Data Acquisition & Processing Report

Type of Survey: Benthic Habitat and Hydrographic

Project No. NPS-STX-2010

Time Frame: April 9, 2010 - April 30, 2010

Locality

Buck Island Reef National Monument, St. Croix, USVI

2010

<u>Chief Scientist</u>

Timothy A. Battista

<u>Lead Hydrograher</u>

John V. Lazar, Jr.

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NPS-STX-10-01-USVI

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NPS R/V Osprey

Chief Scientist

Timothy A. Battista

Lead Hydrograher

John V. Lazar, Jr.

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I. Background

The goal of this project is to acquire critical baseline benthic habitat information for the Buck Island Reef National Monument (BUIS) and/or Salt River Bay National Historical Park and Ecological Reserve (SARI) north of St Croix in the U.S. Virgin Islands. While NOAA and NPS have collaboratively conducted extensive habitat mapping and biological monitoring within and outside BUIS and SARI in the past, funding and vessel access has never afforded the opportunity to conduct a complete bathymetric survey for seafloor characterization within these marine protected areas (MPAs) until now. Backscatter and bathymetry data were collected inside BUIS (Figures 1) from April 9 to April 30, 2010 using a Reson 8125 multibeam echosounder (MBES) mounted on the NPS Vessel R/V Opsrey. Data were acquired to conform to IHO Order 1 accuracy standards in depths shoaler than 40 m. Unfortunately, there not enough time to survey inside SARI's boundaries as well. This acoustic data will be integrated with existing acoustic imagery to create a seamless shallow to deep water (5 – 1,000 m) bathymetric and habitat map of Buck Island Reef National Monument.

II. Area

The mission explored and mapped shallow depth bathymetry aboard the NPS RV Osprey with a Reson 8125 multibeam systems for natural resource management and seafloor characterization. Although two areas of interest for surveying were identified, the area around BUIS was given priority and was the only area surveyed. An estimated 85% of surveyable depths around the island were mapped with the most shoal waters north of the island left unmapped.

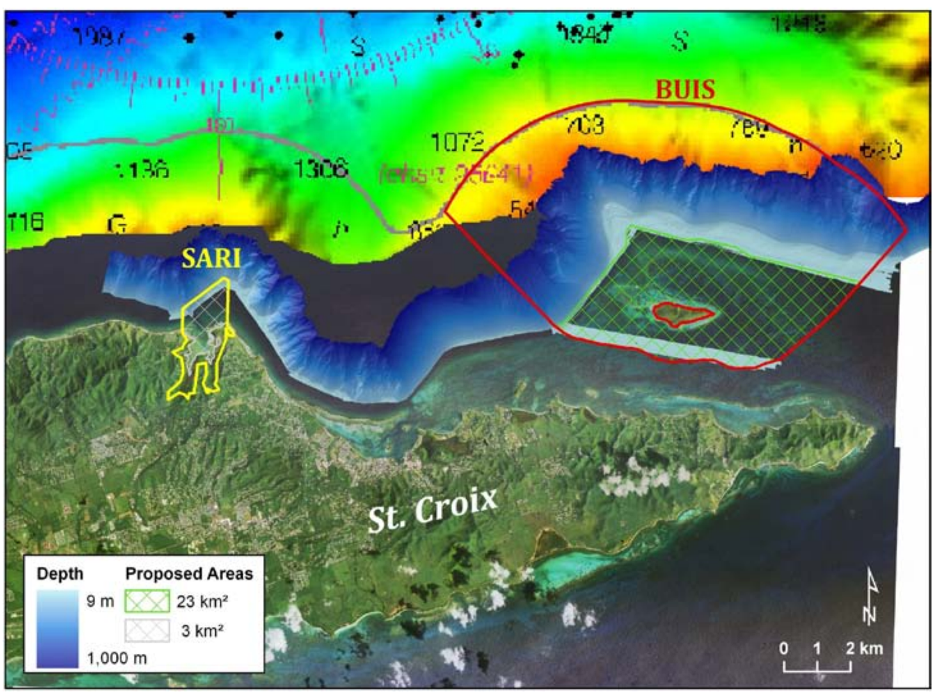


Figure 1 Areas of interest are identified with cross-hatched polygons.

