Data Acquisition & Processing Report

Type of Survey: Benthic Habitat and Hydrographic

Project No. ~~NF-08-04-USVI~~ *M-I905-NF-08*

Time Frame: February 25, 2008 - March 8, 2008

Localities

Tourmaline Bank

Isla De Mona

2008

Chief Scientist

Timothy A. Battista

Lead Hydrograher

Mike L. Stecher

Data Acquisition & Processing Report

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February 25, 2008 - March 8, 2008

Western Coast of Puerto Rico

NOAA Ship NANCY FOSTER

Chief Scientist

Timothy A. Battista

Lead Hydrograher

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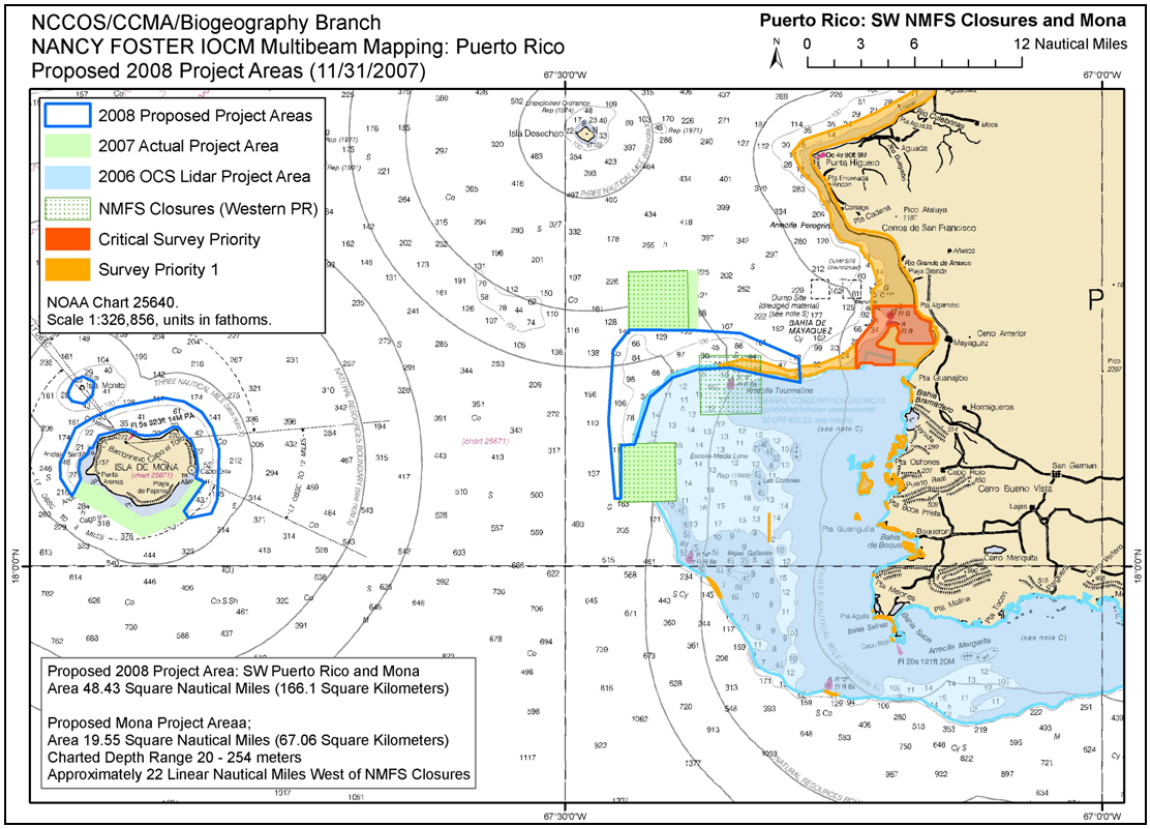
I. Background

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 fifth year of an ongoing scientific research mission on board the NOAA ship NANCY FOSTER from February 25 to March 8, 2008. 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 500 meters. The multibeam data was collected to conform to IHO Order 1 (<100m) and Order 2 (>100m) accuracy standards. The strategies developed for each survey area took into account the minimum depths, general bathymetry, and time allotment. The delineation and identification of seafloor habitats within areas mapped during the mission was assisted by the use of an ROV with video and camera capabilities. Concur

II. Area

The mission explored and m apped moderate depth bathym etry with the NANCY FOSTER's Sim rad EM1002 m ultibeam syste m for natural resource managem ent and seafloor characterization. Priority ar eas for 2008 included the Tourm aline Bank area offshore of western Puerto Rico and the northern portion of Isla De Mona. Concur



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. 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 performed the EM1002 multibeam patch test during the research cruise on March 1 - 2, 2008 (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 60°.

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 1 Hz. The POS also provided the pulse per second (PPS) strobe and the NMEA ZDA message that the EM1002 uses to continually synchronize the system clock.

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

Acquisition Systems

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

Coastal Oceanographics Hypack Max 2008 provided the navigation information to the helms display and was used along with MapInfo to create line plans for the project areas. Coverage BASE surfaces were created with CARIS's HIPS and SIPS during data acquisition to verify coverage. The BASE surfaces were then exported in GeoTiff format to Hypack for creating holiday line plans and delineate ROV transect locations.

IV. Quality Control

The HIPS conversion wizard uses the .ALL format to convert the multibeam data into CARIS HDCS data files. The vessel configuration file (R352_MB.hvf) includes the patch test results, dynamic draft, waterline and the Total Propagated Error 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. Concur

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

down-sloping beams where the survey lines crossed over the reef escarpment providing unreliable soundings. Concur

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

Fig 3: 2008 bathymetry coverage, 105 km^2, shown as 9m grid, Tourmaline Bank, W Puerto Rico.

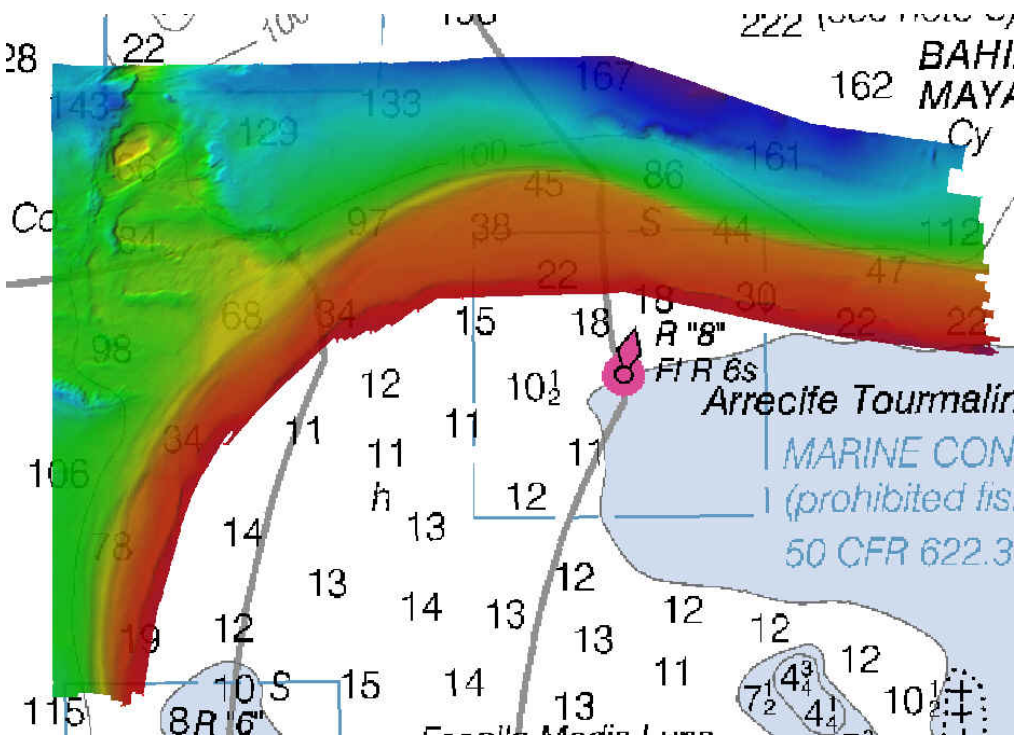


Fig 4: 2008 bathymetry coverage, 77km^2, shown as 9m grid, Isla De Mona, W Puerto Rico

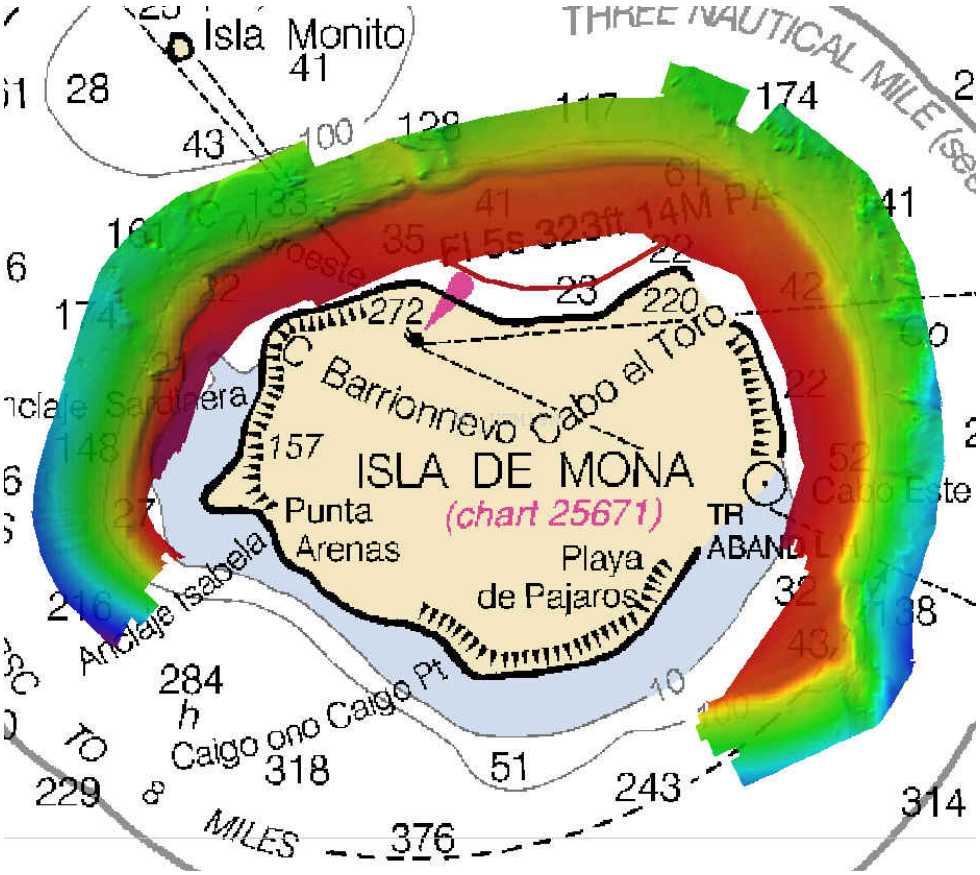


Table 1: BASE Surface Resolutions and Depth Thresholds

Resolution (meters)	Depth Thresholds (meters)
3m	0m to 60m
6m	50m to 150m
9m	Deeper than 140m

Multiple resolution BASE surfaces with different depth thresholds were created for each survey area to demonstrate multibeam coverage according to section 5.2.3 in the NOAA Specs and Deliverables. The surfaces were also stitched together with the combine surface command, therefore creating a single layer and retaining the information from each surface used to create the combined surface. The HIPS export wizard produced 24-bit sun-illuminated geo-referenced images of the BASE depth surfaces, and ASCII XYZ text exports at resolutions in accordance with the depth thresholds for each survey area and as a combined surface. A final analysis was performed on the BASE depth surfaces with the Hips Quality Control Report and is discussed in the Assessment of IHO Compliance section. **Concur**

V. Corrections to Echo Soundings

Instrument corrections

An initial leadline confidence check was measured against the multibeam echosounder prior to the start of field operations on February 24, 2008 at Pier 1 in San Juan, Puerto Rico. The purpose of this check was to verify the system during static conditions by confirming that the digital depths being recorded reflected the actual depths. A sound velocity cast was performed at the site and the leadlines were performed approximately 7.5 meters to port of the multibeam system. The sonar's acquisition system was 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 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 file 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 recorded on February 24, 2008 was 3.75m while tied up at Pier 1 in San Juan, Puerto Rico. Subtracting the initial draft value of 3.75m from the fixed offset (1.68m) for the Reference Point to the EM1002 gives the final draft reading of -2.07m, 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 (March 8) was approximately 3.56m. A total draft change of 0.19m was observed for the cruise duration and entered into the vessel configuration file as a daily change of 0.015m.

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 Multibeam Calibration Procedures & Patch Test Report. The calculated patch test values for latency, roll, pitch and yaw were entered into the vessel configuration file.

Tide Corrections

Existing water level stations were used in conjunction with height and time correctors in a CARIS tide zone definition file (ZDF). Predicted tides, adjusted to MLLW, and ZDFs were supplied by NOAA CO-OPS prior to the commencement of survey operations. Verified six-minute interval water level and final tide zone correctors were applied while post processing the data. During the computation of the TPE, survey specific parameters including the estimated tidal errors, were applied. The estimated tidal error contribution to the total survey error budget was 0.35 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. Concur

Quality control

A position check between two independent DGPS systems was observed and recorded with HYPACK on February 24, 2008 while docked at Pier 1, 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.

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 (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695) served as the primary sources for vertical datum control. Six-minute predicted tides were obtained from the CO-OPS home page (www.co-ops.nos.noaa.gov) and were applied during preliminary processing onboard the vessel. Verified tides with final zoning were applied during post-processing. Concur

Tides Zoning

The tidal zoning data, time and height corrections were provided by NOAA CO-OPS (refer to Appendix J). The verified tides were zone corrected with the H11809CORF.zdf file provided by CO-OPS. Concur

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. Concur

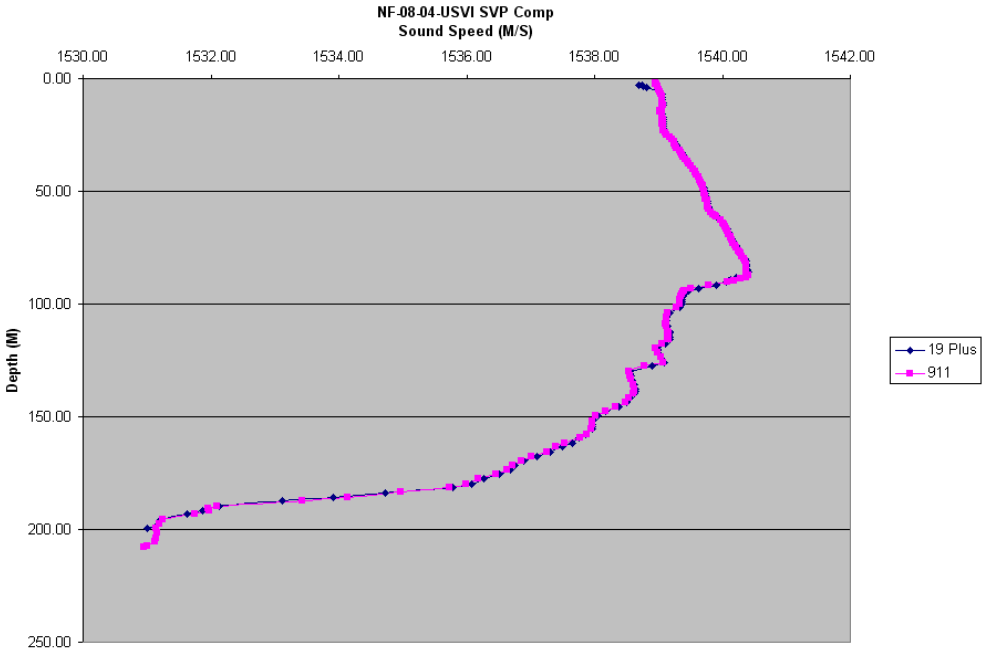
Assessment of sensors

Ancillary sensors

Sound velocity profiles were acquired using the NANCY FOSTER's SeaBird Electronics (SBE) 19 Plus Conductivity, Temperature, and Depth (CTD) profiler (S/N 0523) and the SBE 911 CTD (S/N 0731). Raw CTD data was processed using NOAA's Velocwin V8.85 software, which generated the sound velocity profiles required for real-time sounding corrections. Casts were recorded to the full depth of the area being surveyed.

