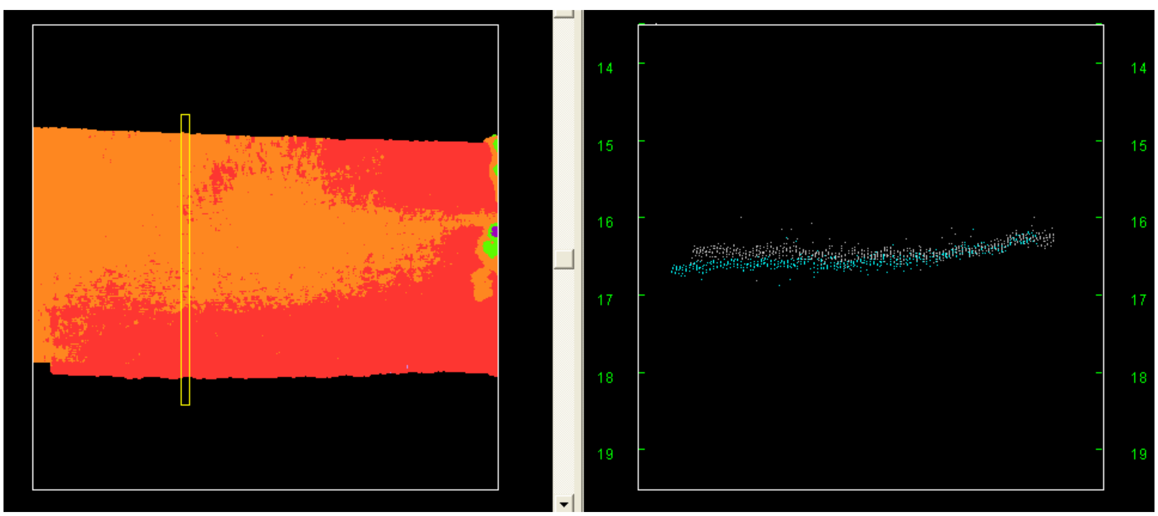
2a) Post-Pitch Alignment



- A Pitch offset of 0.69° was identified and entered into the R352_MB.hvf.

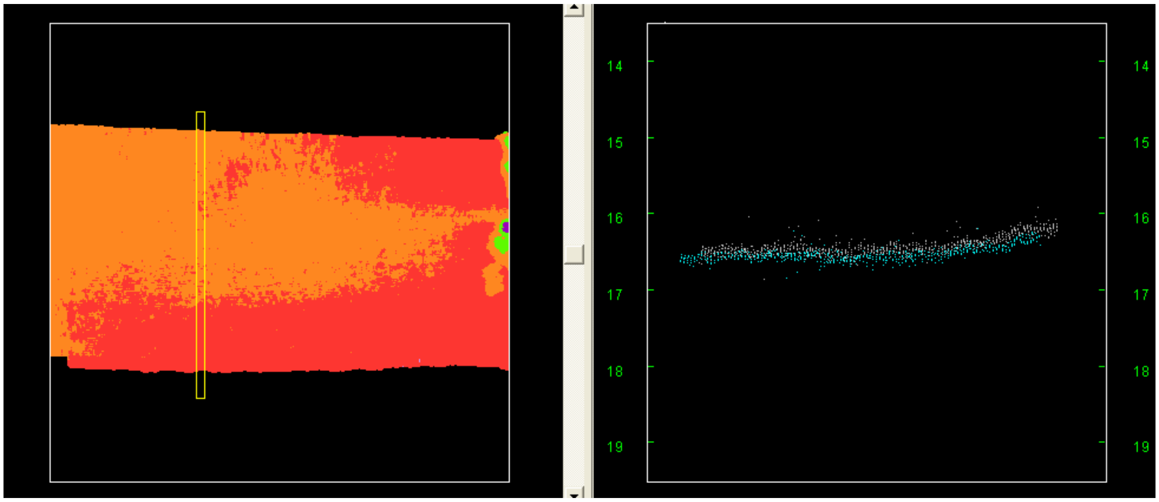
3) Pre-Roll Alignment

- The Roll offset was calculated next, observing the full swath of two-surveyed lines in opposing directions over a flat area.



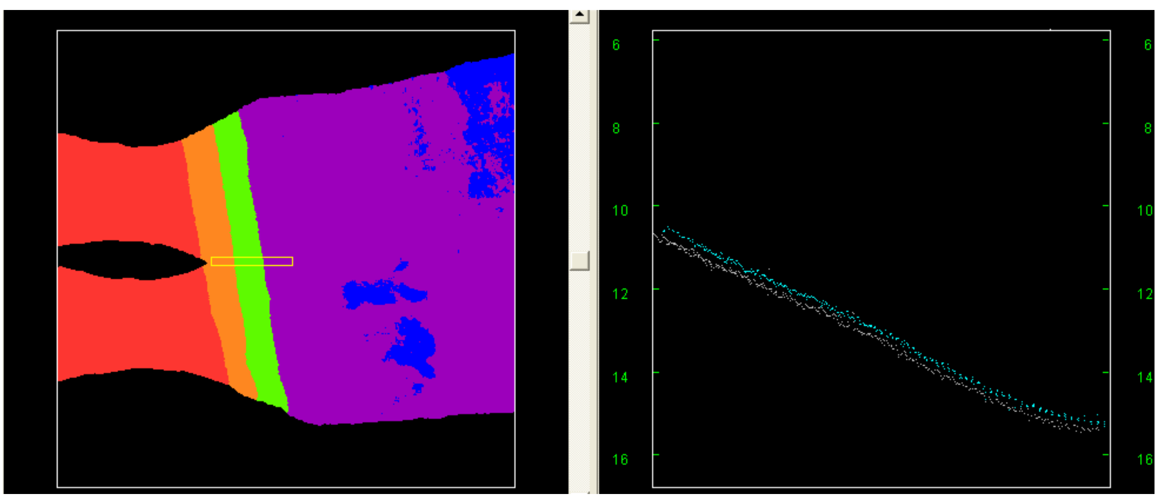
- A roll offset alignment of -0.11° was identified and entered into the R352_MB.hvf.

3a) Post-Roll Alignment



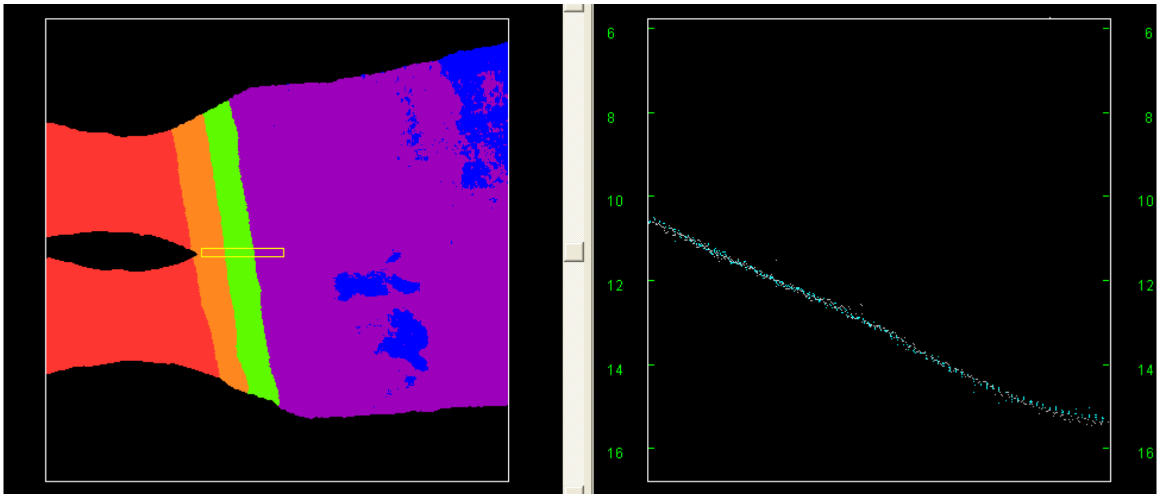
- The Yaw offset was calculated next, outer swaths of two offset parallel lines surveyed in the same direction over a slope.