III. Equipment

Vessel

The National Park Service Research Vessel Osprey measures 27 feet in length, has a beam of 10 feet and draws approximately 2 feet of water. Prior to the arrival of the survey crew, equipment and a mounting frame to support the multibeam sonar had been shipped to St. Croix to expedite the mobilization of the RV Osprey. The frame as shipped was installed the evening of April 9. The sensors and computers were installed and integrated the following day. We quickly realized that the frame as designed would not meet the stringent requirements of a fixed sonar location and searched for solutions. On April 11, we met with a metal fabricator to design cross braces in an attempt to stiffen the frame and remove athwartship motion in the sonar. We installed the bracing (left image) April 12 with little improvement and continued to search for solutions. April 13, we built from shipping lumber a wooden brace (right image) designed to prevent the sonar pole from strumming in the anticipated seas. Initial testing proved promising and we headed out for system calibrations at the eastern edge of the survey area.

Sonar System

A Reson Seabat 8125 multibeam EM7183 SN2007011 and topside SN31381(shown to the left) was mobilized for this cruise to map the shallow water habitats in water depths of less than 75 meters. The Seabat 8125 is a 455-kHz system with a 120° swath consisting of 240 individually formed, electronically roll-stabilized 0.5° beams, with a maximum ping rate of 20Hz, depending on water depth.

The ping rate was reflected by the range scale set by the operator of the sonar, the shallower the range scale, the faster the ping rate. A variety of ranges were used during acquisition, however the 75m range dominated the survey resulting in a nominal ping rate of 5hZ. A spreading loss of 30 log decibels and absorption value of 50 decibels per kilometer were used as general values recommended by Reson for working in seawater. The power was maintained at 220dB and the gain varied between 33dB and 50dB. The sonar data (snippets and bathy) was collected via ethernet with Hypack 2010 Hysweep. Versions of all hardware and software used for this survey can be found in Appendix B.

Vessel Positioning & Orientation

The Applanix POS/MV Wavemaster 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 ± 0.03°. 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 sonar mount to attempt to account for any residual motion between the sonar frame and the vessel; refer to Appendix E for the vessel offset diagram.

The POS obtains its positions from two dual frequency Trimble Zephyr GPS antennae. The two POS antennae are located across the cabin. An auxiliary Trimble DSM 232 DGPS system provided an RTCM differential data stream to the POS. The DSM 232 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 POS system provided all the positioning and attitude data via Group 102, 111 and 113 through the Ethernet to the Hypack Hysweep acquisition software. The POS Group 7 message was used to synchronize the acquisition PC clock. The POS heave bandwidth was set to 8.0 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. There were also serial connections from the POS supplying motion and the NMEA UTC message to the Reson. The UTC message was used to continually synchronize the Reson topside system clock.

Sound Velocity

The Reson was equipped with a real time sound velocity probe (Teledyne Odom Digibar Pro) at the sonar head and interfaced with the topside unit. The primary CTD’s for determining sound velocity throughout the water column was a Seabird Electronics 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. Calibration reports from Seabird Electronics are documented in Appendix B.

Acquisition System

Hypack Hysweep 2010 provided the acquisition platform for integrating the sensor data. 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.

IV. Quality Control

The HIPS Conversion Wizard uses the .HSX format to convert the multibeam data into CARIS HDCS data files. During the conversion process no filters were placed on the data. The vessel configuration used for the data conversion was the NPS_Osprey.hvf file. This file includes the preliminary patch test results, the final patch test results, waterline and the Total Propagated Error (TPE) values (*.hvf & TPE Report, Appendix C). The data was projected to the North American Datum of 1983, Universal Transverse Mercator Zone 20, Northern Hemisphere (NAD83 UTM20N). All the acquired data was converted and preliminary processed in the field.