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

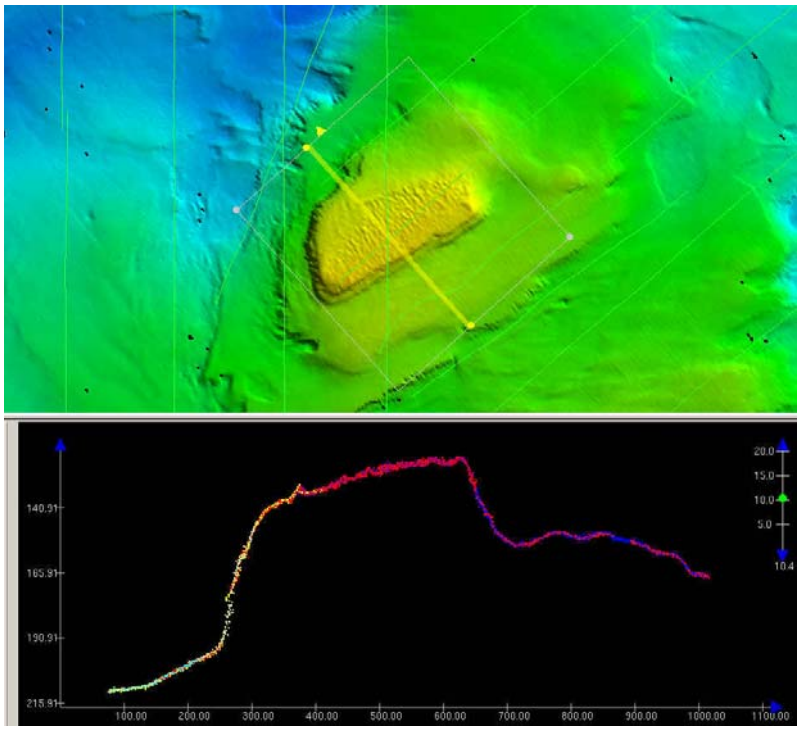
Fig 5: SVP Comparison



Assessment of Patch Test and Results

The Hydrographer believes that the values of latency, pitch, roll and yaw offsets coupled with a thorough review of the patch test meet the requirements for the alignment of the sonar system. The following image represents an area of feature alignment that was collected with a combination of four lines of multibeam data with the EM1002.

Fig 6: Feature mapped with the EM1002 multibeam system



Assessment of Dynamic and Static Draft

Dynamic draft values for the NANCY FOSTER were performed during the Sea Acceptance Test (SAT) offshore of Charleston, South Carolina in March of 2006. Representatives from the NOAA Aviation and Marine Operations (NMAO) performed the survey and evaluated the results. Four-RPM levels were used to determine the dynamic draft: 790, 1000, 1300 and 1600. The observed changes in draft were negligible, with a maximum corrector of 0.041m. The values of the dynamic draft were entered into the vessel configuration files and were applied during the merge process 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
5		

OK Cancel

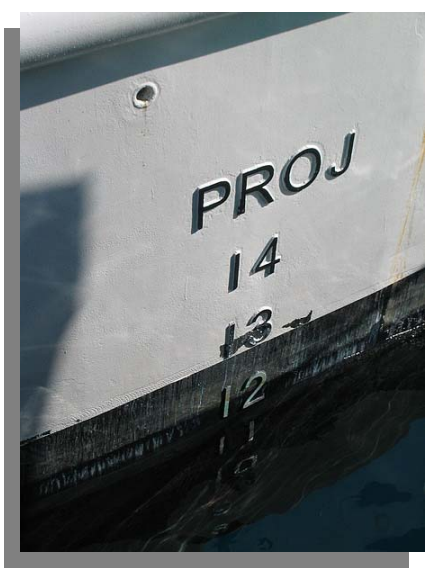


Fig 7: Projection Draft markings

Static draft (waterline) observations were made for the system the day of departure under full load, and at the end of the cruise in San Juan, Puerto Rico. Subtracting the RP from the projection draft markings on the starboard side of the NANCY FOSTER gave the draft to be used in the MERLIN software (-2.07m). A total loss of 0.19m was observed during the cruise at the EM1002. This value was divided into the thirteen days of underway time (0.015m/day) and entered into the vessel configuration file. The initial draft values were verified with lead line observations while tied up at Pier 1 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-08-04-USVI cruise the Lead Hydrographer and Ed Owens (NOS) confirmed these settings. Refer to Appendix E and the 2006 Hydrographic Systems Readiness Review (HSSR) for the NANCY FOSTER for more information.

Assessment of Sensor Calibrations

Each sensor associated with this survey underwent calibration prior to commencement of operations. The digital depths, draft and horizontal offsets were confirmed with a leadline and position check while docked at Pier 1 in San Juan. The offsets to these systems were accurately measured during the PacOrd survey and verified by the Lead Hydrographer as well as other participating hydrographers. The CTD values were confirmed by comparing the two units against each other and both received calibrations by the manufacturer within the previous year. The mounting angle offsets (Patch Test) occurred during the SAT trials and were confirmed again with the documented NF-03-06, NF-07-06 and NF-08-04-USVI cruise calibration procedures. Based on these results the Lead Hydrographer feels that all the systems are adequately calibrated for the purpose of this survey.

Assessment of Object Detection

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

Bottom Coverage and Line Spacing

The survey lines were generally planned parallel to the contours of the seafloor. Line spacing was determined by depth using 10% overlap with 45° to 60° cutoff angles, port and starboard for the EM1002. 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. Concur

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 Tourmaline Bank and Mona Island. The Field Operations Officer (FOO) of the NOAA ship

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

Assessment of IHO Compliance and Quality Control Report

Crosslines totaling approximately 5% of mainscheme were surveyed for the Tourmaline Bank and Mona Island regions. The CARIS generated Quality Control Report compares the crosslines for each project against the 6m 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 CARIS BASE surface QC report was also performed. This utility compares uncertainty values contained in the surface to IHO standards and created a compliance report that is included in Appendix K. Both Tourmaline Bank and Mona Island met and exceeded IHO compliance for IHO order 1 for depths shoaler than 100m, and IHO order 2 for depths deeper than 100m. Concur

VII. Summary Of Submitted Data:

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

Data

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

Approval Sheet (Separate Signed Document Verifying DAPR information)
APPROVAL

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

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

Approved and Forwarded: _____

APPENDIX A:

EM1002 Parameters

EM1002 installation parameters NOAA SHIP NANCY FOSTER
Cruise# NF-08-04-USVI

Software:

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

Motion Sensor:

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

Waterlevel:

Downward Pos. = -2.07

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-08-04-USVI

Sounder Main:

Sounder Mode = Off
Ping Mode = Auto

Sounder Depth is supposed to be within:

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

Sector / Beams:

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

Beam Spacing = Equidistant
Angular Coverare = Automatic

Tracking = Auto

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

Sound Speed:

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

Seabed Imaging:

TVG Law Crossover Angle= 25 deg.

Gain:

Absorbtion Coeff. = 30.00 dB
Range Gate = Normal

Filtering:

Slope Filter = Active
Sector Tracking Filter = Active

Manual Control:

Tx Power = -10 dB
Fixed Gain = 30 dB

Simulator:

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

APPENDIX B:

Hydrographic Hardware/Software Inventory

Hydrographic Systems Inventory Cruise# NF-08-04-USVI				HARDWARE
Equipment type	Manufacturer	Model	Serial #	Firmware
Transducer	Kongsberg/Simrad	EM1002	288	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	SBE	SBE 911	0731	N/A
SVP	SBE	SBE 19	0523	N/A

Hydrographic Systems Inventory Cruise# NF-08-04-USVI			SOFTWARE
Equipment type	Manufacturer	Model	Software Version
Inertial GPS PCS	Applanix	POS/MV 320 V4	3.2
Navigation	Coastal Oceanographics	N/A	2008
Acquisition	Kongsberg/Simrad	MERLIN	5.2 V2
Processing	NOAA	Velocwin	8.85
Processing	CARIS	HIPS & SIPS	6.1 SP2

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=1Hz Talker
ID=IN
Roll Positive Sense=Port UpPitch Positive Sense=Bow UpHeave
Positive Sense=Heave Up Input Select=None

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

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

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

Input Type=RTCM 1 or 9Line=Serial

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

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

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

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

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

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

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

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

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

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

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

Measurement=NormalGAMS=unchecked Disable GAMS Solution

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

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

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

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

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

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

APPENDIX D:

SBE Calibration Reports

19 CTR removed 8Feb08 Installed 8Feb08 ON 9P/NS

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: 0702
CALIBRATION DATE: 28-Nov-07p

SBE 43 OXYGEN CALIBRATION DATA

43 or DO or O_2 or DO_2

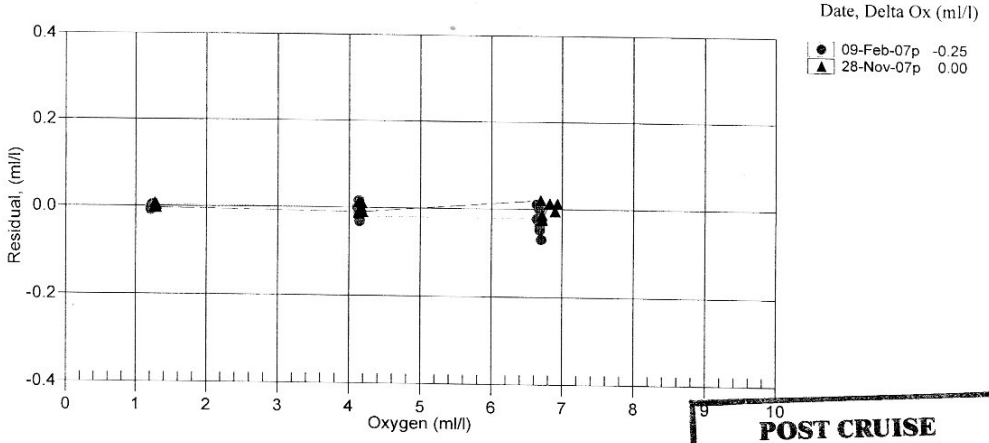
COEFFICIENTS

Soc = 0.3874
Boc = 0.0000
Voffset = -0.4899

TCor = 0.0008
PCor = 1.350e-04

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.26	26.00	0.01	1.053	1.26	0.00
1.26	20.00	0.01	0.994	1.26	-0.00
1.27	30.00	0.01	1.098	1.27	0.01
1.28	12.00	0.01	0.924	1.28	0.00
1.29	6.00	0.00	0.871	1.29	0.00
1.29	2.00	0.00	0.834	1.29	-0.00
4.13	26.00	0.01	2.328	4.12	-0.01
4.13	20.00	0.01	2.137	4.12	-0.01
4.14	30.00	0.01	2.473	4.15	0.01
4.16	12.00	0.01	1.903	4.16	0.00
4.17	6.00	0.00	1.725	4.18	0.01
4.18	2.00	0.00	1.602	4.17	-0.01
6.69	30.00	0.01	3.696	6.71	0.02
6.71	26.00	0.01	3.479	6.70	-0.01
6.72	20.00	0.01	3.167	6.69	-0.02
6.82	12.00	0.01	2.810	6.83	0.01
6.90	2.00	0.00	2.328	6.89	-0.00
6.92	6.00	0.00	2.538	6.94	0.01

oxygen (ml/l) = (Soc * (V + Voffset)) * exp(Tcor * T) * Oxsat(T,S) * exp(Pcor * P)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU]
Oxsat(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



POST CRUISE CALIBRATION

9 plus

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: 04-Jan-08

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
```

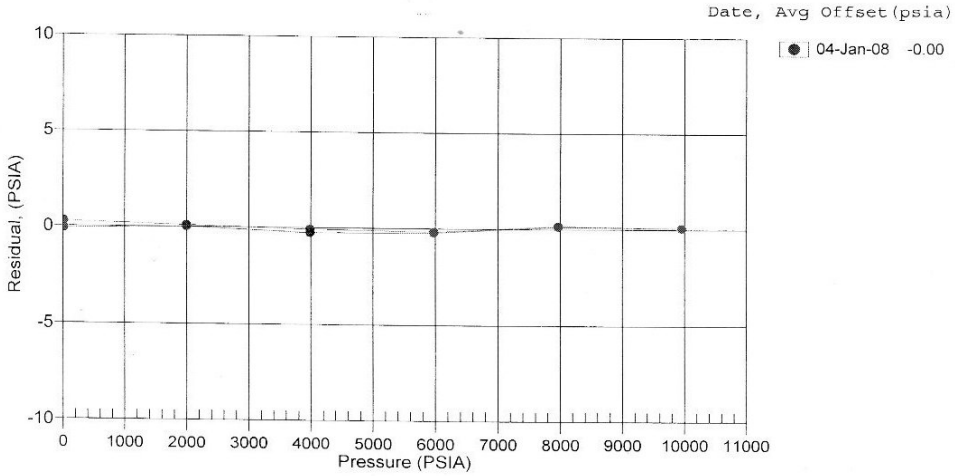
SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 89936

AD590M, AD590B, SLOPE AND OFFSET:

```
AD590M =   1.30208e-002
AD590B =  -9.65521e+000
Slope =    0.99994
Offset =  -0.1501 (dbars)
```

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.026	33002.40	18.4	14.518	14.301	0.275
2001.379	33681.90	18.5	2001.818	2001.482	0.103
3988.556	34345.90	18.6	3988.941	3988.486	-0.070
5975.687	34995.40	18.6	5976.105	5975.532	-0.155
7962.738	35631.30	18.7	7963.600	7962.908	0.170
9950.430	36254.30	18.7	9951.320	9950.509	0.079
7962.989	35631.40	18.8	7963.816	7963.124	0.135
5975.531	34995.40	18.8	5975.895	5975.322	-0.209
3988.414	34345.90	18.8	3988.618	3988.163	-0.251
2001.336	33682.00	18.9	2001.685	2001.348	0.012
14.039	33002.50	18.9	14.167	13.949	-0.090

Residual = corrected instrument pressure - reference pressure



9 plus

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: 04-Jan-08

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 89936

DIGIQUARTZ COEFFICIENTS:

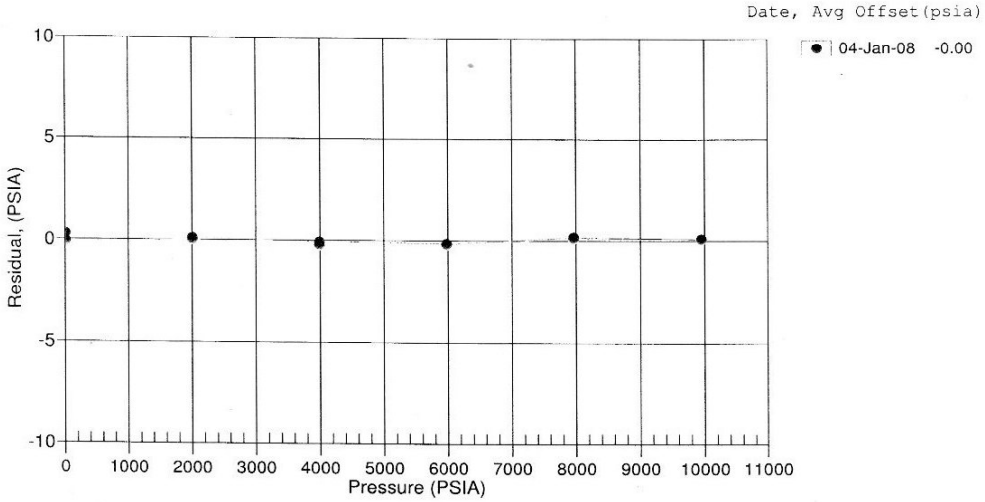
```
C1 =   -4.767972e+004
C2 =   -5.006157e-001
C3 =    1.084620e-002
D1 =    3.613800e-002
D2 =    0.000000e+000
T1 =    3.031386e+001
T2 =   -5.277072e-004
T3 =    3.790810e-006
T4 =    6.671000e-010
T5 =    0.000000e+000
```

AD590M, AD590B, SLOPE AND OFFSET:

```
AD590M =    1.30208e-002
AD590B =   -9.65521e+000
Slope =     0.99994
Offset =   -0.1501 (dbars)
```

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.026	33002.40	18.4	14.518	14.301	0.275
2001.379	33681.90	18.5	2001.818	2001.482	0.103
3988.556	34345.90	18.6	3988.941	3988.486	-0.070
5975.687	34995.40	18.6	5976.105	5975.532	-0.155
7962.738	35631.30	18.7	7963.600	7962.908	0.170
9950.430	36254.30	18.7	9951.320	9950.509	0.079
7962.989	35631.40	18.8	7963.816	7963.124	0.135
5975.531	34995.40	18.8	5975.895	5975.322	-0.209
3988.414	34345.90	18.8	3988.618	3988.163	-0.251
2001.336	33682.00	18.9	2001.685	2001.348	0.012
14.039	33002.50	18.9	14.167	13.949	-0.090

Residual = corrected instrument pressure - reference pressure



Cond 9 plus

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: 2767
CALIBRATION DATE: 11-Dec-07

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -1.01789718e+001
h =  1.55532259e+000
i = -1.42989554e-003
j =  1.97476002e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  3.73572652e-006
b =  1.55200875e+000
c = -1.01734483e+001
d = -8.87480306e-005
m =  5.4
CPcor = -9.5700e-008 (nominal)
```

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.56019	0.00000	0.00000
-0.9286	34.9512	2.82050	4.97135	2.82048	-0.00002
1.0911	34.9511	2.99431	5.08259	2.99432	0.00001
15.0000	34.9502	4.28630	5.84298	4.28633	0.00003
18.5000	34.9491	4.63408	6.03117	4.63407	-0.00001
29.0001	34.9436	5.72083	6.58436	5.72077	-0.00006
32.5000	34.9329	6.09402	6.76383	6.09406	0.00004

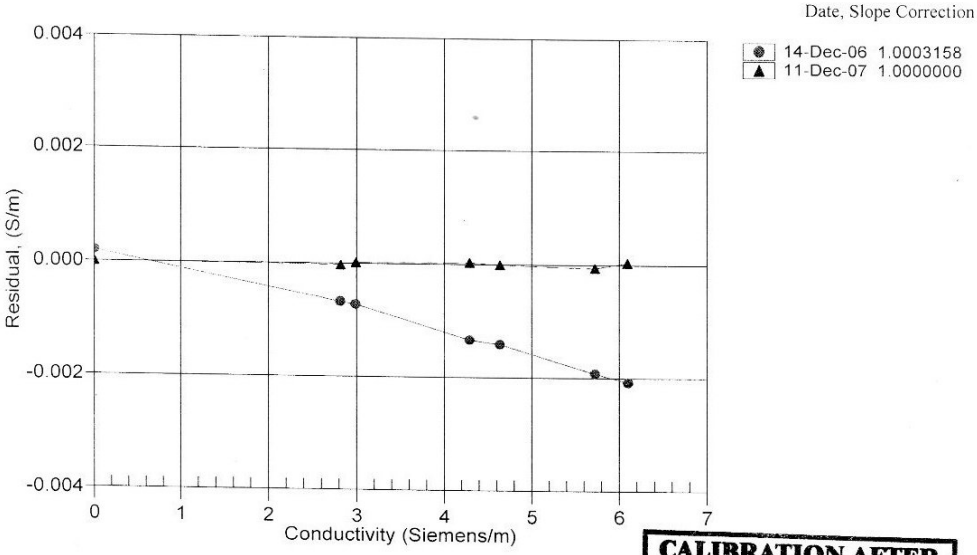
Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

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

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

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

Date, Slope Correction



CALIBRATION AFTER CLEANING AND REPLATINIZING CELL

temp 9 plus

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: 4175
CALIBRATION DATE: 19-Dec-07

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.39923478e-003
h = 6.44698489e-004
i = 2.31336267e-005
j = 2.12402573e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121278e-003
b = 5.99853858e-004
c = 1.57906768e-005
d = 2.12553153e-006
f0 = 3179.258

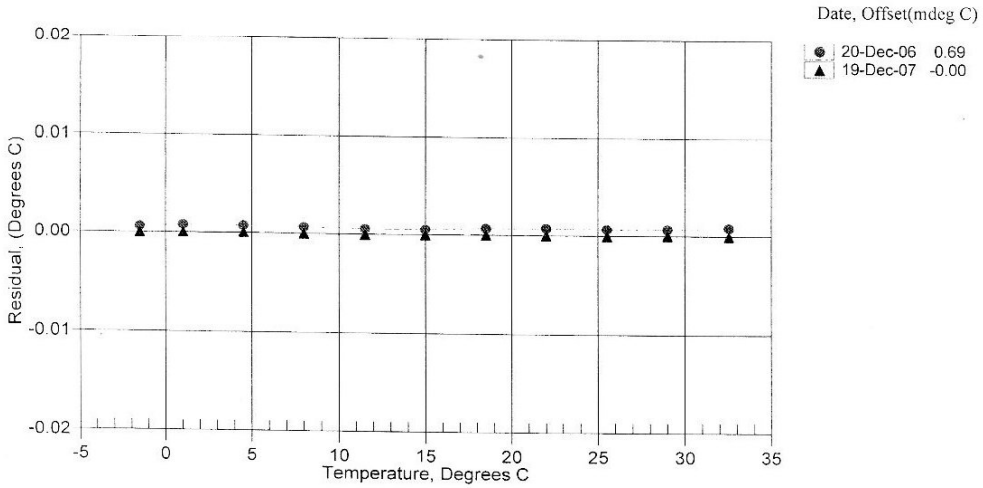
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	3179.258	-1.5000	-0.00003
1.0000	3362.576	1.0000	0.00003
4.5000	3631.900	4.5000	0.00005
8.0000	3916.397	8.0000	-0.00001
11.5000	4216.483	11.4999	-0.00006
15.0000	4532.566	15.0000	-0.00002
18.5000	4865.026	18.5000	0.00004
22.0000	5214.226	22.0000	0.00000
25.5000	5580.539	25.5000	-0.00001
29.0000	5964.315	29.0000	0.00002
32.5000	6365.873	32.5000	-0.00002

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

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

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

Residual = instrument temperature - bath temperature



19 plus

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: 0523
CALIBRATION DATE: 26-Nov-07

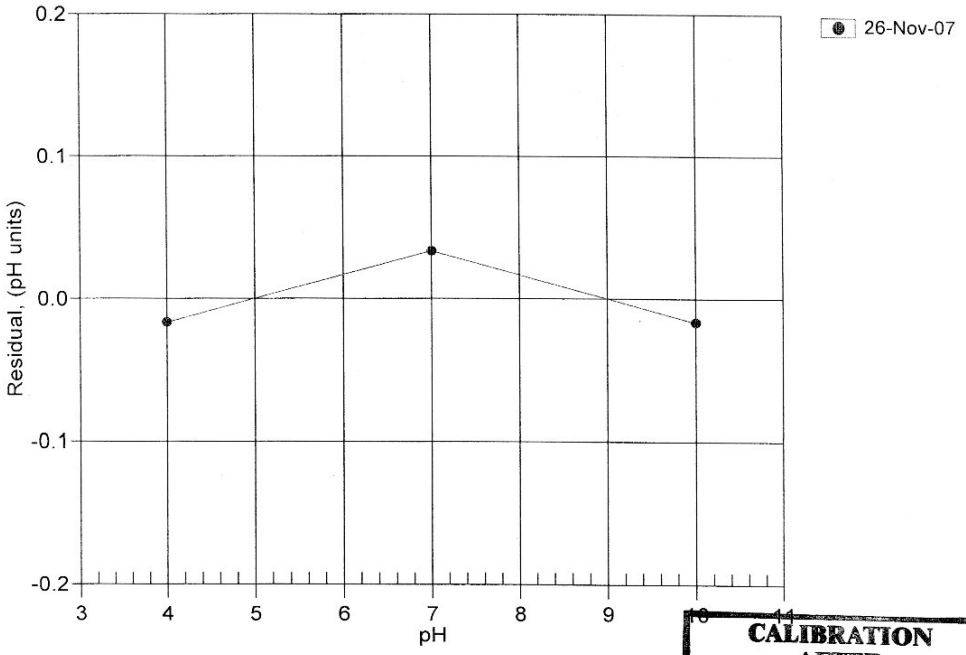
SBE18 pH CALIBRATION DATA

pH COEFFICIENTS
pHslope = 4.4730
pHoffset = 2.5383

pH	Temperature (deg C)	Vout	Instrument Output (pH units)	Residual (pH units)
4.0	18.3	1.758	3.983	-0.017
7.0	18.3	2.547	7.034	0.034
10.0	18.3	3.310	9.983	-0.017

pH = 7.0 + (Vout - pHoffset) / (pHslope * °K * 1.98416E-4)

Where:
Vout = pH sensor output in volts
K is the water temperature in degrees Kelvin
Residual = instrument pH - buffer pH



CALIBRATION AFTER MODIFICATIONS

19 plus

SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 1448
CALIBRATION DATE: 05-Dec-07

SBE19 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.21859833e-003
h =  5.94566895e-004
i =  1.97276377e-006
j = -2.34531644e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.64763691e-003
b =  5.84312197e-004
c =  8.80080831e-006
d = -2.34498332e-006
f0 = 2629.941
```

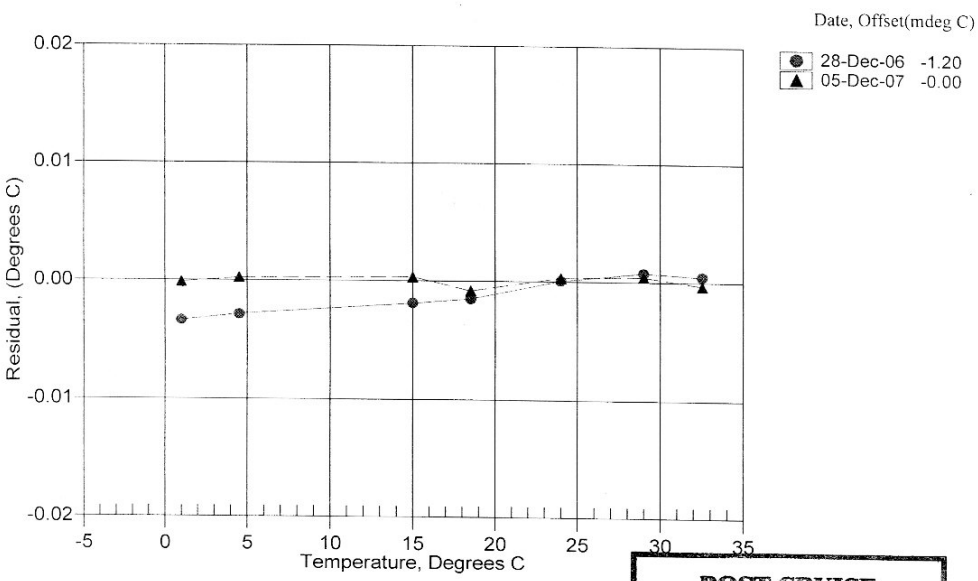
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2629.941	0.9999	-0.00015
4.5000	2845.609	4.5002	0.00023
14.9999	3567.463	15.0002	0.00033
18.5000	3834.220	18.4992	-0.00084
24.0000	4281.528	24.0003	0.00032
29.0000	4718.757	29.0004	0.00044
32.5000	5042.715	32.4997	-0.00032

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

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

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

Residual = instrument temperature - bath temperature



POST CRUISE CALIBRATION

19 plus

SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 1448
CALIBRATION DATE: 05-Dec-07

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

GHIJ COEFFICIENTS