4) Pre-Yaw Alignment



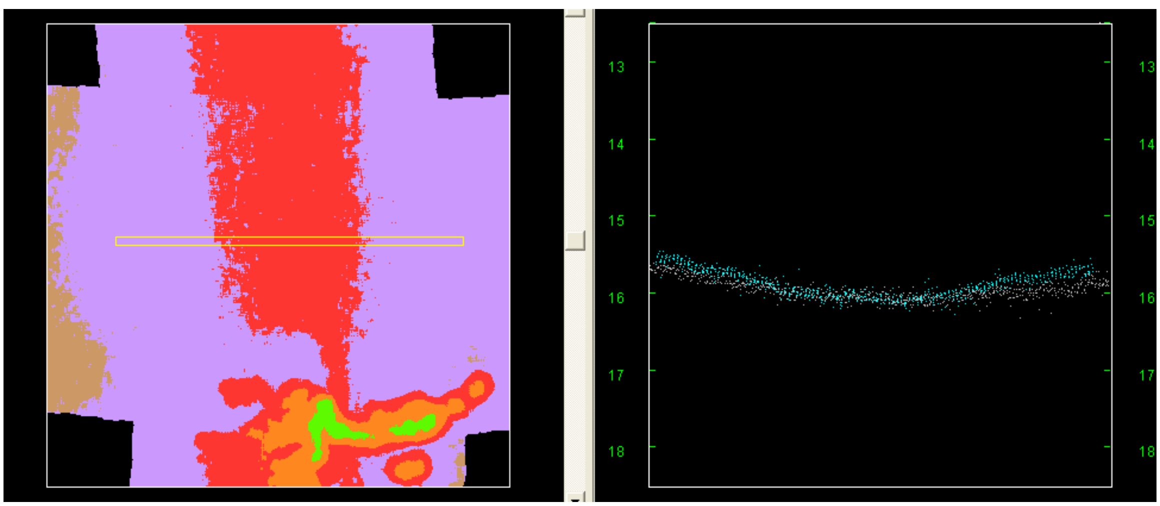
- A Yaw offset alignment of -1.7° was identified and entered into the R352_MB.hvf

4a) Post-Yaw Alignment



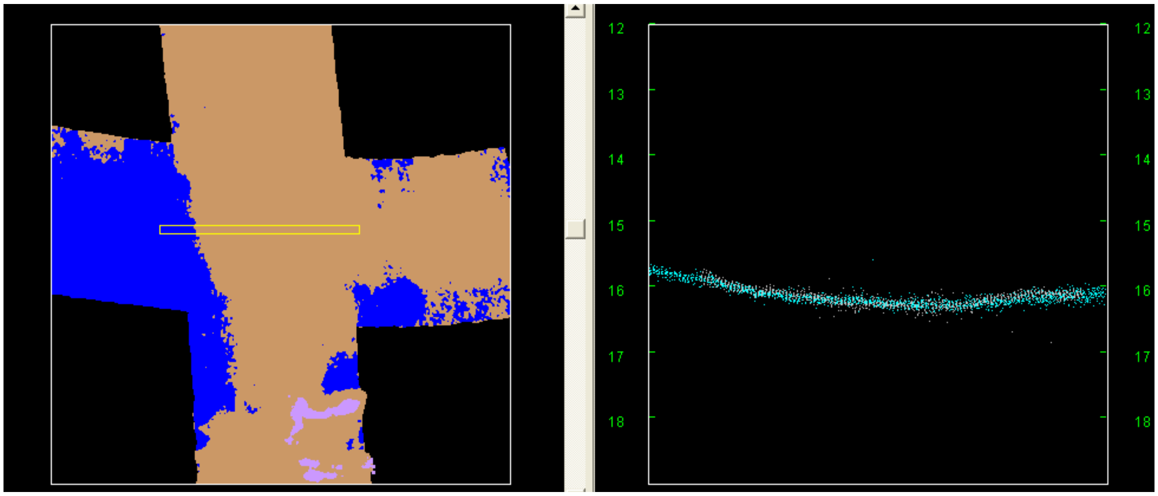
- The outer beam angle offset was the final calculation, observing the nadir beams versus the full swath, of two perpendicular lines over a flat area.

4) Pre-Outer beam angle offset



- An outer beam angle offset of -0.36 was identified and entered into the Merlin acquisition system.

4a) Post-Outer beam angle offset



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-07-06 cruise and for post-processing.

Calibration Lines

Line	Direction	Speed	Bias Measured
0006_20070213_174133_raw	NE	5	Y1
0008_20070213_175929_raw	SW	5	L1,P1
0009_20070213_180528_raw	NE	5	P2,Y2
0010_20070213_180905_raw	SW	7.5	L2
0011_20070213_181736_raw	NW	4	R1
0012_20070213_182402_raw	SE	4	R2
0001_20070213_161328_raw	NW	5	OBC
0002_20070213_162443_raw	SW	4	OBC
0003_20070213_170149_raw	SW	5	OBC Check
0004_20070213_171019_raw	NE	5	OBC Check

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
00014_07044104	1600	14.4	32.74N	79.85W

Tide Correction

Predicted tides applied.

Gauge ID

Approximate distance of gauge from calibration site: Variable

Approximate water level range at calibration site: .050 **(meters)**

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	0.69	-1.70	-0.11

Corrections calculated in: CARIS HIPS

[X] Caris [ ] ISIS

[ ] Other ____________________

Caris Vessel Configuration File

Name: R352_MB.hvf

Version: 6.1 SP 1 HF 1-4

New [ ] Appended values with time tag [X]

Evaluator: Mike Stecher, Lead Hydrographer

Calibration Date: April 14, 19 & 21, 2007

Ship	NOAA Ship Nancy Foster
Vessel	
Echosounder System	RESON 8124
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:

[ ] 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-07-06 DAPR

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

Calibration date: February 13,2007

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 3.22 was used for the entire survey.

Static Draft Survey

(Vessel waterline with respect to RP)

Survey date: April, 14 2007

The 8124 draft was measured at the beginning and end of the cruise. The initial draft reading (RP to WL) for the 8124 at the moon pool was 2.18m. A total draft change of .07m was observed for the cruise duration and entered into the vessel configuration file R352_8124.hvf as a daily change of 0.007m.

(Moon pool shaft + sonar head) – WL – RP = Draft

5.442m-1.67-1.588=2.18m

Static Draft Correction -2.18 **(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 were entered into the CARIS vessel configuration file, R352_8124.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_8124.hvf

Table

	Draft (m)	Speed (m/s)
1	0.007	2.600
2	0.041	3.160
3	0.002	4.070
4	0.032	5.030
5		

OK Cancel

Calibration Survey Information

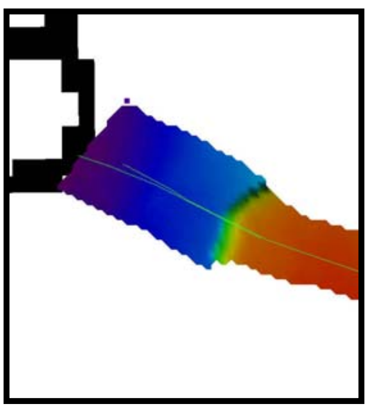
A patch test was performed for the temporary Reson 8124 installation during the Abrir La Sierra bank survey area. Biases were estimated by running a series of calibration lines, as described in the NOS Hydrographic Specifications and Deliverables, March 2003 Edition (HSSD). The patch test calibration quantified residual biases between the POS/MV V4's Inertial Measurement Unit and the Reson 8124 multibeam transducer alignment. The patch test also identified time latency within the positioning and acquisition system. All alignment values in the CARIS vessel configuration file and acquisition software were changed to zero before the patch test data was collected.

Calibration Area

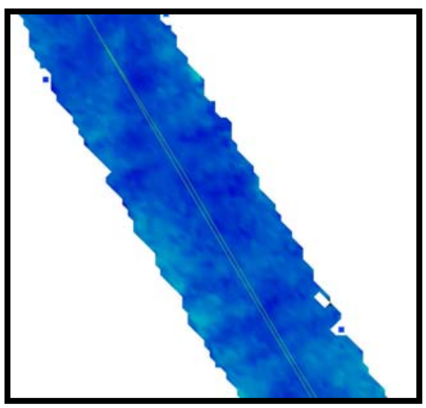
Site Description for Latency, Pitch, Roll and Yaw Procedures

Several areas within the Abrir La Sierra Bank were chosen for the patch test procedure. The areas identified provided the steep and smooth slopes with little change in across track depth to accurately assess the latency, pitch and yaw biases for the Reson 8124 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 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 latency, pitch and yaw transects at approximately 5 knots. Navigation latency was determined by examining the roll timing error as per the precise timing procedure.