Preliminary data processing consisted of: application of sound velocity, zero tides, and CARIS Bathymetry Associated with Statistical Error (BASE) surface creation. The Hips Subset Editor was the second phase of editing. With the BASE surfaces of depth and standard deviation identifying areas of outliers, Subset editing was used to remove erroneous soundings while identifying potential tidal and motion artifacts. The verification and alignment of features from adjacent lines also confirmed preliminary sensor offsets. BASE surfaces were created to illustrate adequate sonar coverage and to also identify systematic errors or artifacts within the data set. The 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

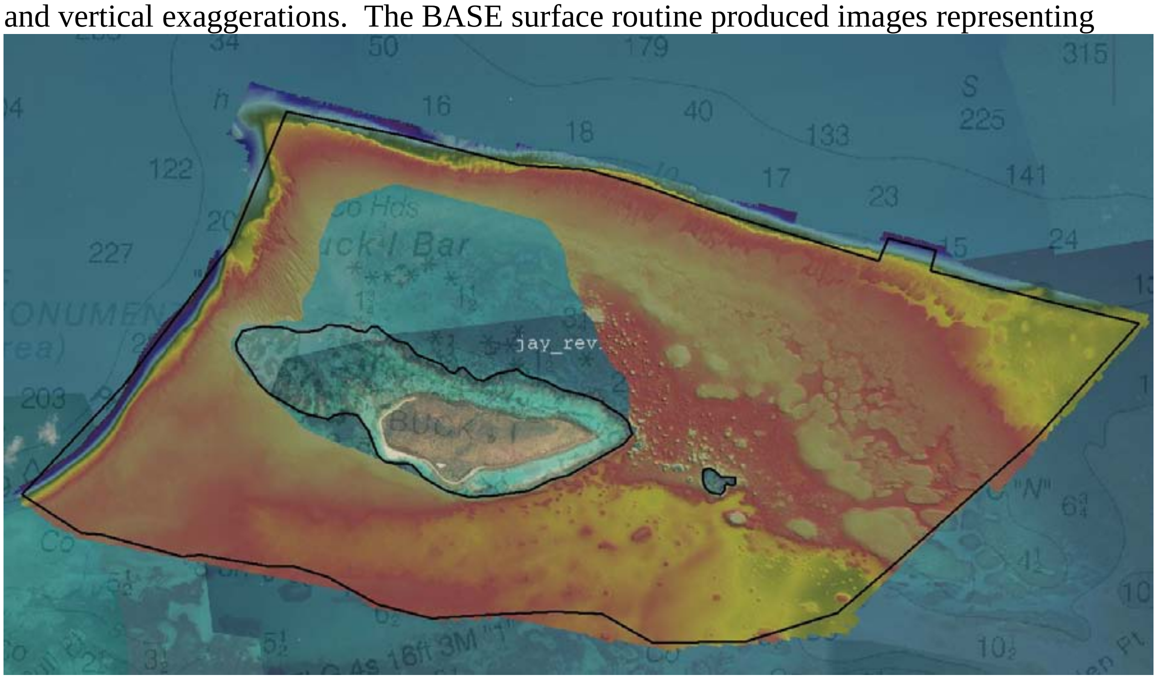


Figure 2 Bathymetric surface of Buck Island Survey Area

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.

Following in the office subset editing of the entire dataset the Lead Hydrographer completed final processing and review of the dataset. This included the re-application of sound velocity profiles, application of zoned verified tides and post patch test refinement from the application of post-processed kinematic data from the POS system. Refer to Appendix F for a multibeam processing flow chart. 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 the survey area. 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. The Hips Quality Control Reports are documented in Appendix H

V. Corrections to Echo Soundings

Instrument corrections

Leadline confidence checks were measured against the Seabat 8125 multibeam echosounder prior to and at the end of field operations on days 101 and 118 while tied up at Green Key Marina, St. Croix, USVI. The purpose of these checks was to verify the system during static conditions by confirming that the digital depths being recorded reflected the actual depths. The sound velocity cast and leadline check were performed on the starboard side 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 0.1 meters to starboard of the nadir beam and verified to the leadline values. No instrument correction was necessary because of insufficient evidence of systematic error.

Sensor Offsets

On April 11 the Field Team measured the sensor offsets of NPS RV Osprey. These offsets were entered into the Hypack acquisition software, POS/MV software and into the CARIS vessel configuration file in the appropriate areas. The offsets used for the sonar and positioning systems are documented in Appendices C and F.