```
g = -4.06447827e+000
h =  4.84119504e-001
i =  1.55732281e-003
j = -4.85211340e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.86544061e-002
b =  4.33492000e-001
c = -4.05843410e+000
d = -1.74539613e-004
m =  2.1
CPcor = -9.5700e-008 (nominal)
```

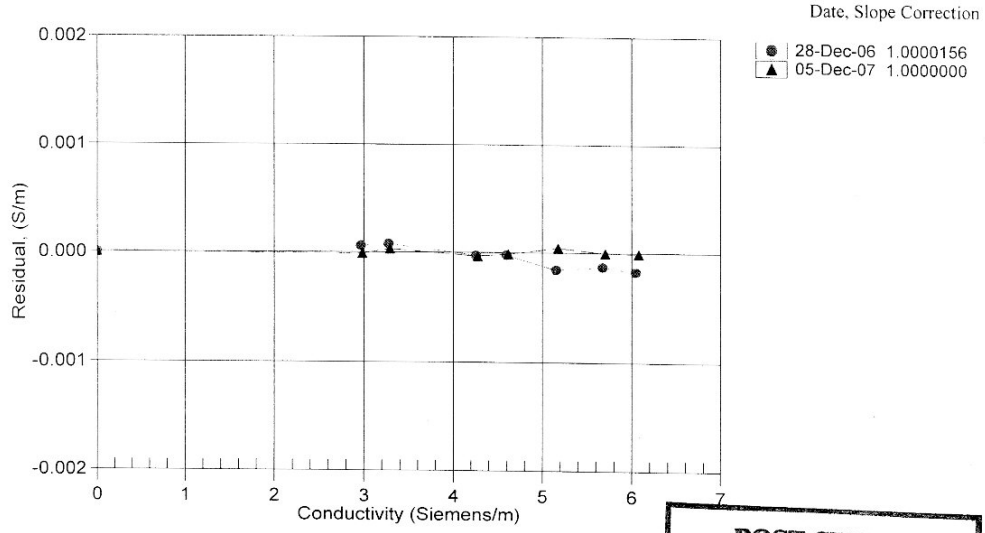
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88536	0.00000	0.00000
1.0000	34.8907	2.98172	8.28428	2.98171	-0.00001
4.5000	34.8715	3.28942	8.65001	3.28945	0.00003
14.9999	34.8277	4.27285	9.72609	4.27282	-0.00003
18.5000	34.8182	4.61859	10.07694	4.61858	-0.00001
24.0000	34.8076	5.17747	10.61948	5.17752	0.00004
29.0000	34.8009	5.70008	11.10262	5.70008	-0.00000
32.5000	34.7946	6.07263	11.43457	6.07262	-0.00001

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

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

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

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



POST CRUISE CALIBRATION

19 plus

SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 1448
CALIBRATION DATE: 06-Dec-07

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

QUADRATIC COEFFICIENTS:

PA0 = 1.478825e+002
PA1 = -3.897866e-002
PA2 = 3.130657e-008

STRAIGHT LINE FIT:

M = -3.897662e-002
B = 1.480594e+002

PRESSURE PSIA	INST OUTPUT(N)	COMPUTED PSIA	ERROR %FS	LINEAR PSIA	ERROR %FS
14.55	3431.0	14.52	-0.01	14.33	-0.07
59.86	2267.0	59.68	-0.06	59.70	-0.05
119.84	725.0	119.64	-0.07	119.80	-0.01
179.84	-818.0	179.79	-0.02	179.94	0.03
239.84	-2353.0	239.77	-0.02	239.77	-0.02
299.84	-3885.0	299.79	-0.02	299.48	-0.12
239.83	-2357.0	239.93	0.03	239.93	0.03
179.81	-824.0	180.02	0.07	180.18	0.12
119.85	718.0	119.91	0.02	120.07	0.08
59.86	2260.0	59.95	0.03	59.97	0.04
14.55	3427.0	14.67	0.04	14.49	-0.02

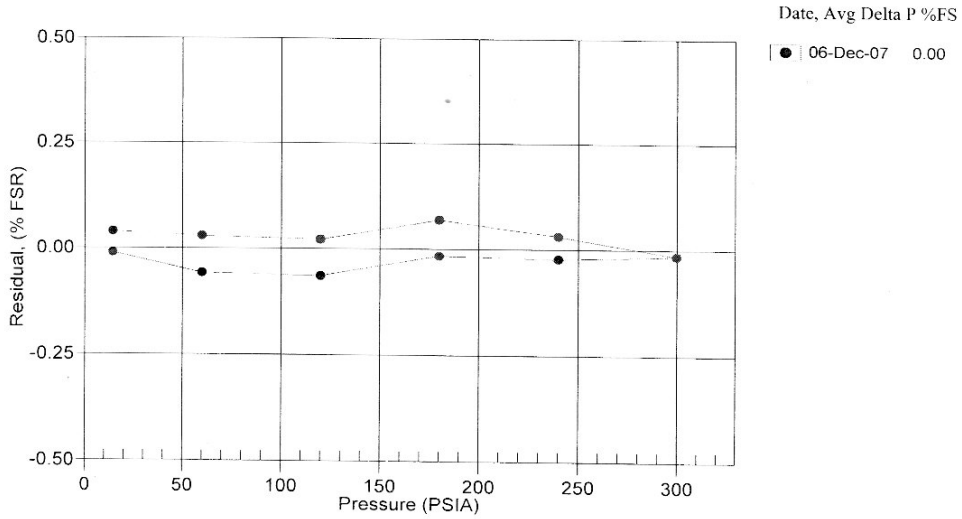
Straight Line Fit:

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



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: 1.490
Roll Offset: 0.040
Azimuth Offset: 0.500

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer:
Model: em1002
Serial Number:

Depth Sensor:

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

Transduer #1:

Pitch Offset: 0.140
Roll Offset: -0.080
Azimuth Offset: -0.400

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer:
Model: em1002
Serial Number:

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

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

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.000 Pitch:0.000 Roll:0.000
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 2.000
Transducer timing error: 0.000
Navigation timing error: 0.000
Gyro timing error: 0.010
Heave timing error: 0.010
PitchTimingStdDev: 0.010
Roll timing error: 0.010
Sound Velocity speed measurement error: 0.600
Surface sound speed measurement error: 0.500

Tide measurement error: 0.010
Tide zoning error: 0.100
Speed over ground measurement error: 0.250
Dynamic loading measurement error: 0.000
Static draft measurement error: 0.030
Delta draft measurement error: 0.000
StDev Comment: 0>„J †J@3†Jp4†J 1†J0 …J .†J0^„J`}€J° †Ja

Svp Sensor:

Time Stamp: 2006-064 00:00

Comments (null)
Svp #1:

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

DeltaX: 1.856
DeltaY: 0.811
DeltaZ: 1.676

SVP #2:

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

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Time Stamp: 2007-044 00:00

Comments (null)
Svp #1:

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

DeltaX: 1.856
DeltaY: 0.811
DeltaZ: 1.676

SVP #2:

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

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Time Stamp: 2008-051 00:00

Comments (null)
Svp #1:

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

DeltaX: 1.856
DeltaY: 0.811
DeltaZ: 1.676

SVP #2:

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

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

WaterLine:

Time Stamp: 2006-064 00:00

Comments
Apply No
WaterLine 0.000

Time Stamp: 2008-056 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-057 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-058 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-059 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-060 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-061 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-062 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-063 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-064 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-065 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-066 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-067 00:00

Comments
Apply Yes
WaterLine -0.015

Time Stamp: 2008-068 00:00

Comments
Apply Yes
WaterLine -0.015

Total Propagated Error (TPE) Report

NOAA Ship NANCY FOSTER 2006

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

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

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

Detailed Discussion of Error Estimates

Heave % Amplitude

Error: 5.0

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

Discussion: See *Heave* discussion below.

Heave

Error: 0.05

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

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

Gyro

Error: 0.02

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

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

Roll

Error: 0.02

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

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

Pitch

Error: 0.02

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

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

Navigation

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

Timing Transducer

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

Navigation Timing

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

Gyro Timing

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

Heave Timing

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

Pitch Timing

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

Roll Timing

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

Sound Velocity Measured

Error: 0.05

Definition: *Sound Velocity Measured* is the standard deviation of the measurement of sound velocity readings in meters/second.

Discussion: *Sound Velocity Measured* is based on SEACAT manufacturer specifications.

Surface

Error: 0.05

Definition: *Surface* is the standard deviation of the measurement of surface sound speed readings in meters/second.

Discussion: This value is currently being researched. In the meantime, NOAA Ship NANCY FOSTER will use 0.05, which is what NOAA Ship THOMAS JEFFERSON used for its Simrad SSVS.

Tide Measured

Error: 0.05

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

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

Tide Zoning

Error: 0.3

Definition: *Tide Zoning* is the standard deviation of the tide values associated with zoning in meters.

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

Offset X

Error: 0.02

Definition: *Offset X* is the standard deviation of the measured X offsets of the vessel.

Discussion: *Offset X* is the accuracy limit of whatever survey method was used to survey the vessel.

Offset Y

Error: 0.02

Definition: *Offset Y* is the standard deviation of the measured X offsets of the vessel.

Discussion: *Offset Y* is the accuracy limit of whatever survey method was used to survey the vessel.

Offset Z

Error: 0.02