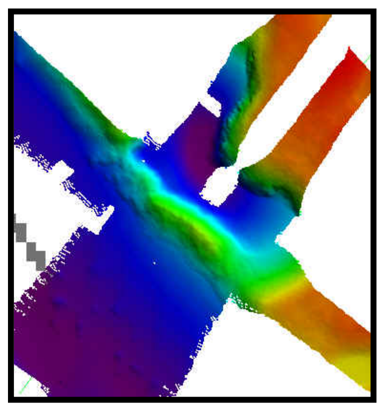
Pitch Area



Roll/Latency Area



Yaw Area

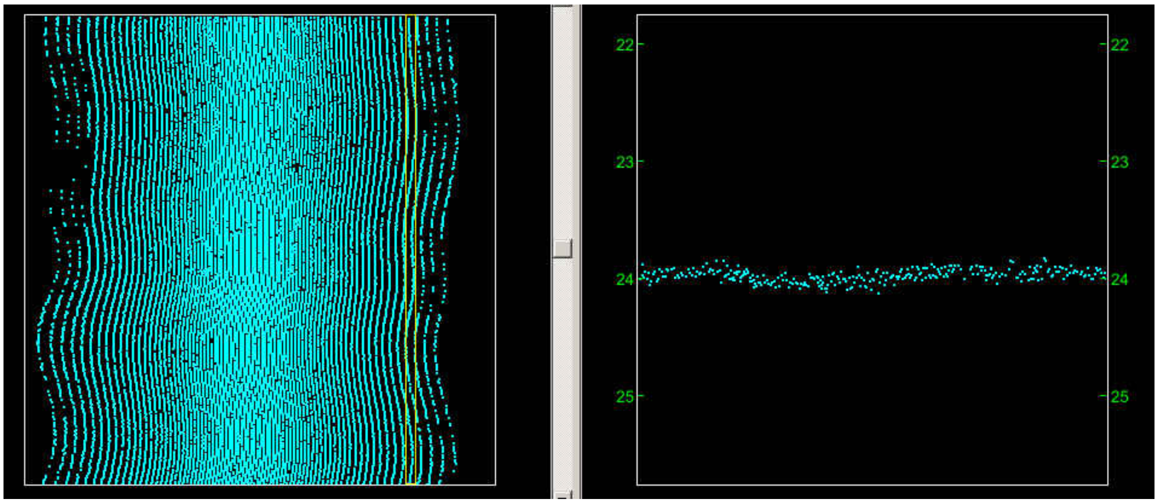


Calibration Survey Information

The hydrographer performed the biases calculations in the order described in the HSSD using CARIS HIPS's calibration tool.

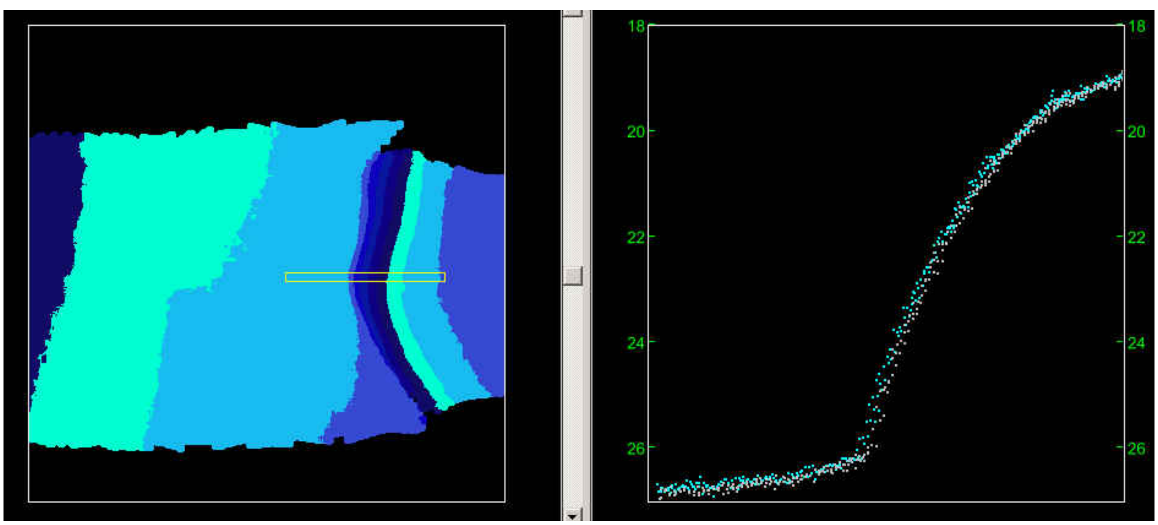
- Navigation latency was determined by examining the roll timing error observed in the outer beams (precise timing procedure). Zero timing error was determined, typical of the POS/MV system.

1) Latency



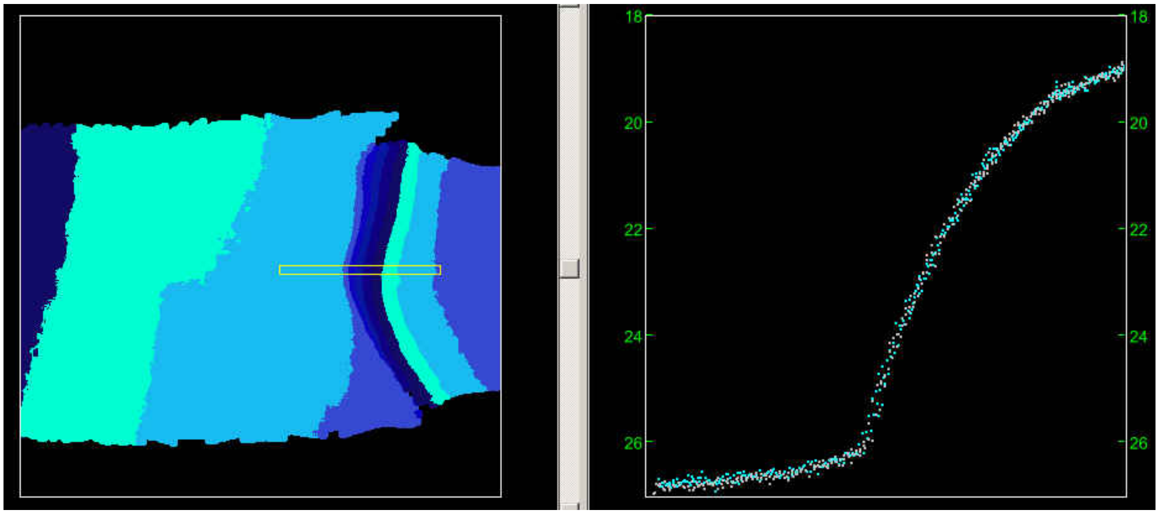
- The pitch offset was calculated next, observing nadir data with two-surveyed lines in opposing directions over a slope.

2) Pre-Pitch Alignment



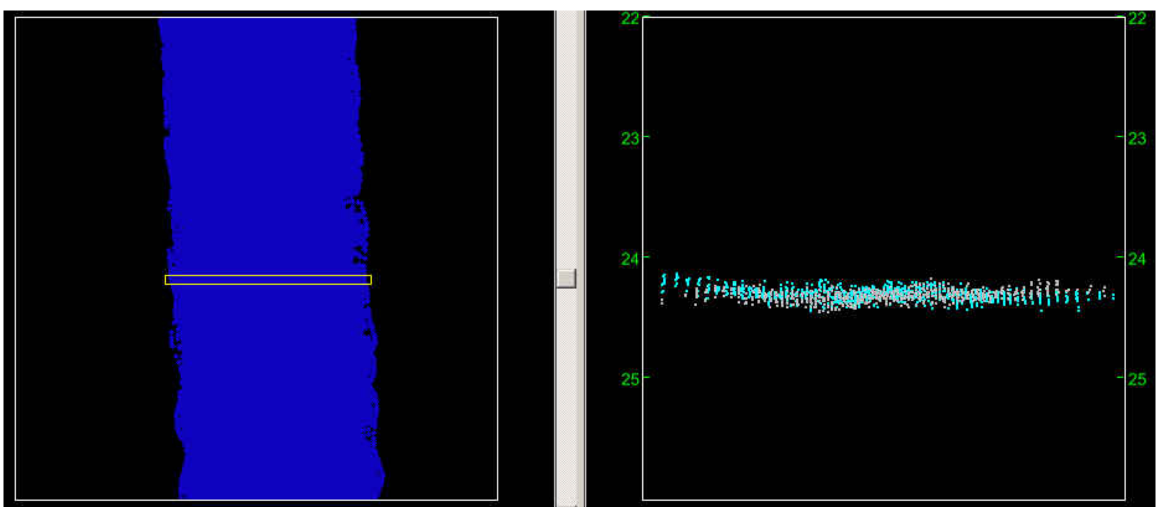
- A pitch offset alignment of -0.52° was identified and entered into the R352_8124.hvf