Static and Dynamic Draft Corrections

Static draft values were obtained from visual observations of the draft marks on the starboard side of the RV Osprey sonar pole. The static draft observed on April 11, 2009 was 0.90m while tied up at Green Key Marina, St. Croix, USVI. Subtracting the digital recorded raw depth of 1.28m from the leadline value of 2.20 results in a draft of 0.92m. However, measurements recorded from the Reference Point to the 8125 and from the RP to the Waterline resulted in a draft of 0.90m. A final leadline comparison was made within the survey area on April 28th with a raw depth of 2.34 subtracted from the leadline value of 3.24 resulting in a confirmed draft of 0.90m which is what was used in the CARIS hvf. Soft sediments within the marina likely resulted in the leadline measuring a deeper depth than what the sonar recorded.

Dynamic draft values were not measured nor used for NPS RV Osprey.

System Alignment and Calibrations

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

Tide Corrections

Water level station 9751364 at Christiansted Harbor, St. Croix USVI was 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 levels from NOAA CO-OPS 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 0.10 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 G.

VI. Statement of Accuracy and Suitability for Charting

Assessment of horizontal control

<u>Positioning equipment and methods</u>

The horizontal datum for this project is the North American Datum of 1983 Universal Transverse Mercator Zone 20, Northern Hemisphere (NAD83 UTM20N). Differential GPS (DGPS) corrected positions from the POS/MV were supplied to all the acquisition systems. Each acquisition system has visual alarms to notify the operator if the DGPS fix is lost or if HDOP values of 4.0 are exceeded; none were observed. Differential beacon corrections were received from U.S. Coast Guard Continually Operating Reference Station (CORS) Isabel, Puerto Rico at a frequency of 295.0 kHz with the Trimble DSM 232 receiver.

Raw positioning and attitude data was recorded from the POSMV for post processed kinematic solutions. NGS CORS Kingshill Site VIKH, provided the base station data for post-processing. The post processed data the horizontal positioning applied in CARIS.

Quality control

Position checks between two independent DGPS systems were not able to be observed.

Statement of accuracy and compliance with HSSDM

Based on 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 station at Christiansted Harbor, VI (9751364) served as the primary source for vertical datum control. Verified tides with final zoning were applied during post-processing.

Tides Zoning

The tidal zoning data, time and height corrections were provided by NOAA CO-OPS (refer to Appendix G). The verified tides were zone corrected with the I912NCCOS2010CORP.zdf file provided by CO-OPS.

Statement of accuracy and compliance with HSSDM

The hydrographer believes that the zoning of tide correctors from the primary tide station is adequate for the purpose and location of the survey.

Assessment of sensors

Ancillary sensors

Sound velocity profiles were acquired using the NOAA Chesapeake Bay Office’s SeaBird Electronics (SBE) 19 Plus Conductivity, Temperature, and Depth (CTD) profiler (S/N 6398). Raw CTD data was processed using NOAA’s Velocwin V8.96 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 surface velocities recorded by the Teledyne Odom Digibar surface velocimeter. Each unit had been calibrated prior to use for this survey; refer to Appendix B for the SBE calibration report.

Assessment of Patch Test and Results

The Hydrographer believes that the values of the latency, pitch, roll and gyro coupled with a thorough review of the patch test lines in Caris HIPS HDCS editor, adequately meet the alignment requirements for the survey. The following Figures provide confirmation of the yaw and roll offset values respectively.