Definition: *Offset Z* is the standard deviation of the measured X offsets of the vessel.

Discussion: *Offset Z* is the accuracy limit of whatever survey method was used to survey the vessel.

Vessel Speed

Error: 0.25

Definition: *Vessel Speed* is the standard deviation for the vessel speed measurements in meters/second.

Discussion: *Vessel Speed* requires further research. In the meantime, NANCY FOSTER is using what THOMAS JEFERSON

Loading

Error: 0

Definition: *Loading* is the measurement standard deviation of the vertical changes during the survey because of fuel consumption, etc. *Loading* corresponds to the Caris waterline measurement error.

Discussion: *Loading* is not currently used. Further investigation is required.

Draft

Error: 0.03

Definition: *Draft* is the standard deviation of the vessel draft measurements in meters.

Discussion: *Draft* is the accuracy limit of the draft measuring method.

Delta Draft

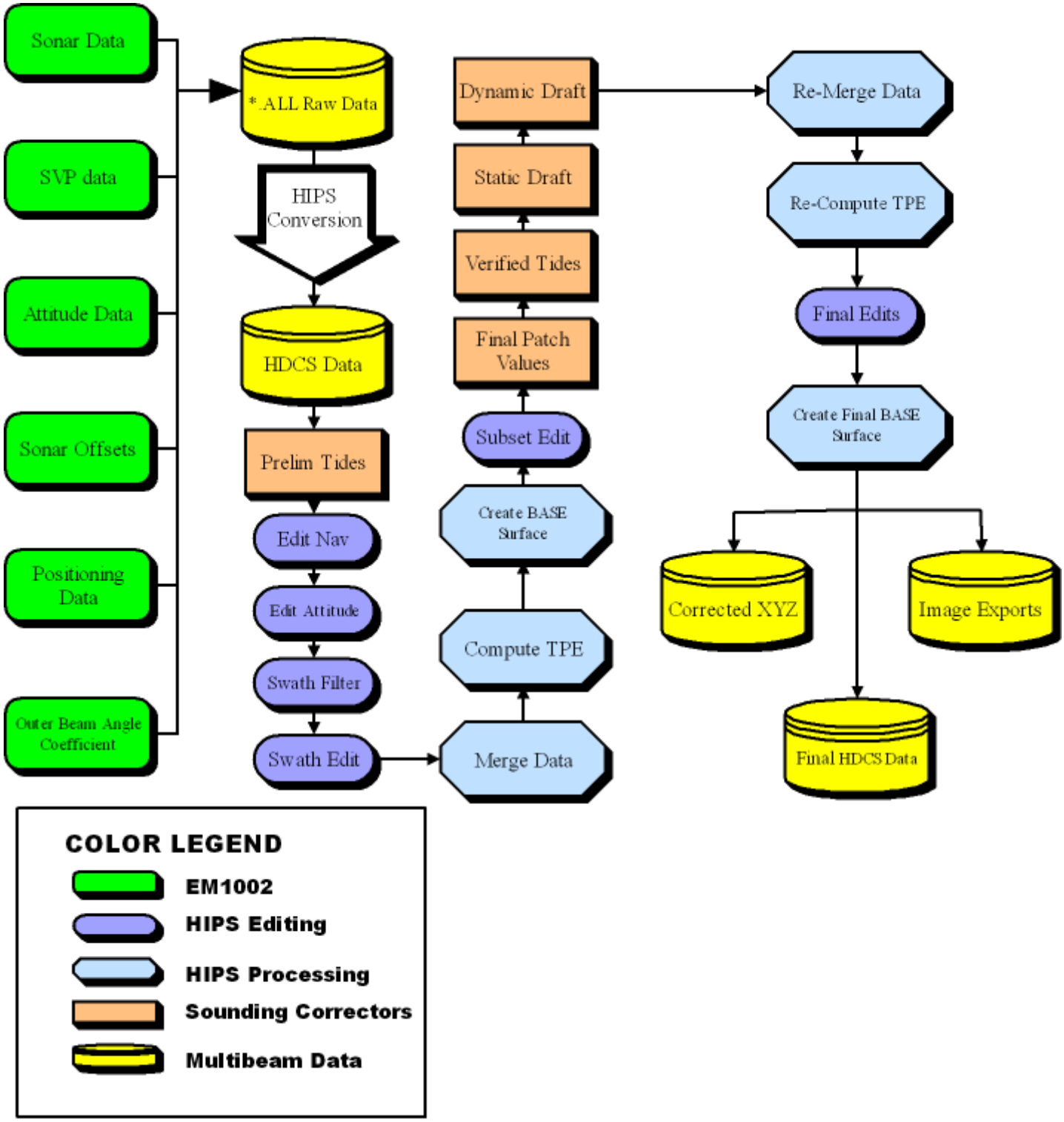
Error: 0

Definition: *Delta Draft* is the standard deviation of the dynamic vessel draft measurements in meters.

Discussion: *Delta Draft* is not currently used. Further investigation is required.

APPENDIX F:

CARIS Processing Flow Chart


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

APPENDIX G:

NOAA Ship NANCY FOSTER Static Offset 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

SERIAL NO. 00656.001.02-03

INSPECTION/DEFICIENCY REPORT

JOB ORDER NO.

VESSEL NAME: NOAA SHIP NANCY FOSTER

DATE SUBMITTED: 7-Feb-06

WORK ITEM NO: 501

PARAGRAPH: para. 7.5

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

TITLE OF WORK ITEM: SURVEY

TYPE OF REPORT

NOTICE [ ] IDR/CFR [X] REQ REPORT [ ] PCP [ ] INFO ONLY [ ] OTHER

BALANCE REPORT

[ ] PRINTS/DWG [ ] CFM/CFE [ ] GFM/GFE [ ] CONFLICTING PRINTS/DWGS SUPPLIED

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

incorrect: [ ] SPECIFICATIONS [ ] COMPARTMENT [ ] LOCATION REFERENCED SYSTEM:

PROBLEM/CONDITION:

Contractor accomplished Alignment Survey.
See attached results.

RECOMMEND: [ ] ISSUE A CHANGE ORDER [X] ACCEPT REQUIRED REPORT [ ] ACCEPT PCP [ ] ACCEPT INFO [X] 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

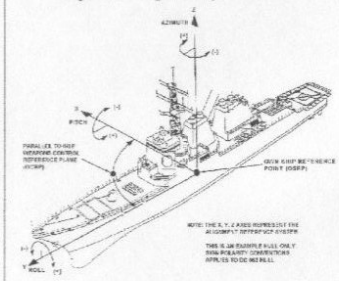
Bow Down = Positive

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

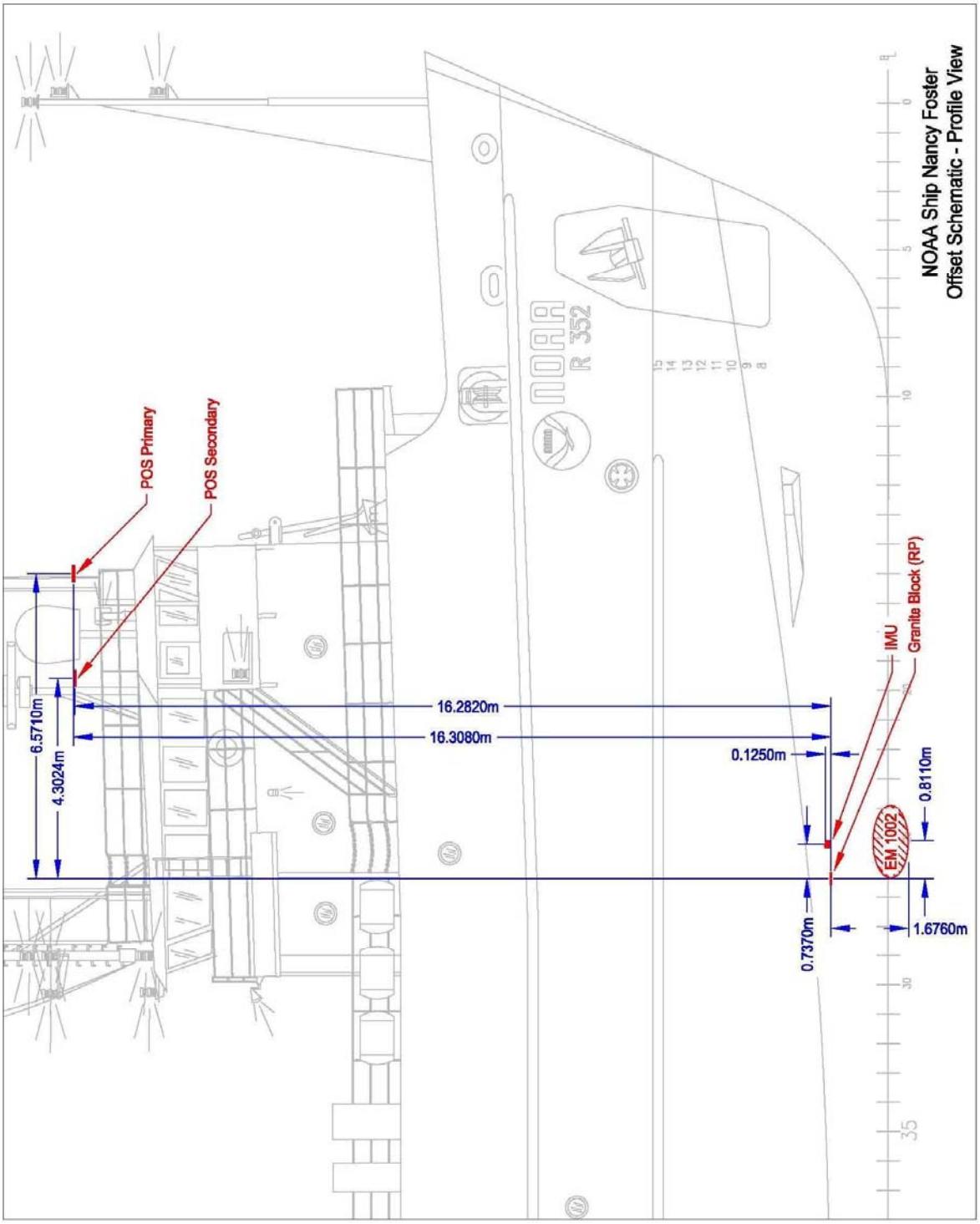
Z dimension readings lower than Granite Block = positive, higher than Granite Block =negative

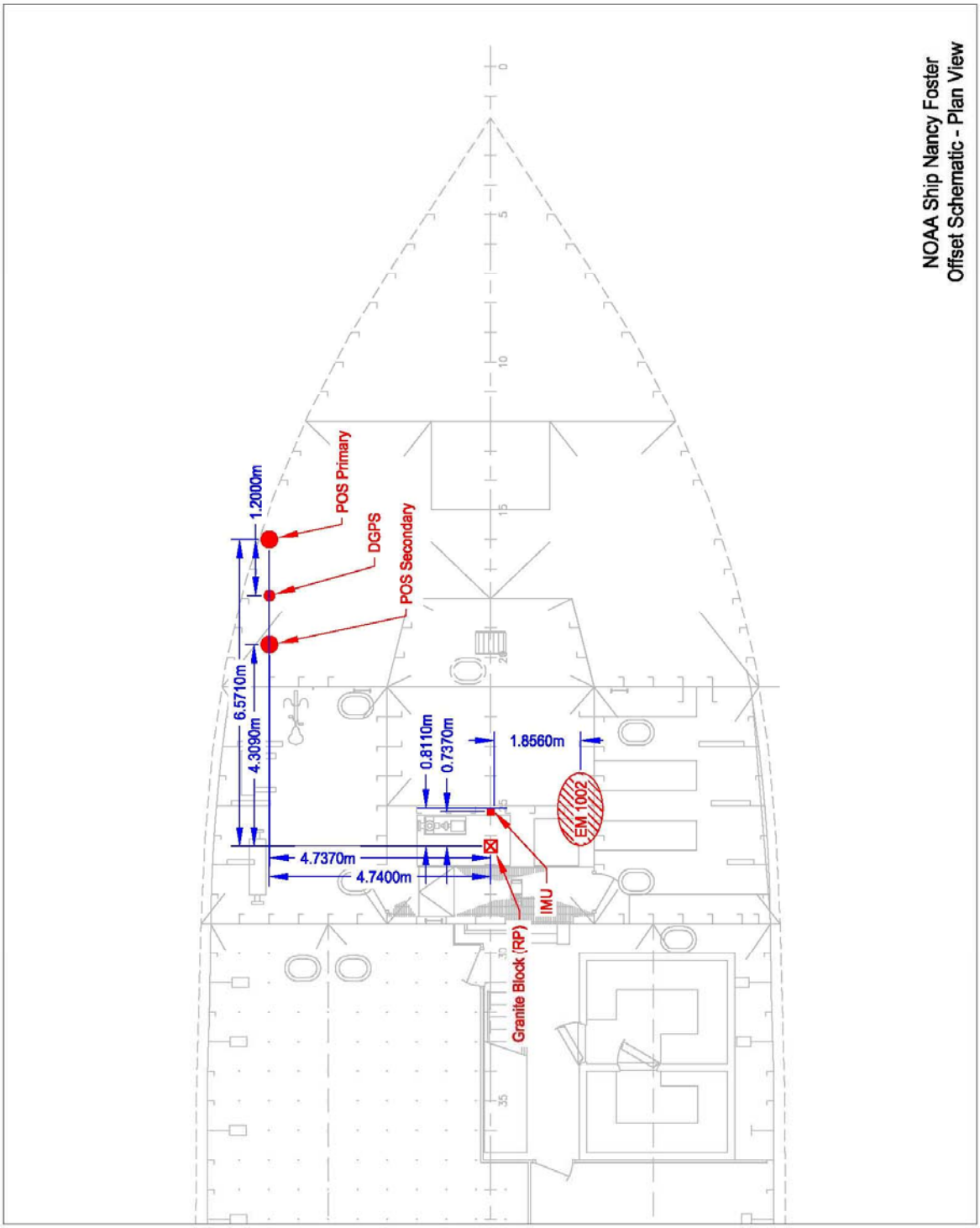
Figure 3-53. Sign Polarity Convention



APPENDIX H:

NOAA Ship NANCY FOSTER Offset Diagram


NOAA Ship Nancy Foster
Offset Schematic - Profile View
POS Primary
POS Secondary
6.5710m
4.3024m
16.2820m
16.3080m
0.1250m
0.7370m
IMU
Granite Block (RP)
EM 1002
0.8110m
1.6760m
NOAA
R 352


NOAA Ship Nancy Foster
Offset Schematic - Plan View
POS Primary
DGPS
POS Secondary
1.2000m
6.5710m
4.3090m
0.8110m
0.7370m
1.8560m
EM 1002
4.7370m
4.7400m
IMU
Granite Block (RP)

APPENDIX I:

Multibeam Calibration Procedures & Patch Test Report

Calibration Date: March 1 & 2, 2008

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

Calibration type:

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

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

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

Pre-calibration Survey Information

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

Vessel reference frame defined with respect to:

[ ] IMU [X] Reference Position

Reference to IMU Lever Arm

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

IMU frame w.r.t vessel reference frame

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

Reference to Sensor Lever Arm

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

[X] Measurements verified for this calibration.

Reference Centerline Survey report
[X] Drawing and table attached.

[X] Drawing and table included with project report/DAPR: ~~NF-08-04-USVI~~ DAPR ***M-I905-NF-08***

Position/Motion Sensor Calibration (for POS/MV model 320 M4)
Calibration date: Feb 7, 2006

Reference to primary GPS Lever Arm

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

Heave Settings: Bandwidth 18.00 Damping Period .707

Reference to Center of Rotation Lever Arm

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

Firmware version 3.22 was used for the entire survey.

Static Draft Survey
(Vessel waterline with respect to RP)

Survey date: FEB 24, 2008

Prior to conducting the patch test and survey, initial confidence checks were performed to ensure an accurate measurement of water depths. While the Nancy Foster was tied up at Pier 1 in San Juan, Puerto Rico the survey team initially observed the static draft of the starboard PROJ draft marks at +/-3.75m(12.3ft.). 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 - 3.75m = -2.07

Static Draft Correction -2.07 (meters)

Dynamic Draft Survey

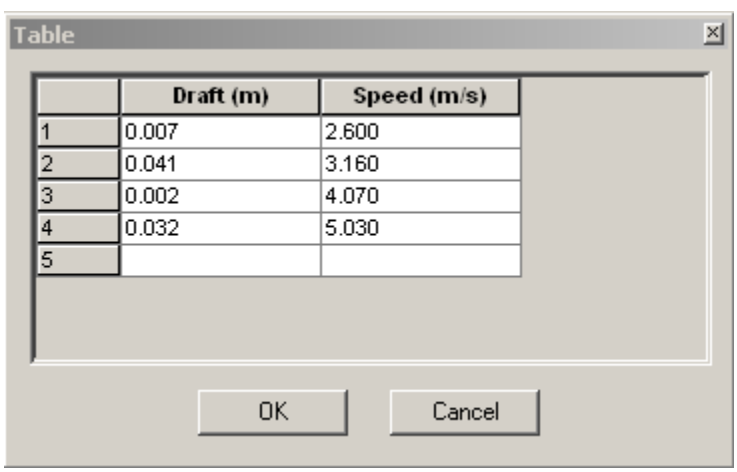
(Vessel waterline with respect to vessel reference frame and vessel speed)

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

Tabular Summery of Dynamic Draft Results

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

Dynamic Draft Table, R352_MB.hvf



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		

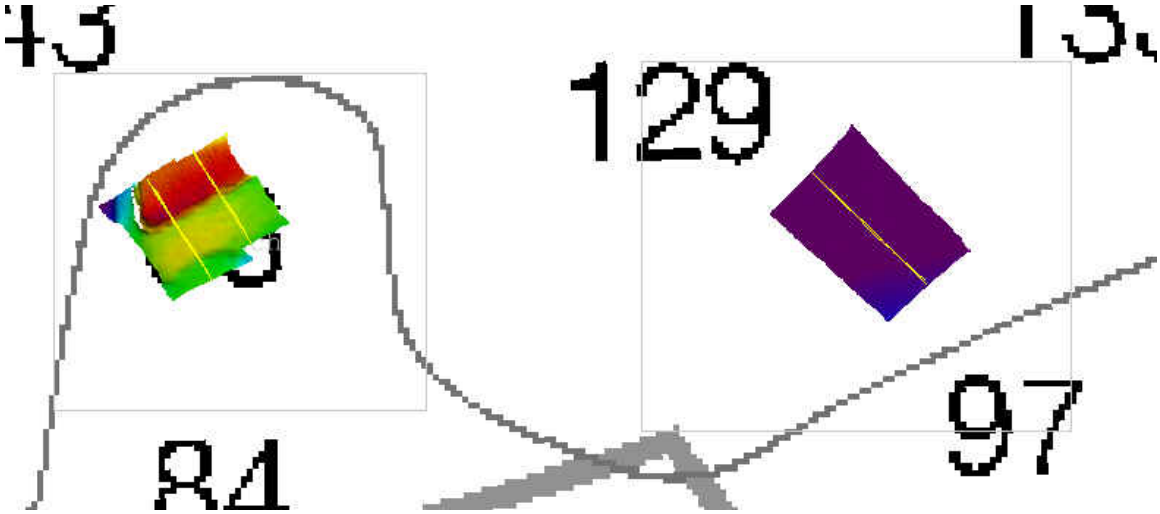
OK Cancel

Calibration Survey Information

An annual patch test was performed during the ~~NF-08-04-USVI~~ ***M-I905-NF-08*** cruise. Biases were estimated by running a series of calibration lines, as described in the NOS Hydrographic Specifications and Deliverables, 2008 Edition (HSSD). The patch test calibration quantified residual biases between the POS/MV V4's Inertial Measurement Unit and the EM1002 multibeam transducer alignment. The patch test also identified time latency within the positioning and acquisition system. All values in Merlin and in the CARIS vessel configuration file were changed to zero before the patch test was collected.

An area offshore of western Puerto Rico 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 five lines were surveyed. Vessel speeds were consistent for the pitch and yaw transects at approximately 5 knots. Vessel speeds were increased to approximately 8 knots for the second latency line of the patch test.

A relatively flat area approximately 4km to the west was chosen for the roll calibration. One planned survey line was collected in reciprocal directions at approximately 5 knots.



The hydrographer performed the biases calculations in the order described in the HSSD using CARIS HIPS's calibration tool. The patch test results were proven with seafloor alignment from opposing swaths throughout the data set. The CARIS vessel configuration file R352_MB.hvf was updated with the values obtained from the patch test and used for the duration of the ~~NF-08-04-USVI~~ ***M-I905-NF-08*** cruise and for post-processing.

Calibration Lines

Line	Direction	Speed	Bias Measured
0093_20080301_221418_raw	**SE**	**5**	**P1,Y1**
0094_20080301_223056_raw	**NW**	**5**	**P2,L1**
0095_20080301_225247_raw	**NW**	**8**	**L2**
0096_20080301_230414_raw	**SE**	**5**	**P3,Y2**
0097_20080301_231911_raw	**NW**	**5**	**P4**
0100_20080302_005518_raw	**SE**	**5**	**R1**
0100_20080302_005518_raw	**NW**	**5**	**R2**

Sound Velocity Correction

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

Sound Velocity Measurements

Cast	Time	Depth(m)	LAT	LONG
NF0804_JD61_3	21:44	329	18:12N	67.26W

Tide Correction

Predicted tides applied.

Approximate distance of gauge from calibration site: Variable

Water level corrections applied:

[X] Predicted [ ] Verified