2a) Post-Pitch Alignment



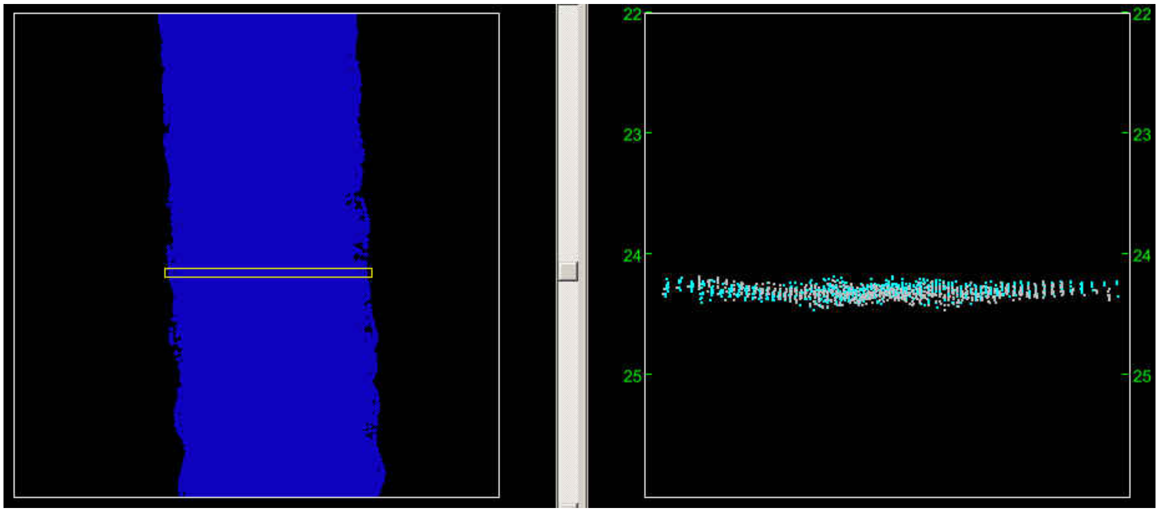
- The Roll offset was calculated next, observing the full swath of two-surveyed lines in opposing directions over a flat area.

3) Pre-Roll Alignment



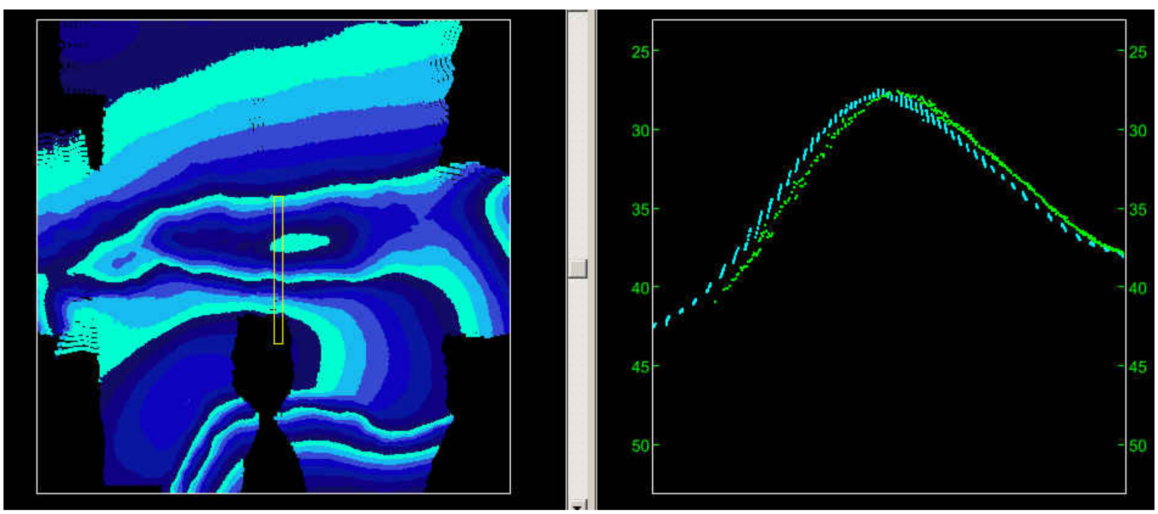
- A roll offset alignment of -0.10° was identified and entered into the R352_8124.hvf.

3a) Post-Roll Alignment



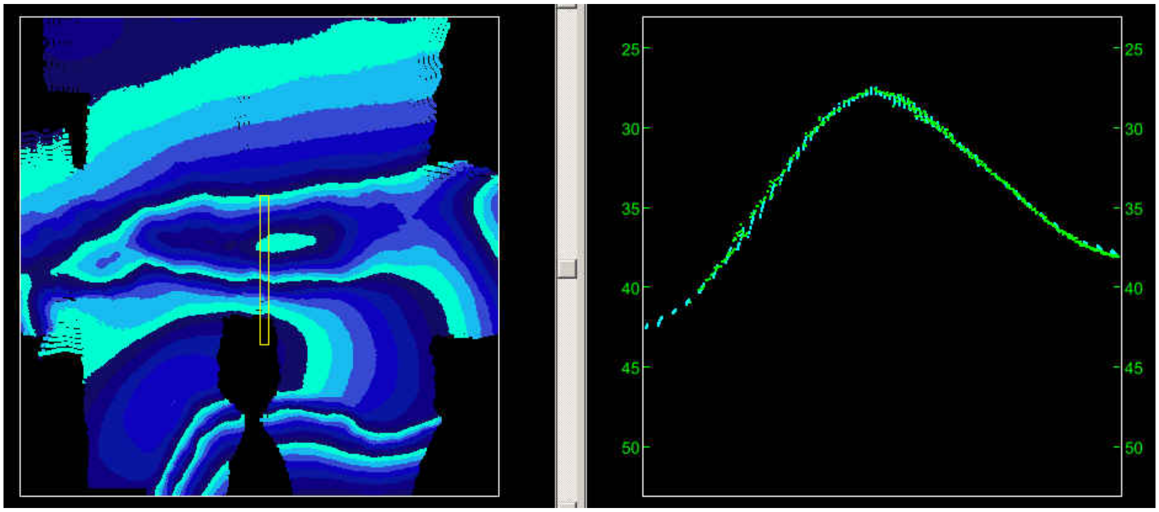
- The Yaw offset was calculated next, outer swaths of two offset parallel lines surveyed in the same direction over a slope.

4) Pre-Yaw Alignment



- A Yaw offset alignment of 4.00° was identified and entered into the R352_8124.hvf

4a) Post-Yaw Alignment



The patch test results were proven with seafloor alignment from opposing swaths throughout the data set. The CARIS vessel configuration file R352_8124.hvf was updated with the values obtained from the patch test and used for the duration of the NF-07-06 cruise and for post-processing.

Calibration Lines

Line	Direction	Speed	Bias Measured
542	NW	5	L1, R1
543	SE	5	L2, R2
648	SE	5	Y1
649	SW	5	Y2
650	NE	5	Y3
679	NW	5	P1
681	SE	5	P2

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
JD109_2	1608	26.7	18 05 28	67 23 46
JD111_3	1028	85.49	10 03 49	67 25 00

Tide Correction

Predicted tides applied.