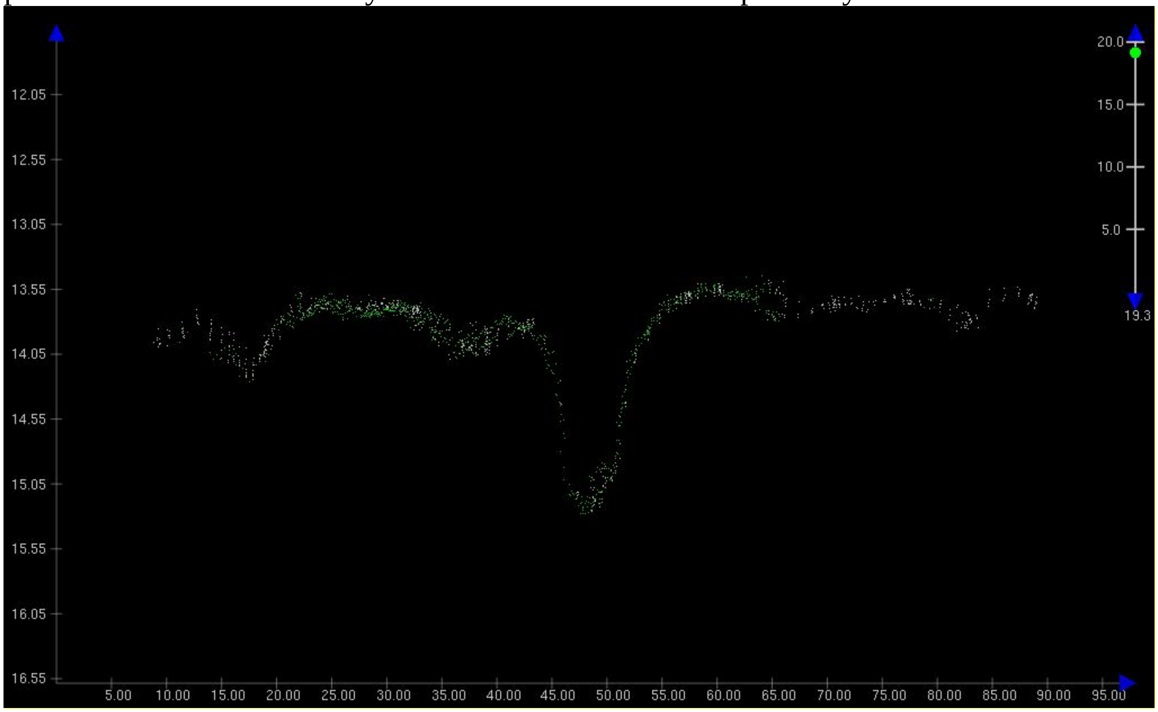


Figure 3 Feature confirmation of Yaw offset

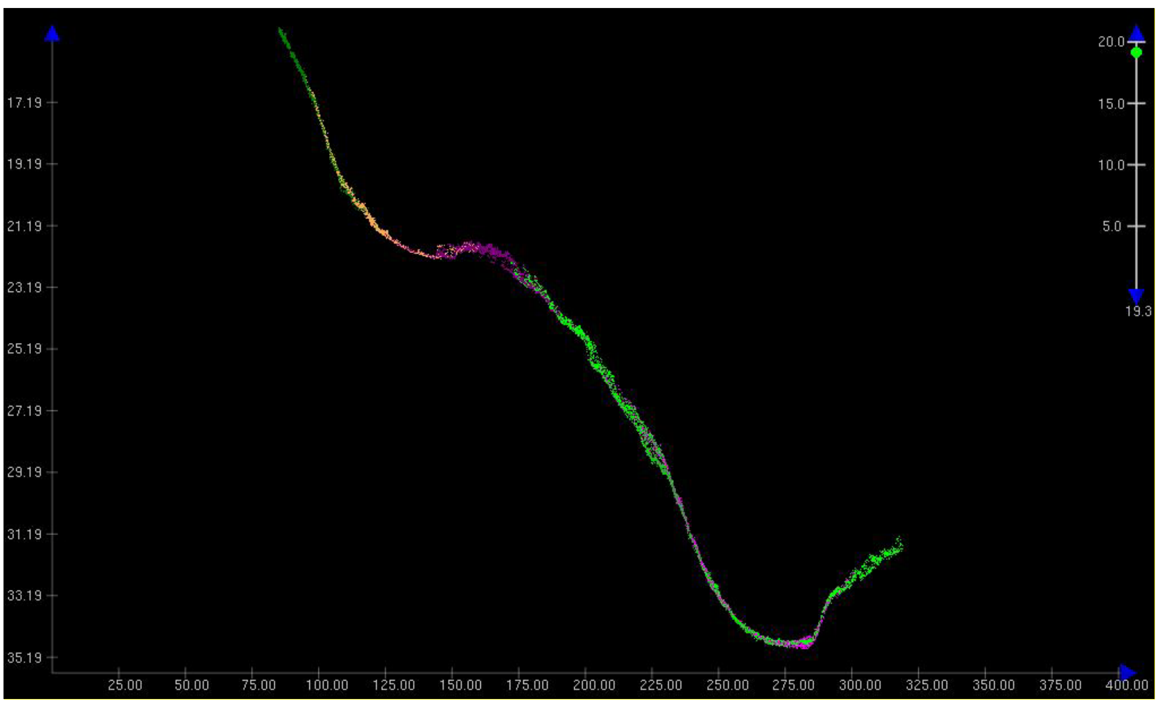


Figure 4 Feature confirmation of Roll offset

Assessment of Dynamic and Static Draft

There are no dynamic draft values for RV Osprey.

Static draft values were obtained from visual observations of the draft marks on the starboard side of the RV Osprey sonar pole. The static draft observed on April 11, 2009 was 0.90m while tied up at Green Key Marina, St. Croix, USVI. Subtracting the digital recorded raw depth of 1.28m from the leadline value of 2.20 results in a draft of 0.92m. However, measurements recorded from the Reference Point to the 8125 and from the RP to the Waterline resulted in a draft of 0.90m. A final leadline comparison was made within the survey area on April 28th with a raw depth of 2.34 subtracted from the leadline value of 3.24 resulting in a confirmed draft of 0.90m which is what was used in the CARIS hvf. Soft sediments within the marina likely resulted in the leadline measuring a deeper depth than what the sonar recorded.

The Lead Hydrographer feels that the static draft corrections and the lack of dynamic draft corrections are adequate for this survey.

Assessment of Horizontal and Vertical offsets

Sensor Offsets

The Lead Hydrographer verified the sensor offset inputs for the POS/MV and the RV_Osprey vessel configuration file. Refer to Appendix E and W for more information.

Assessment of Sensor Calibrations

Both the CTD and velocimeter underwent calibration prior to commencement of operations. The digital depths and draft offsets were confirmed with a leadline while docked at Green Key Marina, St. Croix, USVI. Based on real-time tolerance monitoring and seafloor feature alignment the horizontal positions align well with other GIS raster datasets of imagery that confirm feature alignment. The 8125 elevations and positions were also confirmed with cross check confirmation lines. The offsets to these systems were accurately measured with a tape measure and construction level while floating in the dock. The Lead Hydrographer checked and confirmed the measurements