[ ] Preliminary

[X] Zoned

Data Acquisition and Processing Guidelines

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

Navigation Timing Error (NTE)

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

Transducer Pitch Offset (TPO)

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

Transducer Roll Offset (TRO)

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

Transducer Azimuth Offset (TAO or yaw)

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

Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
Mike Stecher	0.0	0.14	-0.4	-0.08

Corrections calculated in: CARIS HIPS

[X] Caris [ ] ISIS

[ ] Other _____

Caris Vessel Configuration File

Name**:** R352_MB.hvf

Version: 6.1 SP 2

New ☐ Appended values with time tag X

Evaluator: Mike Stecher, Lead Hydrographer

APPENDIX J:

CO-OPS Tide Requirements, Tide Note and Correspondence

WATER LEVEL INSTRUCTIONS
M-I905-NF-2008 Virgin Island and Puerto Rico
(01/22/2008 LH)

1.0. TIDES AND WATER LEVELS

1.1. Specifications

Tidal data acquisition, data processing, tidal datum computation and final tidal zoning shall be performed utilizing sound engineering and oceanographic practices as specified in National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables (HSSD),dated June 2006, and OCS Field Procedures Manual (FPM), dated May 2006. Specifically reference Chapter 4 of the HSSD and Sections 1.5.8, 1.5.9, 2.4.5, and 3.4.2 of the FPM.

1.2. Vertical Datums

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

The operatin g National Water Level Observati on Network (NWLON) stations at Magu eyes Island (9759110) and Charlotte Amalie (9751639) will serve as datum control for the survey area including det ermination at each subordinate station. Therefore, it is critical that these stations remain in operation during all periods of hydrography.

1.2.1. Water Level Data Acquisition Monitoring

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

1.2.2. NWLON Water Level Station Operation and Maintenance

The operating water level stations at Magueyes Island (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695) will also provide water level reducers for this project, reiterating the importance of their operation during all periods of hydrography. See Sections 1.1. and 1.2. concerning responsibilities.

No leveling is required by NOAA's Nancy Foster personnel.

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

1.3. Tide Reducer Stations

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

Tide Component Error Estimation

The estimated tidal error contribution to the total survey error budget in the vicinity of Virgin Island and Puerto Rico is 0.35 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, no subordinate stations will be required at survey areas. It should be noted that the tidal error component can be significantly greater than stated if a substantial meteorological event or condition should occur during time of hydrography.

1.3.2. GOES Satellite Enabled Subordinate Stations

This section is not applicable for this project.

1.3.3. Benchmark Recovery and GPS Requirements

This section is not applicable for this project.

1.3.4. This section is not applicable for this project.

1.4. Discrete Tidal Zoning

1.4.1. The water level station at Magueyes Island (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695) are the reference stations for preliminary tides for hydrography in Virgin Island and Puerto Rico. The time and height correctors listed below for applicable zones should be applied to the preliminary data at Magueyes Island (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695) during the acquisition and preliminary processing phases of this project. Preliminary data may be retrieved in one month increments over the Internet from the CO-OPS Home Page at http://tidesandcurrents.noaa.gov/olddata and then clicking on "Preliminary Water Level". The Commanding Officer must notify CO-OPS/RDD personnel immediately of any problems concerning the preliminary tides. Preliminary data are six-minute time series data relative to MLLW in metric units on Greenwich Mean Time. For the time corrections, a negative (-) time correction indicates that the time of tide in that zone is earlier than (before) the preliminary tides at the reference station. A positive (+) time correction indicates that the time of tide in that zone is later than (after) the predicted tides at the reference station. For height corrections, the water level heights **relative to MLLW** at the reference station are multiplied by the range ratio to estimate the water level heights relative to MLLW in the applicable zone.

Zone	Time Corrector(mins)	Range Ratio	Predicted Reference Station
PR1	-24	x1.9	6 9759 110
PR2	-30	x1.9	6 9759 110
PR3	-24	x1.8	8 9759 110
PR4	-30	x1.8	8 9759 110
PR5	-24	x1.8	1 9759 110
PR6	-30	x1.8	1 9759 110
PR7	-24	x1.6	7 9759 110
PR8	-30	x1.6	7 9759 110
PR9	-24	x1.5	2 9759 110
PR10	-30	x1.5	2 9759 110
PR11	-24	x1.3	0 9759 110
PR12	-24	x1.3	0 9759 110
PR13	-18	x1.0	9 9759 110
PR14	-18	x1.0	9 9759 110
PR16	-12	x1.0	1 9759 110
PR18	-6	x0.9	4 9759 110
PR20	0	x1.0	0 9759 110
PR21	+6	x0.9	4 9759 110
PR24	+6	x0.9	2 9759 938
PR25	0	x1.0	0 9759 938
PR26	-6	x1.1	8 9759 938
PR27	0	x1.3	8 9759 938
SA500	0	x1.0	0 9759 412

SA501	+18	x1.0	8	9759	412
SA503	+6	x1.0	8	9759	412
VIR2	-12	x0.9	6	9752	235
VIR3	-12	x0.8	8	9752	235
VIR4	-6	x0.7	5	9752	235
VIR5	0	x1.0	8	9752	695
VIR6	0	x1.0	0	9752	695

1.4.2. Polygon nodes and water level corrections referencing Magueyes Island (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695) are provided in CARIS® format denoted by a *.zdf extension file name.

NOTE: The tide corrector values referenced to Magueyes Island (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695) are provided in the zoning file "I905NF2008CORP" for this project and are in the fourth set of correctors designated as TS4. Longitude and latitude coordinates are in decimal degrees. Negative (-) longitude is a MapInfo® representation of West longitude

"Preliminary" data for the control water level station, Magueyes Island (9759110), Mona Island (9759938), Aguadilla (9759412), Culebra (9752235) and Vieques (9752695), are available in near real-time and verified data will be available on a weekly basis for the previous week. These water level data may be obtained from the CO-OPS web site at http://tidesandcurrents.noaa.gov/olddata . From this site, click on either "Preliminary Water Level" or "Verified Water Level" to obtain preliminary or verified/historical water level data as appropriate.

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

1.4.3 Zoning Diagram(s)

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

1.4.4 Final Zoning

Upon completion of project M-I905-NF-2008, submit a Pydro generated request for smooth tides, with times of hydrography abstract and mid/mif tracklines attached. Forward this request to smooth.tides@noaa.gov . Provide the project number, as well as a sheet number, in the subject line of the email.
CO-OPS will review the times of hydrography, final tracklines, and six-minute water level data from all applicable water level gauges. After review, CO-OPS will send a notice indicating that the tidal zoning scheme sent with the project instructions has been approved for final zoning. If there are any discrepancies, CO-OPS will make the appropriate adjustments and forward a revised tidal zoning scheme to the field group and processing branch for final processing.

1.5 TideBot