Gauge ID

Approximate distance of gauge from calibration site: N/A

Approximate water level range at calibration site: .050 **(meters)**

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	-0.52	4.00	-0.10

Corrections calculated in: CARIS HIPS

[X] Caris   [ ] ISIS

[ ] Other ____________________

Caris Vessel Configuration File

Name**:** R352_8124.hvf

Version: 6.1 SP 1 HF 1-4

New [X] Appended values with time tag [ ]

Evaluator: Mike Stecher, Lead Hydrographer

APPENDIX J:

CO-OPS Tide Requirements, Tide Note and Correspondence

Tide Requirements for M-I911-NF-2007
IOCM Multibeam Mapping: Puerto Rico
CFL 02/20/2007

5.0. TIDES

5.1. Purpose: All tide requirements in these instructions are in direct support of hydrographic survey operations.

5.2 through 5.6. Refer to Standing Instructions.

5.7. Vertical Datums:
Refer to Standing Instructions.

5.7.1. The operating National Water Level Observation Network (NWLON) stations at Magueyes Island, PR (945-9110) and San Juan, PR (975-5371) will serve as datum control for the survey area. Therefore, it is critical that these stations remain in operation during all periods of hydrography.

5.7.1.1. Water level data acquisition monitoring
Refer to Standing Instructions.

5.7.1.2. Water level station operation and maintenance
Refer to Standing Instructions.

5.7.1.3. No leveling is required at Magueyes Island, PR (945-9110) by NOAA Ship Nancy Foster.

5.8. Water Level Station Requirements: The operating water level stations at Magueyes Island, PR (945-9110), Aguadilla, PR (975-9412), and Mona Island, PR (975-9938) will also provide water level reducers for this project, reiterating the importance of their operation during all periods of hydrography. See Sections 5.7.1.1. and 5.7.1.2. concerning responsibilities.

5.8.1. There are no subordinate water level stations required for this project.

5.8.1.2. This section is not applicable for this project.

5.8.1.3 Tide Component Error Estimation: The estimated tidal error contribution to the total survey error budget in the vicinity of western Puerto Rico, Magueyes Island, PR (945-9110), Aguadilla, PR (975-9412), and Mona Island, PR (975-9938) is 0.14 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 station will not be required in the vicinity of western Puerto Rico. 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.

5.9. Zoning: For hydrography in the area of western Puerto Rico, Magueyes Island, PR (945-9110), Aguadilla, PR (975-9412), and Mona Island, PR (975-9938) are the reference stations for predicted tides. Predictions 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 “Predicted

Water Level". Predictions are six-minute time series data relative to MLLW in metric units on Greenwich Mean Time. Apply the following time and height correctors to the predicted tides at Magueyes Island, PR (945-9110), Aguadilla, PR (975-9412), and Mona Island, PR (975-9938) during the acquisition and preliminary processing phases of this project for correcting all sounding data.

Zone Name	**Time Corrector(mins)**	**Range Ratio**	**Predicted Reference**
PR18	-6	x0.94	9759110
PR21	+6	x0.94	9759110
PR20	0	x0.94	9759110
PR16	-12	x1.01	9759110
PR14	-6	x0.99	9759938
PR8	0	x0.82	9759412
PR10	+6	x0.75	9759412
PR12	-6	x1.18	9759938
PR25	0	x0.99	9759938
PR24	+6	x0.92	9759938

NOTE: The tide corrector values referenced to Magueyes Island, PR (945-9110), Aguadilla, PR (975-9412), and Mona Island, PR (975-9938) are provided in the zoning file "I911NF2007CORP" 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.

NOTE: For time corrections, a negative (-) time correction indicates that the time of tide in that zone is earlier than (before) the predicted tides at the reference station, whereas, 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.

Water level gauges for this project have been installed by CO-OPS prior to the start of the survey. Upon completion of project M-I911-NF-2007, 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 .

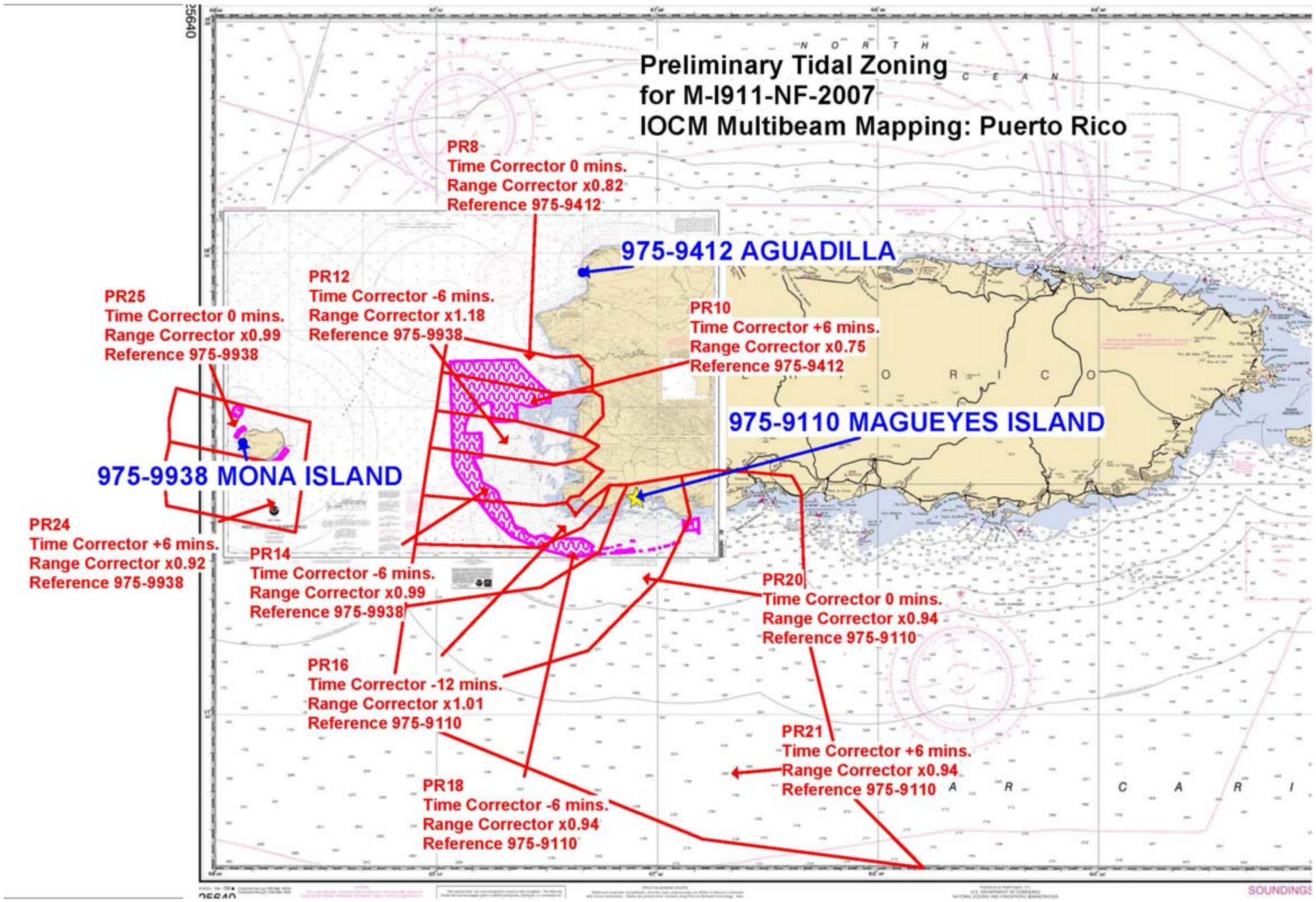
CO-OPS will review the times of hydrography, final tracklines, and six-minute water level data from all applicable water level gauges. After review, CO-OPS will send a notice indicating that the tidal zoning scheme sent with the project instructions has been approved for final zoning. If there are any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

5.9.1. Zoning Diagram(s) A zoning diagram, created in MapInfo, is to assist with the zoning provided in Section 5.9.

5.9.2. Tidebot:
Refer to Standing Instructions.

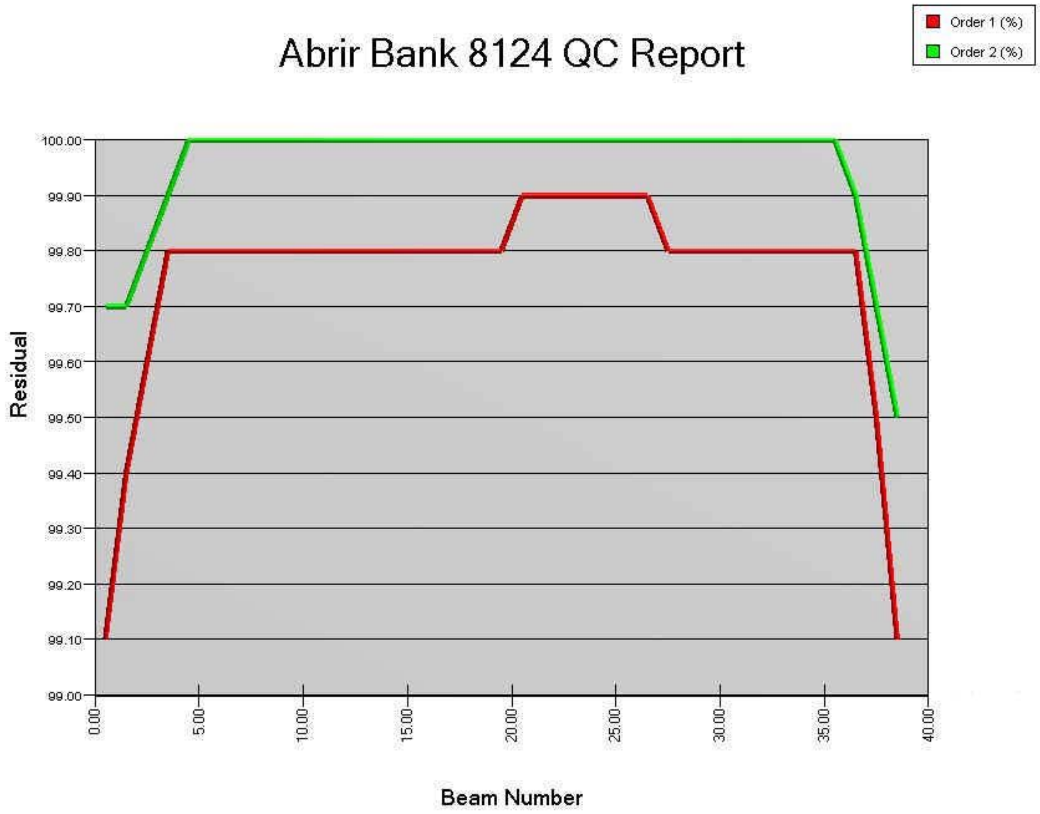
5.10. Tidal Records:

Refer to Standing Instructions on what data records, reports and requests to submit to CO-OPS and the address where these documents should be submitted too.


Preliminary Tidal Zoning
for M-I911-NF-2007
IOCM Multibeam Mapping: Puerto Rico
PR8
Time Corrector 0 mins.
Range Corrector x0.82
Reference 975-9412
975-9412 AGUADILLA
PR12
Time Corrector -6 mins.
Range Corrector x1.18
Reference 975-9938
PR25
Time Corrector 0 mins.
Range Corrector x0.99
Reference 975-9938
PR10
Time Corrector +6 mins.
Range Corrector x0.75
Reference 975-9412
975-9110 MAGUEYES ISLAND
975-9938 MONA ISLAND
PR24
Time Corrector +6 mins.
Range Corrector x0.92
Reference 975-9938
PR14
Time Corrector -6 mins.
Range Corrector x0.99
Reference 975-9938
PR20
Time Corrector 0 mins.
Range Corrector x0.94
Reference 975-9110
PR16
Time Corrector -12 mins.
Range Corrector x1.01
Reference 975-9110
PR21
Time Corrector +6 mins.
Range Corrector x0.94
Reference 975-9110
PR18
Time Corrector -6 mins.
Range Corrector x0.94
Reference 975-9110
25640
SOUNDINGS

APPENDIX K:

CARIS Quality Control Reports



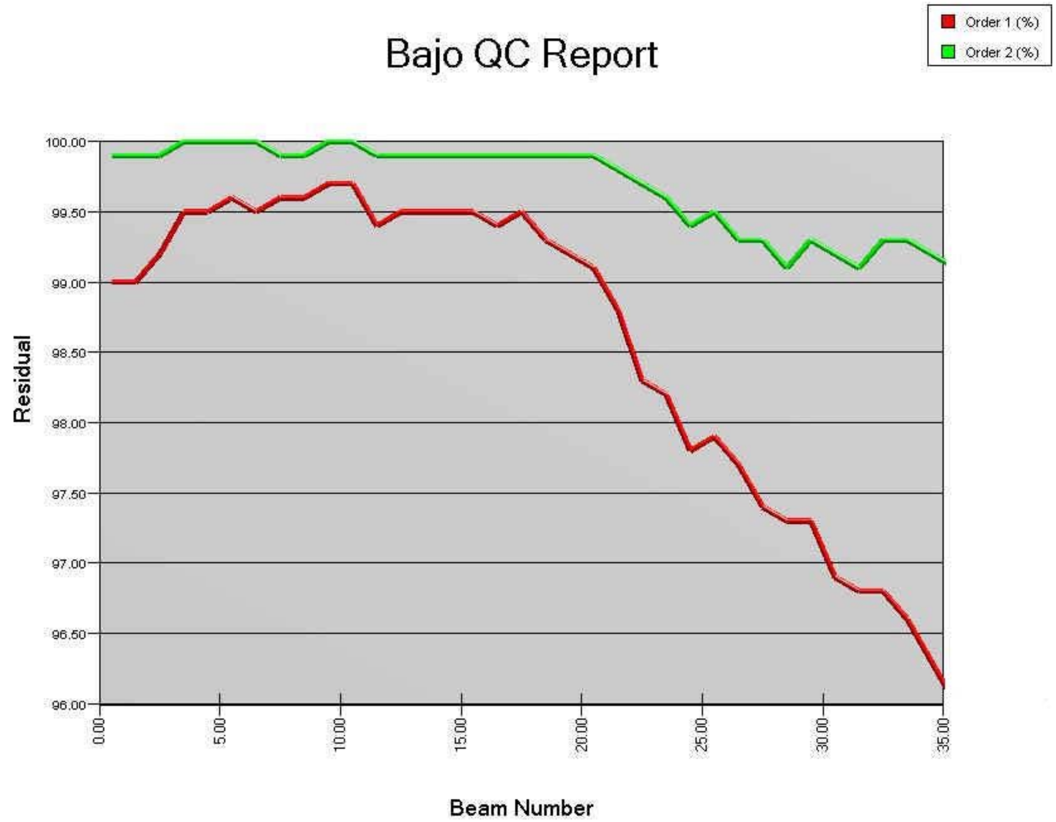
BASE Surface QC Report

Date and Time: 10/8/2007 3:15:08 AM
Surface: C:\CARIS\HIPS\61\FieldSheets\NF-07_06_HAB\Abrir_UTM19N\Abrir_5m.hcs
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 1,238,005
Number of nodes populated: 1,235,797 (99.8216485393839%)
Number of holidays detected: 0

S-44 Order 1:
Range: 20.0 to 100.0
Number of nodes considered: 398,910
Number of nodes within: 374,976 **(94.0%)**
Residual mean: -0.412853129449897

S-44 Order 2:
Range: 100.0 to 5000.0
Number of nodes considered: 414,285
Number of nodes within: 414,285 **(100.0%)**
Residual mean: -4.23603113467842