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

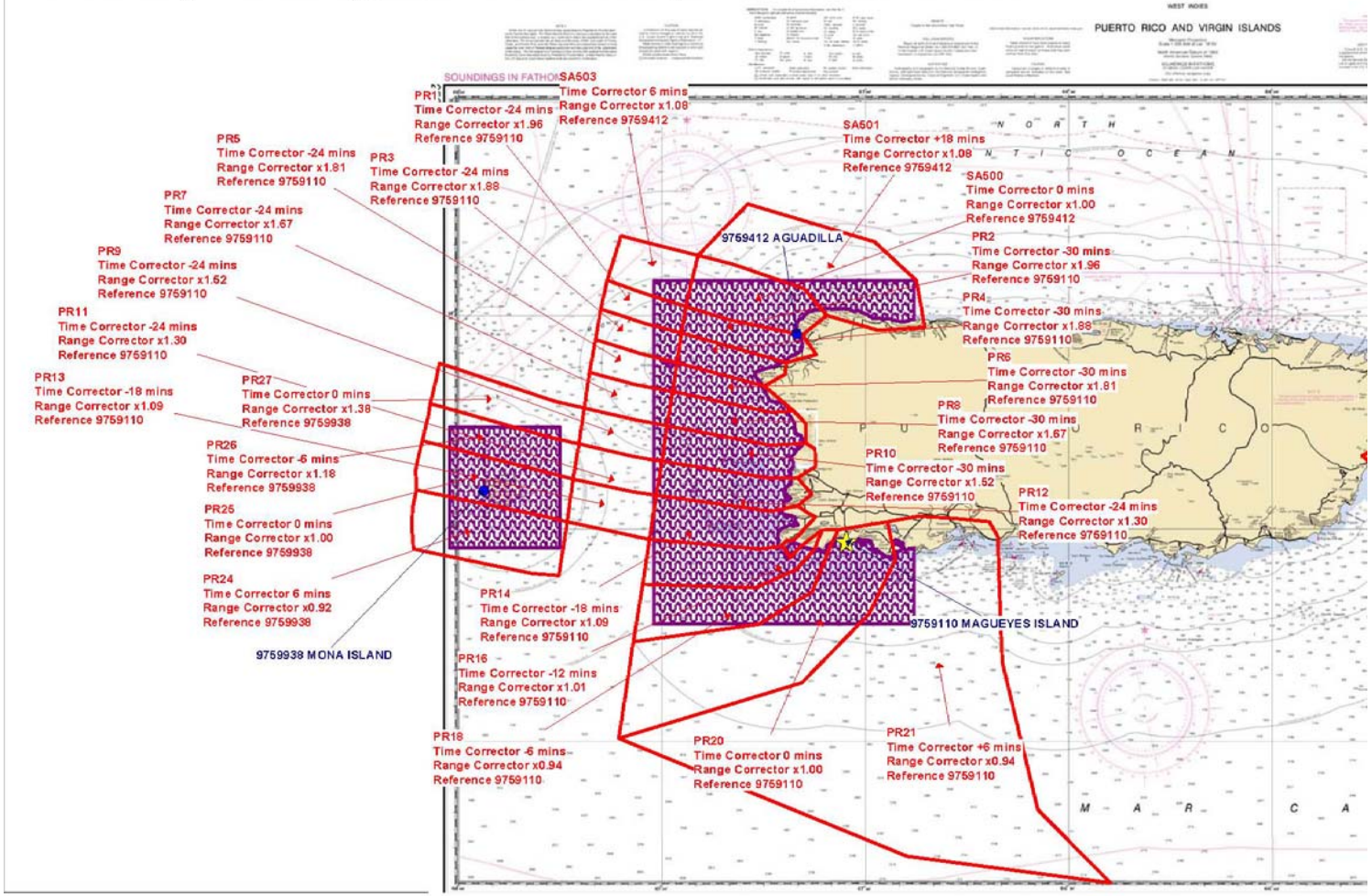
1.6 Water Level Records

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

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

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

Preliminary Tidal Zoning for M-I905-NF-2008 Virgina Island and Puerto Rico



May 12, 2008

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

FROM: Mike Stecher, Hydrographer, CCMA Biogeography Team
SUBJECT: Request for Approved Tides/Water Levels

Please provide the following data:

1. Tide Note
2. Final zoning in Mapinfo, MIX and CARIS format
3. Six minute water level data

Transmit Data to the Following:

Mike Stecher
8835 N. Edison St.
Portland, OR
97203
mike@solmarhydro.com

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

Project No.: M-I905-NF-08

Registry No.: H11808 and H11809

State: Florida

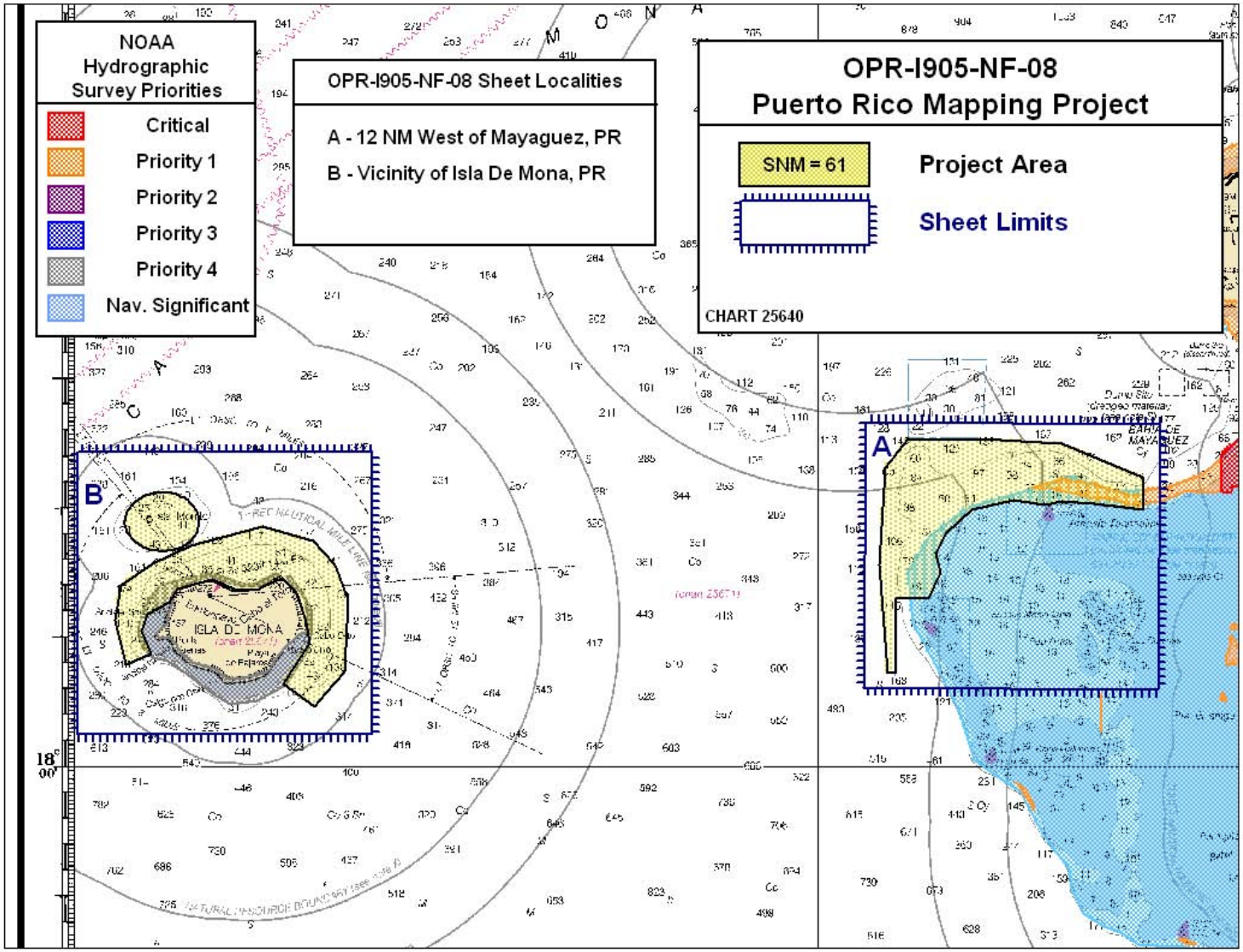
Locality: Key West

Sublocality: 12 NM West of Mayaguez, PR and the Vicinity of Isla De Mona, PR

Times of Hydrography: DN 055 – DN 068 2008

Attachments containing:

1. Trackline Shape Files


NOAA
Hydrographic
Survey Priorities
Critical
Priority 1
Priority 2
Priority 3
Priority 4
Nav. Significant
OPR-I905-NF-08 Sheet Localities
A - 12 NM West of Mayaguez, PR
B - Vicinity of Isla De Mona, PR
OPR-I905-NF-08
Puerto Rico Mapping Project
SNM = 61
Project Area
Sheet Limits
CHART 25640
A
B
ISLA DE MONA
18° 00'

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

TIDE NOTE FOR HYDROGRAPHIC SURVEY

DATE : May 23, 2008

HYDROGRAPHIC BRANCH: Atlantic
HYDROGRAPHIC PROJECT: M-I905-NF-2008
HYDROGRAPHIC SHEET: H11808

LOCALITY: 12 NM West of Mayaguez, Puerto Rico
TIME PERIOD: February 24 - March 8, 2008

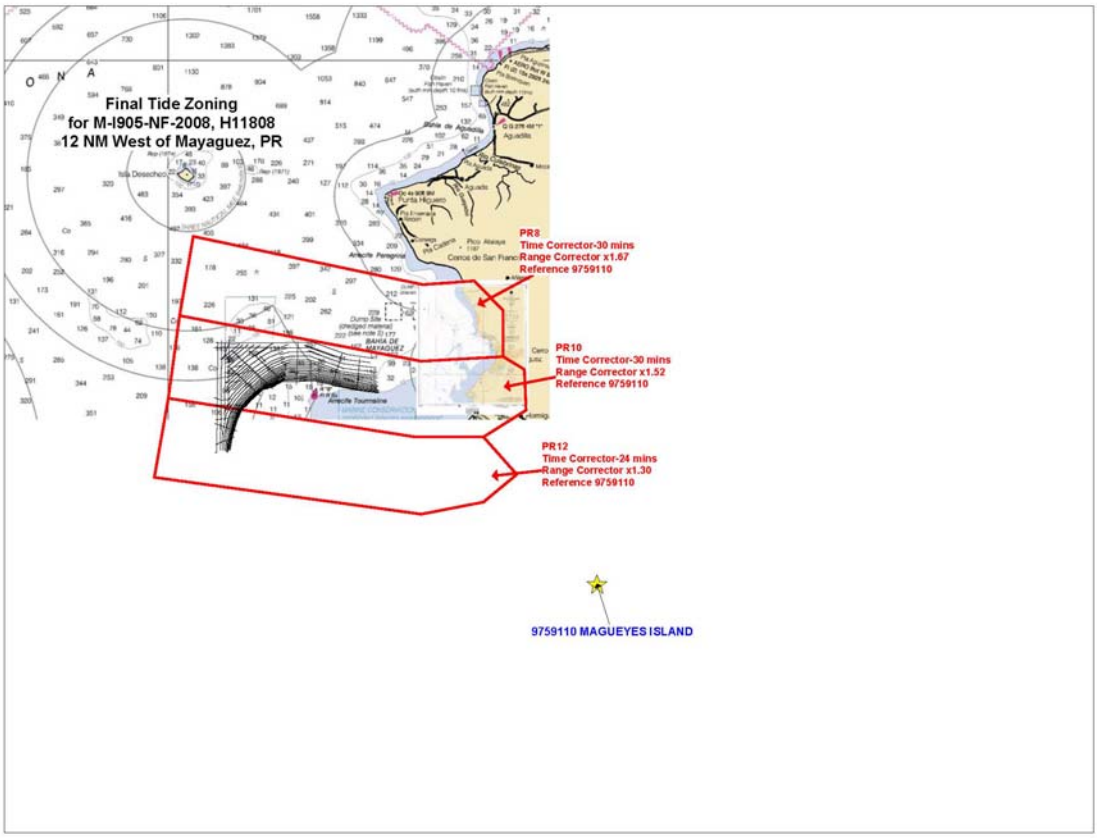
TIDE STATION USED: 975-9110 Magueyes Island, PR
Lat. 17° 58.3'N Long. 067° 2.8' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 0.201 meters

REMARKS: RECOMMENDED ZONING
Use zone(s) identified as: PR8, PR10 & PR12

Refer to attachments for zoning information.

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

CHIEF, PRODUCTS AND SERVICES DIVISION


Final Tide Zoning
for M-I905-NF-2008, H11808
12 NM West of Mayaguez, PR
PR8
Time Corrector-30 mins
Range Corrector x1.67
Reference 9759110
PR10
Time Corrector-30 mins
Range Corrector x1.52
Reference 9759110
PR12
Time Corrector-24 mins
Range Corrector x1.30
Reference 9759110
9759110 MAGUEYES ISLAND

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

TIDE NOTE FOR HYDROGRAPHIC SURVEY

DATE : May 23, 2008

HYDROGRAPHIC BRANCH: Atlantic
HYDROGRAPHIC PROJECT: M-I905-NF-2008
HYDROGRAPHIC SHEET: H11809

LOCALITY: Vicinity of Isla De Mona, Puerto Rico
TIME PERIOD: February 24 - March 8, 2008

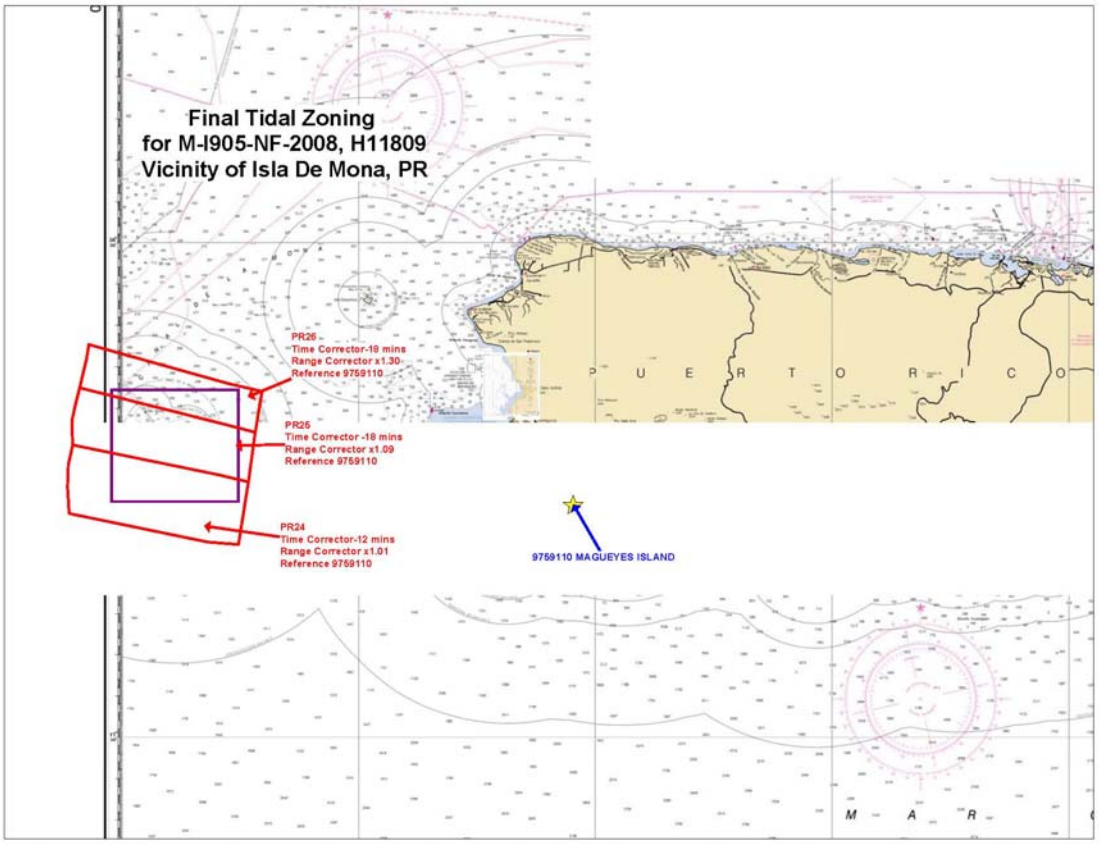
TIDE STATION USED: 975-9110 Magueyes Island, PR
Lat. 17° 58.3'N Long. 067° 2.8' W
PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters
HEIGHT OF HIGH WATER ABOVE PLANE OF REFERENCE: 0.201 meters

REMARKS: RECOMMENDED ZONING
Use zone(s) identified as: PR24, PR25 & PR26

Refer to attachments for zoning information.

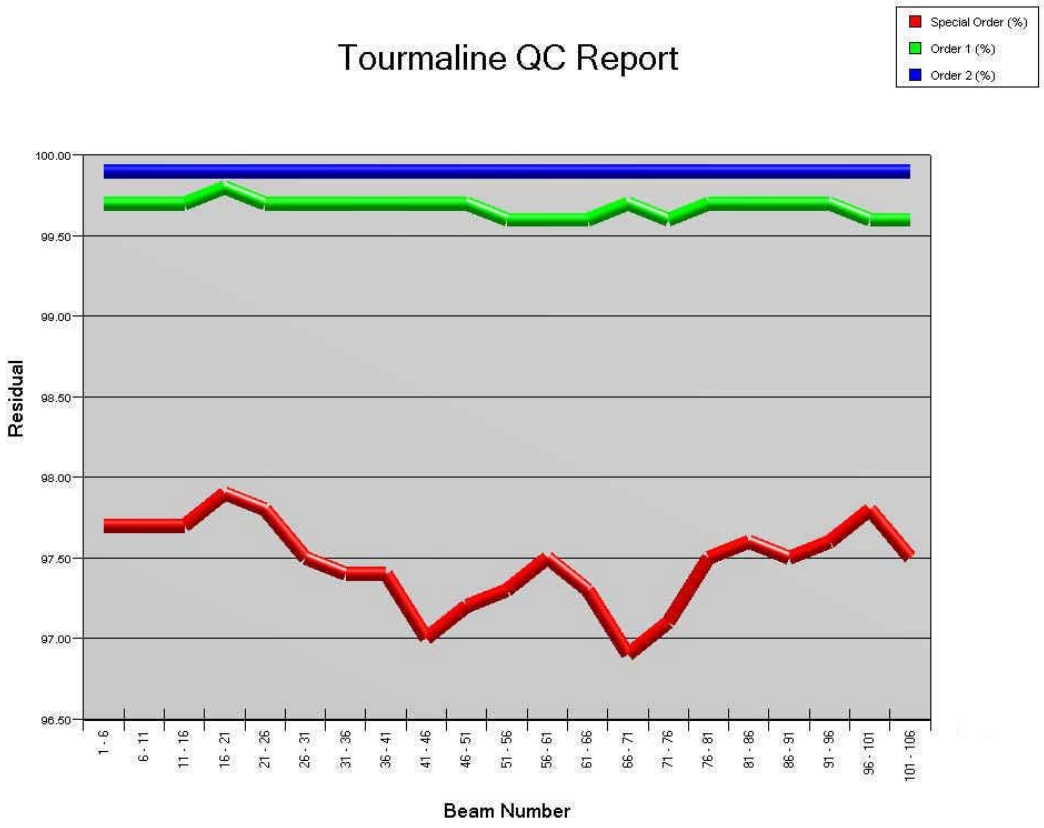
Note 1: Provided time series data are tabulated in metric units (meters), relative to MLLW and on Greenwich Mean Time on the 1983-2001 National Tidal Datum Epoch (NTDE).

CHIEF, PRODUCTS AND SERVICES DIVISION


Final Tidal Zoning
for M-I905-NF-2008, H11809
Vicinity of Isla De Mona, PR
PR26
Time Corrector-19 mins
Range Corrector x1.30
Reference 9759110
PR25
Time Corrector -18 mins
Range Corrector x1.09
Reference 9759110
PR24
Time Corrector-12 mins
Range Corrector x1.01
Reference 9759110
9759110 MAGUEYES ISLAND
P U E R T O R I C O
M A R

APPENDIX K:

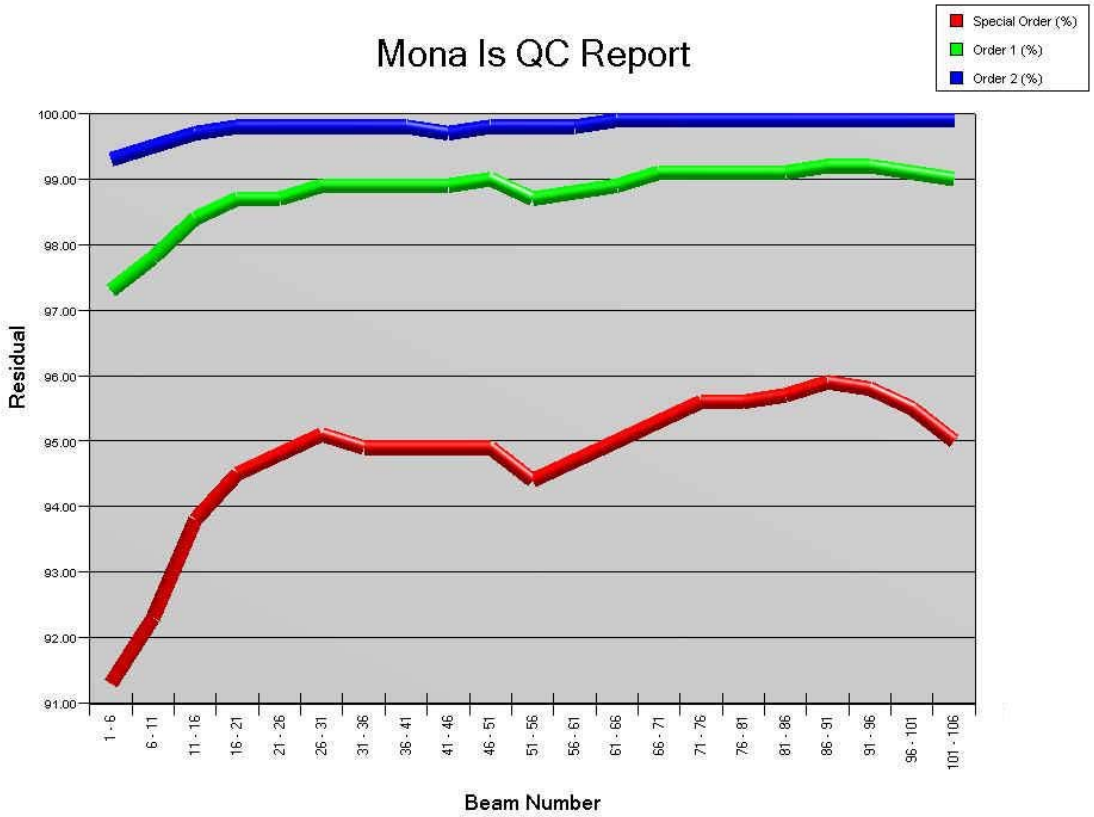
CARIS Quality Control Reports



BASE Surface Tourmaline QC Report

Date and Time: 9/15/2008 12:31:21 PM
Surface: C:\CARIS\HIPS\61\FieldSheets\NF0804_USVI\TB_UTM19N\6m.hns
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 2,915,537
Number of nodes populated: 2,915,057 (99.9835364805866%)
Number of holidays detected: 0
IHO S-44 Special Order:
Range: 0.0 to 20.0
Number of nodes considered: 930
Number of nodes within: 7 (0.753%)
Residual mean: 0.336252608461999
S-44 Order 1:
Range: 20.0 to 100.0
Number of nodes considered: 893,030
Number of nodes within: 884,138 (99.004%)
Residual mean: -0.739306815893229
S-44 Order 2:
Range: 100.0 to 5000.0
Number of nodes considered: 2,021,097
Number of nodes within: 2,015,001 (99.698%)
Residual mean: -4.40607943314015



BASE Surface Mona Island QC Report

Date and Time: 9/15/2008 4:42:02 PM
Surface: C:\CARIS\HIPS\61\FieldSheets\NF0804_USVI\MI_UTM19N\6m.hns
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation.

Number of nodes processed: 2,207,244
Number of nodes populated: 2,146,929 (97.2674067751458%)
Number of holidays detected: 0

IHO S-44 Special Order:

Range: 0.0 to 20.0
Number of nodes considered: 16,439
Number of nodes within: 10,017 (60.934%)
Residual mean: 0.027614595183534

S-44 Order 1:

Range: 20.0 to 100.0
Number of nodes considered: 715,369
Number of nodes within: 698,614 (97.658%)
Residual mean: -0.704993654962055

S-44 Order 2:

Range: 100.0 to 5000.0
Number of nodes considered: 1,415,121
Number of nodes within: 1,405,473 (99.318%)
Residual mean: -4.66703771000019

APPENDIX L:

~~NF-08-04-USVI~~ *M-I905-NF-08* Cruise Instructions

CRUISE INSTRUCTIONS: NOAA SHIP NANCY FOSTER

Cruise Title: **Characterization of midwater seafloor habitats of western Puerto Rico**

Cruise Number ~~NF-08-04-USVI~~ ***M-I905-NF-08***

Period of Cruise:
DEP: 2/25/08 ~~NF-08-04-USVI~~ ***M-I905-NF-08***
ARR: 3/8/08

Area of Operation: West 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 fifth 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 (Tourmaline Bank), Mona Island, and Monito Island. Scientists will collect high resolution multibeam in mid-water depths approximately 10 to 300 meters so as to continue to characterize seafloor habitats within all U.S. States, Territories, and Commonwealths. The objective of this project is to collect a multibeam bathymetry dataset with 100% seafloor ensonification, along with multibeam backscatter suitable for seafloor characterization. Multibeam data will be collected to conform to IHO Order 1 (< 100m) and Order 2 (>100m) accuracy standards. The strategies developed for each survey area will take into account the minimum depths, general bathymetry, and time allotment. The delineation and identification of seafloor habitats will be assisted by the use of a moderate-depth ROV and drop camera. The vehicle has video and frame camera capability to depths of 300 meters and will be used to point sampling within areas mapped during this mission.

2.0 Schedule of Operations:

2.1 Daily Schedule:

Actual survey and ground truthing locations will be made available to the Operations Officer during the daily operations meeting. The following are estimates of locations.

23 February (Saturday): 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.
GT: Ground Truthing (GT) team configures remaining camera gear and conducts USBL, POS/MV, GPS integration with Hypack; and installs hydrophone pole.

24 February (Sunday):
Survey NF: Survey team installs survey gear, does a gear shake-down of multibeam unit and survey planning. Install EM 3002D multibeam to the moon pool using ship divers. Conduct dockside calibration tests.
GT: Continued preparations.
All: Team scientists meeting and meeting with ship officers on safety and scientific operations.