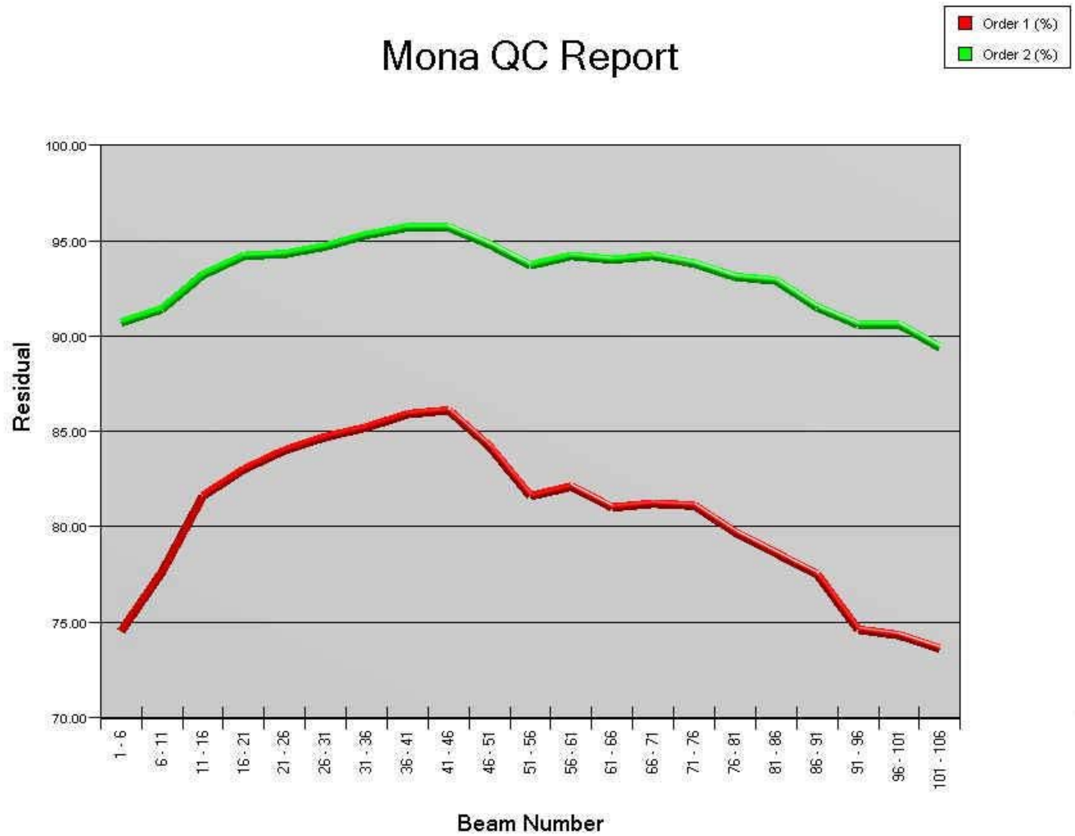
BASE Surface QC Report

Date and Time: 9/30/2007 5:34:54 PM
Surface: C:\CARIS\HIPS\61\FieldSheets\NF-07_06_HAB\Bajo_UTM19N\Bajo_5m.hcs
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 1,641,501
Number of nodes populated: 1,641,446 (99.9966494080722%)
Number of holidays detected: 0

S-44 Order 1:
Range: 20.0 to 100.0
Number of nodes considered: 431,398
Number of nodes within: 416,822 **(96.621%)**
Residual mean: -0.738233000177107

S-44 Order 2:
Range: 100.0 to 5000.0
Number of nodes considered: 1,210,048
Number of nodes within: 1,210,048 **(100.0%)**
Residual mean: -4.62367689312812



BASE Surface QC Report

Date and Time: 10/14/2007 10:26:06 AM
Surface: C:\CARIS\HIPS\61\FieldSheets\NF-07_06_HAB\Mona_UTM19N\Mona_5m.hcs
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 962,424
Number of nodes populated: 962,209 (99.977660573718%)
Number of holidays detected: 0

S-44 Order 1:
Range: 20.0 to 100.0
Number of nodes considered: 228,023
Number of nodes within: 190,132 **(83.383%)**
Residual mean: -0.385224378633516

S-44 Order 2:
Range: 100.0 to 5000.0
Number of nodes considered: 671,473
Number of nodes within: 671,470 **(100.0%)**
Residual mean: -5.6531365895207

APPENDIX L:

NF-07-06 Cruise Instructions

Project Instructions for the NOAA Ship Nancy Foster

Characterization of mid-water seafloor habitats of southwest Puerto Rico

Cruise Number: NF-07-06-USVI HAB

Cruise Dates: April 14, 2007 through April 24, 2007

Operating Area: Puerto Rico

Sea days: 11

Chief Scientist:
Timothy A. Battista
NOAA/NOS/NCCOS
Center for Coastal Monitoring and Assessment
SSMC 4, Station 9311, N/SCI-1
1305 East West Hwy
Silver Spring, MD 20910
Tel: 301-713-3028
Fax: 301-713-4384
E-mail: Tim.Battista@noaa.gov

Ship Operations:
Captain Emily Christman
Commanding Officer, Atlantic
Marine Operations Center-Atlantic
439 West York Street
Norfolk, VA 23510-1145
Telephone Number: 757-441-6778
Fax Number: 757-441-6495
E-mail Address: ChiefOps.MOA@noaa.gov

CRUISE INSTRUCTIONS: NOAA SHIP NANCY FOSTER

Cruise Title: **Characterization of mid-water seafloor habitats of southwest Puerto Rico**

Cruise Number NF-07-06-USVI HAB

Period of Cruise:
DEP: 4/14/07 NF-07-06-USVI HAB
ARR: 4/24/07

Area of Operation: Southwest side of Puerto Rico and Mona Island (See Figure 1)

1.0 Scientific Objectives:

The Center for Coastal Monitoring and Assessment (CCMA) will be conducting the fourth 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 data in high priority conservation areas within Puerto Rico. Scientists will collect high resolution multibeam in mid-water depths approximately 20 to 1000 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 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.

12 April (Thursday): Nancy Foster arrives in San Juan, Puerto Rico
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning. Install Seabat 8124 multibeam to the moon pool using ship divers.
GT: Ground Truthing (GT) team configures remaining camera gear and conducts USBL, POS/MV, GPS integration with Hypack; and installs hydrophone pole.

13 April (Friday):
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning. Conduct dockside calibration tests.
GT: Ground Truthing (GT) team conducts pier side deployment test of drop camera.
All: Team scientists meeting and meeting with ship officers on safety and scientific operations.

14 April (Saturday):

Transit/Survey NF: (0800-2400) Ship transit from San Juan to El Hoyo. Collect deep water surveys on transit down with EM 1002.

15 April (Sunday):
Patch Test/Survey NF: (2400-0800) Survey team conducts Patch Test to calibrate the Seabat 8124 multibeam echosounder (MBES) system at El Hoyo and begins shallow water survey.
GT: (0800-1600) Conduct ground truthing of south shore shallow.
Survey NF: (1600-2400) MBES south shore.

16 April (Monday):
Survey NF: (2400-0800) MBES south shore.
GT: (0800-1600) GT south shore
Survey NF: (1600-2400) MBES south shore.

17 April (Tuesday):
Survey NF: (2400-0800) MBES south shore.
GT: (0800-1600) GT south shore
Survey NF: (1600-2400) MBES south shore.

18 April (Wednesday):
Survey NF: (2400-0800) MBES Mona Island.
GT: (0800-1600) GT Mona Island.
Survey NF: (1600-2400) MBES Mona Island.

19 April (Thursday):
Survey NF: (2400-0800) MBES west shore.
GT: (0800-1600) GT west shore.
Survey NF: (1600-2400) MBES west shore.

20 April (Friday):
Survey NF: (2400-0800) MBES west shore.
GT: (0800-1600) GT west shore.
Survey NF: (1600-2400) MBES west shore.

21 April (Saturday):
Survey NF: (2400-0800) MBES west shore.
GT: (0800-1600) GT west shore.
Survey NF: (1600-2400) MBES west shore.

22 April (Sunday):
Survey NF: (2400-0800) MBES west shore.
GT: (0800-1600) GT west shore.
Survey NF: (1600-2400) MBES west shore.

23 April (Monday):
Survey NF: (2400-0800) MBES west shore.
GT: (0800-1600) GT west shore.
Survey NF: (1600-2400) MBES west shore.

24 April (Tuesday):
Survey NF: (2400-0600) MBES west shore
Transit: (0600-1400) Transit to San Juan.
Demobilization: (1400-1800) Demobilization

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. The CCMA Hydrographer (Mike Stetcher) and AHB will conduct an annual patch of the unit during sea trials 2/13/06. Installation of the Seabat 8124 will occur in San Juan. The 8124 is being configured to mount to the moon pool flange. An additional extended cable is being fabricated to allow the data transmission from the transducer head to the acquisition station located in the dry lab. An ISIS acquisition software license is being investigated for use from within NOAA. If that is unavailable, and ISIS licensed will be rented. The patch test for the 8124 will occur at El Hoyo, and area surveyed by CCMA in 2006.