25 February (Monday):
Transit/Survey NF: (0800-2400) Ship transit from San Juan to Tourmaline Bank. Survey team conducts Patch Test to calibrate the EM 3002D multibeam echosounder (MBES) system and begins shallow water survey.

26 February (Tuesday):
Survey NF: (2400-0800) MBES Tourmaline Bank Project Area.
GT: (0800-1600) Conduct ground truthing of Tourmaline Bank Project Area.
Survey NF: (1600-2400) MBES Tourmaline Bank Project Area.

27 February (Wednesday):
Survey NF: (2400-0800) MBES Tourmaline Bank Project Area.
GT: (0800-1600) GT Tourmaline Bank Project Area
Survey NF: (1600-2400) MBES A Tourmaline Bank Project Area.

28 February (Thursday):
Survey NF: (2400-0800) MBES Tourmaline Bank Project Area.
GT: (0800-1600) GT Tourmaline Bank Project Area
Survey NF: (1600-2400) Tourmaline Bank Project Area.

29 February (Friday):
Survey NF: (2400-0800) MBES Tourmaline Bank Project Area.
GT: (0800-1600) GT Tourmaline Bank Project Area
Survey NF: (1600-2400) Tourmaline Bank Project Area.

01 March (Saturday):
Survey NF: (2400-0800) MBES Tourmaline Bank Project Area.
GT: (0800-1600) GT Tourmaline Bank Project Area
Survey NF: (1600-2400) Tourmaline Bank Project Area.

02 March (Sunday):
Survey NF: (2400-0800) MBES Tourmaline Bank Project Area.
GT: (0800-1600) GT Tourmaline Bank Project Area
Survey NF: (1600-2400) Tourmaline Bank Project Area.

03 March (Monday):
Survey NF: (2400-0800) Transit to Mona Island and begin MBES.
GT: (0800-1600) GT Mona Island.
Survey NF: (1600-2400) MBES Mona Island.

04 March (Tuesday):
Survey NF: (2400-0800) MBES Mona Island.
GT: (0800-1600) GT Mona Island.
Survey NF: (1600-2400) MBES Mona Island.

05 March (Wednesday):
Survey NF: (2400-0800) MBES Mona Island.
GT: (0800-1600) GT Mona Island.
Survey NF: (1600-2400) MBES Mona Island.

06 March (Thursday):
Survey NF: (2400-0800) MBES Mona Island.
GT: (0800-1600) GT Mona Island.
Survey NF: (1600-2400) MBES Mona Island.

07 March (Friday):
Survey NF: (2400-0800) MBES Mona Island.
GT: (0800-1600) GT Mona Island.
Survey NF: (1600-2400) MBES Mona Island.

08 March (Saturday):
Survey NF: (2400-0600) MBES Monito Island
Transit: (0600-1400) Transit to San Juan.
Demobilization: (1400-1800) Demobilization

09 March (Sunday):
Media: (0900-1200) Media event and school tours.

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 NOAA ship and AHB will conduct an annual patch of the unit during sea trials 1/30/07. 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 ???????, PR Patch test area for EM 1002?

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 e nsure 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. S tatic 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 co llection along a series of transects as described in Figure 3. Alternatively, yaw bias can al so 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 v6.1 calibration program in the following orde r: Latency, pitch, roll and yaw.

An area within the Tourmaline Bank conservation area 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

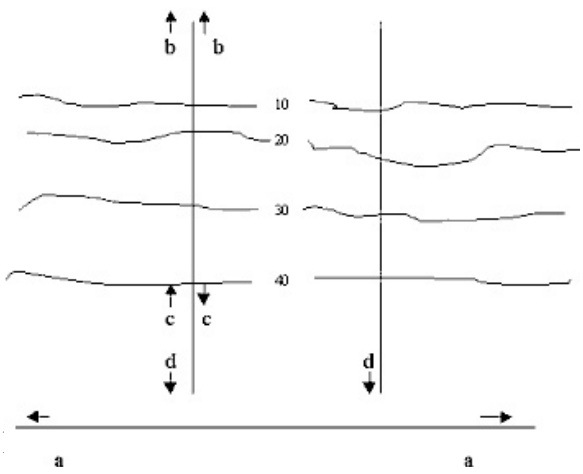


Figure 3: a = Roll, b = Latency, c = Pitch, d =Yaw

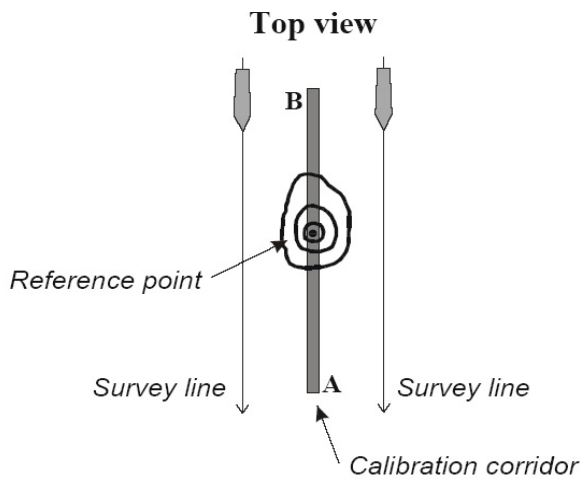


Figure 4: Yaw bias test performed on submerged object

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

Data Acquisition Methodology:

Upon the completion of the verifiable patch test, Bajo de Cico, Abrir la Sierra Bank , followed by Mona Island. Due to the shoal depths a long Puerto Rico, a line spacing of 55 meters is required to provide sufficient coverage. Reducing the antic ipated coverage area will be required. The line plan is generally orientated parallel with the contours to maximize swath coverage and im prove acoustic retu rns. The line plan has taken into account water depths, swath width filters and overlap requirem ents (Tab le 2). Restri cting th e swath li mit ensures the data will meet IHO standards, and m ake the data cleaning process m ore efficient. All deep survey areas wi ll be accepting soundings 55° from nadir, port and starboard, with 10% swath overla p. Area s shoaler than 55 m eters will accept 60° port and starboard with a 1 0% 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 the n exported into geo tiff format. These geo tiffs will be superimposed on top of the charts in 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.

Ground Truthing Operations:

Benthic habitats in moderate depth water (>10m and <300m) around the southwestern Puerto Rico and Mona Island will be visually-characterized using a ROV and drop camera system. This data will be collected to train and validate an automated benthic habitat characterization technique which uses fine-scale (<5 m) multibeam data. The topside control system will be operated from the Wet Lab. The load bearing umbilical will be deployed using the J-frame. A hydrophone pole will be mounted/deployed over the port side forward of the J frame. The pole can be easily retrieved before transiting to a new location. The 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
1) Underwater video + camera equipment + tow bodies (Drop camera)
2) USBL Underwater tracking system and hydrophone pole
3) 6 USB 250GB Maxtor 5000XT hard-drives (CCMA).
4) Five high end laptops and two flat screen monitors.
5) CARIS, ArcGIS, ISIS

6.0 Scientific Personnel:

6.1 Chief Scientist Authority

The Chief Scientist has the authorit y to revise or alter the technical portions of the instructions provided that, after consultation with the Commanding Officer, it is ascertained that the proposed changes will not: 1) jeopardize the safety of the personnel on the ship, 2) exceed the time 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

Scientist:	Organization:	GT	Multibeam	Date
Tim Battista	NOAA	X		2/25-3/8
Mike Stetcher	Contractor		X	2/25-3/8

Ed Owens	NOAA		X	2/25-3/8
Bryan Costa	NOAA		X	2/25-3/8
Survey Tech	NOAA		X	2/25-3/8
Charlie Menza	NOAA	X		2/25-3/8
Zach Hecht-Leavitt	NOAA	X	X	2/25-3/8
Lance Horn	NURC	X		2/25-3/8
ROV Operator	NURC	X		2/25-3/8
Marc Kagan	NOAA			2/25-2/28
Susan Soltero	Univision			2/25-2/28
Michelle Sharer	UPRM	X		3/3-3/8
Jorge Sabater	UPRM	X		2/25-3/3
Rene Esteves	UPRM	X		2/25-3/3

******* CFMC party of five scientists will be joining the ship for one day to observe. Date to be determined. Various scientists and Media will be arriving and departing throughout the cruise. A NOAA launch will be utilized to transit to Mayaguez.**

TASK TEAMS

Ground Truthing

Battista, Menza, Hecht-Leavitt, Horn, ROV operator, Scharer, Sabater, and Esteves

Multibeam

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

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 least 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 Meals and Berthing:

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

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

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

16.0 Medical Forms:

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

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 Gary Bulmer, NOAA
Commanding Officer, Marine Operations Center Atlantic

Date_____

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

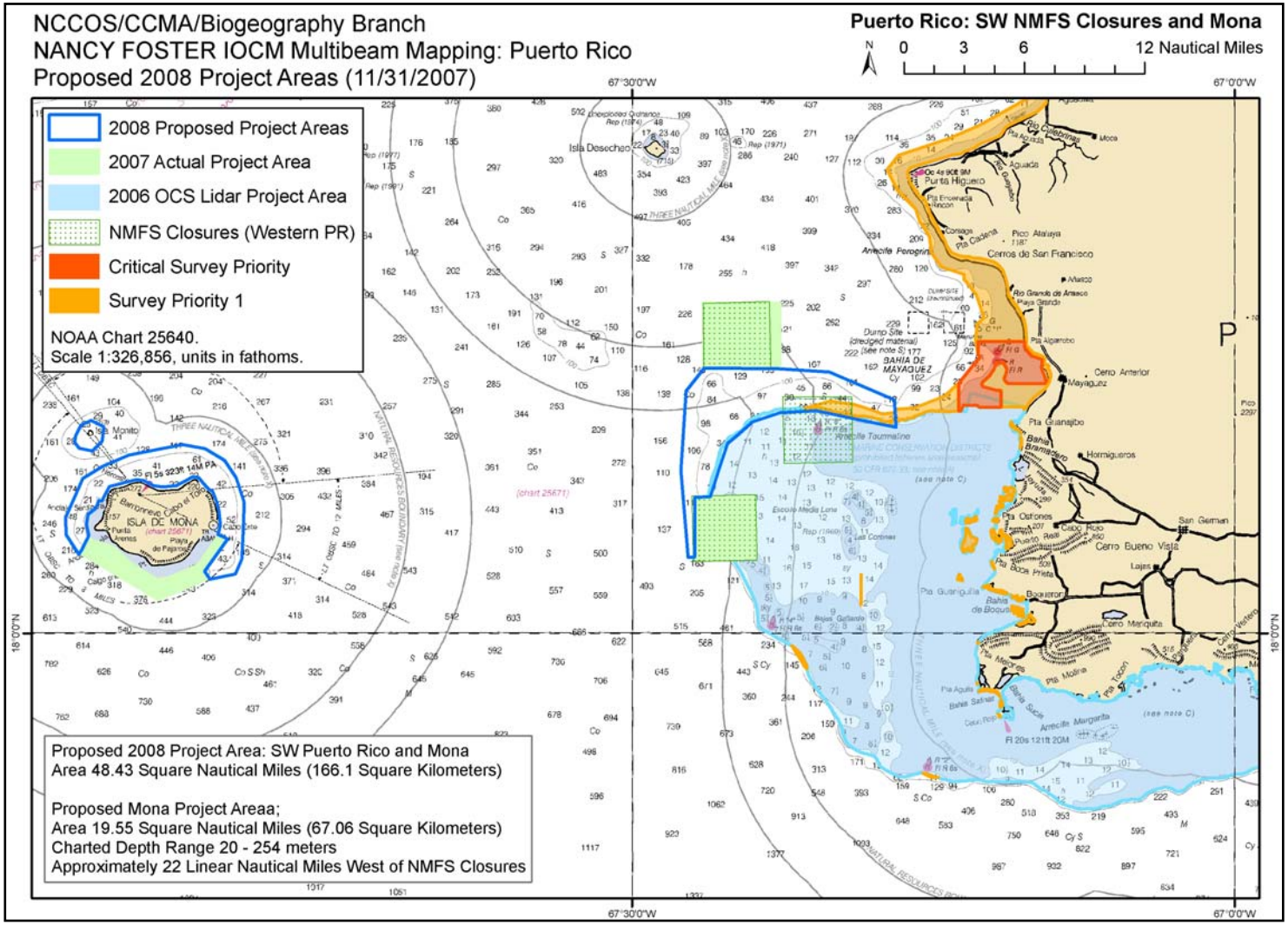


Table 2: Line Spacing Specifications

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

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

a = Multibeam Swath Angle

d = Water Depth (ft)

s = Swath Sidelap

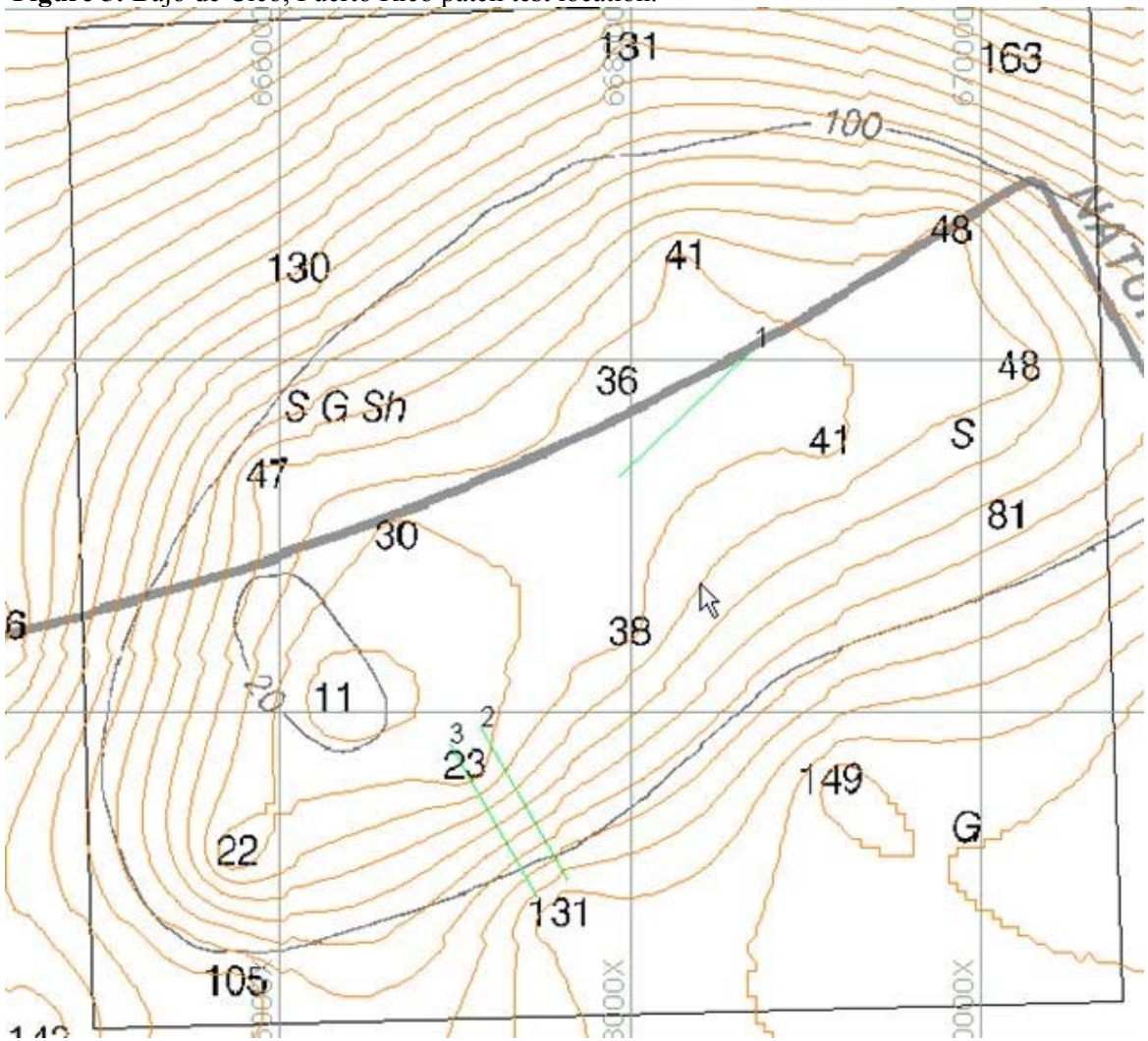



Figure 5: Bajo de Cico, Puerto Rico patch test location.