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 time positioning data is received, and the time the computed position reaches the acquisition system. To ensure quality results from the patch test 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. Static transducer draft, settlement and squat corrections, sound velocity corrections, and preliminary tide corrections will be applied to the data prior to bias determination. The general patch test procedure requires multibeam data collection along a series of transects as described in Figure 3. Alternatively, yaw bias can also be determined by surveying two lines on each side of a submerged object in relatively shallow water (Fig. 4). Patch test results will be calculated with CARIS's v5.4 calibration program in the following order: Latency, pitch, roll and yaw.

An area south of Parguera has been identified (Fig. 5) 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

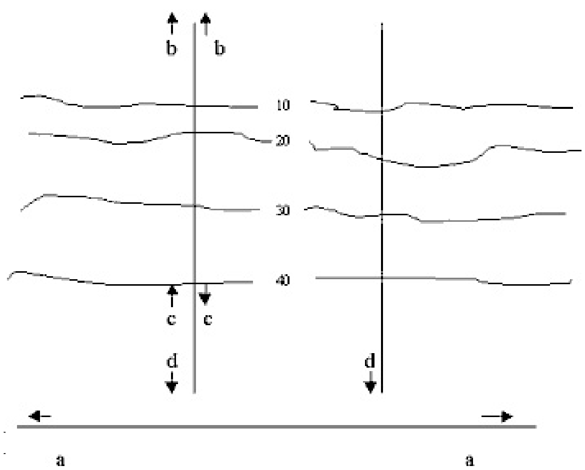


Figure 3: a = Roll, b = Latency, c = Pitch, d =Yaw

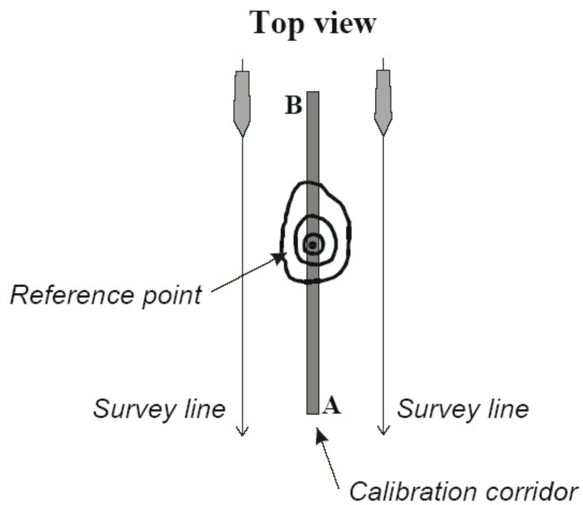


Figure 4: Yaw bias test performed on submerged object

l be

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

Data Acquisition Methodology:

Upon the completion of the verifiable patch test, the area on the south side of Puerto Rico, followed by Mona Island, and finishing with western Puerto Rico. At this time a line plan has not been conducted but it is estimated that 490 square kilometers of area would prefer to be acquired. Due to the shoal depths along Puerto Rico a line spacing of 55 meters is required to provide sufficient coverage. Reducing the anticipated coverage area will be required. The line plan is generally orientated parallel with the contours to maximize swath coverage and improve acoustic returns. The line plan has taken into account water depths, swath width filters and overlap requirements (Table 2). Restricting the swath limit ensures the data will meet IHO standards, and make the data cleaning process more efficient. All deep survey areas will be accepting soundings 55° from nadir, port and starboard, with 10% swath overlap. Areas shoaler than 55 meters will accept 60° port and starboard with a 10% overlap. Surveying operations in the shallow water should ideally be performed during daylight hours at higher tides to maximize swath widths, and for vessel safety reasons. Surveying during calm waters and steady piloting of the vessel will improve data quality. This is a preliminary line plan and field adjustments may be required.

The EM1002 data packets will be logged in Simrad Merlin navigation program to create real time coverage maps to ensure coverage. Seabat 8124 will be logged in ISIS navigation program to create real time coverage maps to ensure coverage. During line turns data will be transferred to CARIS processing stations where preliminary zoned tides, swath filters and SVP cast corrections will be applied. The preliminary data will be used to create preliminary sun-illuminated Base surfaces for QA/QC analysis and then exported into geo tiff format. These geo tiffs will be superimposed on top of the charts in Coastal Oceanographics Hypack for additional line planning and navigation purposes.

Data Quality Assurance/Quality Control Methodology:

To ensure that the data collected meets IHO Level 1 & 2 standards several quality assurance/quality control measures will be implemented. The velocity of sound through the water column will be derived from conductivity, temperature, and depth measurements (CTD casts) collected no more than 4 hours apart. A CTD cast will be will be taken prior to the commencement of daily multibeam operations. Spatial variability will be taken into account as well as temporal variability when determining cast locations. These locations will be recorded and each cast will be compared to the previous to identify any significant changes in the water column. Turns will be limited and vessel speed will be adjusted to ensure that 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. System confidence checks prior to, and during, multibeam operations will be conducted. These include position checks, lead lines and bar checks. Cross lines 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.

Drop Camera Operations:

Benthic habitats in moderate depth water (>20m and <300m) around the southwestern Puerto Rico and Mona Island will be visually-characterized using a 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 load bearing umbilical will be deployed using the J-frame. A hydrophone pole will be borrowed from UNCW NURC (Lance Horn) and mounted/deployed over the port side forward of the J frame. The pole can be easily retrieved before transiting to a new location. The drop camera system has been designed to be a stable, easily deployable, operational using ships power, and dependable underwater imaging system. A ship deck hand will be required during recovery and deployment, but can otherwise be operated by the scientists.

The sampling approach will deviate from years past given that the drop camera will not be operated to conduct transects, but rather frequent point samples. The selection of point sampling stations 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. The drop camera has its own contained cable reel system capable of 1 m/s deployment speeds and 1 m/s recovery speeds. Deployment of the drop camera at the deepest depths (300m) will require the most time on station. Time estimates: 1) 15 minutes to deploy the drop camera to the seafloor, 2) 10 minutes of imaging the seafloor, and 3) 10 minutes for retrieval. The scientists anticipate sampling between 20 to 25 stations per day for an 8 hour daylight shift.

5.0 Requirements and Equipment:

5.1 Vessel Provided:

1) Hand held radios for communication between bridge and deck.
2) EM 1002 and Reson 8124 multibeam Shipboard multibeam, CARIS Processing station, Hypack, Velociwin
3) CTD's 100m and1000 m depth rating.

5.2 Program Provided:

	Equipment	Leg
1)	Underwater video + camera equipment + tow bodies (Drop camera)	Charleston
2)	USBL Underwater tracking system and hydrophone pole	Charleston
3)	6 USB 250GB Maxtor 5000XT hard-drives (CCMA).	USVI
4)	Five high end laptops and two flat screen monitors.	USVI
5)	CARIS, ArcGIS, ISIS	USVI

6.0 Scientific Personnel:

6.1 Chief Scientist Authority

The Chief Scientist has the authority 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 allotted for the project, 3) result in undue additional expense, or 4) alter the general intent of the Project Instruction.

6.2 Scientific Personnel List:

Chief Scientist: Tim Battista
Lead Hydrographer: Mike Stetcher

Male:	Organization:	GT	Multibeam
Tim Battista	NOAA	X	
Mike Stetcher	NOAA		X
Bryan Costa	NOAA		X
Survey Tech	NOAA		X
Charlie Menza	NOAA	X	
Ken Buja	NOAA	X	
Graduate Student	UPRM	X	
Graduate Student	UPRM	X	

TASK TEAMS

Ground Truthing

Battista, Menza, Buja, Graduate Students

MULTIBEAM

1) **NF Team A (2400-0800): Stetcher**, Costa
2) **NF Team B (1600-2400): TBD**, Foster Survey Tech.

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

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

6.4 History Reports:

Upon acceptance of this proposal, and receipt by the Chief Scientist of the forms, the Chief Scientist will forward completed copies of the NOAA Health Services Questionnaire for all embarking scientific personnel to the Commanding Officer for review at lease 7 days in advance of the cruise.

7.0 Miscellaneous Activities:

None known at this time.

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
No foreign nationals are expected as science party participants in this cruise.

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 Reports:
The requirement for a formal cruise report by the Chief Scientist is left to the discretion of the CCMA Center Director. A Ship Operations Evaluation Form is to be completed by the Chief Scientist(s) and forwarded to:
Office of Marine and Aviation Operations
Program Services and Outsourcing Division
SSMC3, Room 12872
1315 East-West Highway
Silver Spring, MD 20910-3282

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_________________________