and offsets entered into software. The CTD values were confirmed by comparing the two units against each other at the surface and both received calibrations by the manufacturer within the previous year. The Patch Test occurred on April 14, 2010,was initially processed while in the field to derive preliminary offset values and reprocessed in the office with Post Processed Kinematic horizontal positions applied. 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 8125 ping rates are range dependent and set by the sonar operator. During acquisition the predominant sonar range was 75m resulting in a ping rate of 5hZ and 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.

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 a 60° cutoff angle port and starboard 8125. The line plan spacing did not exceed three times average water depth. Holiday lines were planned according to BASE surfaces created in the field. The resolutions for creating holiday plans were 1m for the shelf regions and 8m for depths generally greater than 100m. Preliminary review of the data in the field by the Lead Hydrographer determined that the bottom coverage and line spacing were considered adequate for the purposes of this survey.

Vessel speed

Survey operations were primarily conducted at a vessel speed of approximately 4-5 knots for the entire survey area. Given a relatively constant ping rate, speeds were maintained 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". Additionally, survey speeds were decreased while in shoal areas surrounding the island. 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 across the site. CARIS generated Quality Control Reports were compiled for each survey area. This routine compares the crosslines for each project against the 1m depth BASE surface. The results of the QC report are based on individual HDCS soundings associated with each beam 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 H. The survey appears to meet and exceed IHO compliance for IHO order 1 for depths shoaler than 100m.

VII. Summary of Submitted Data:

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

Data

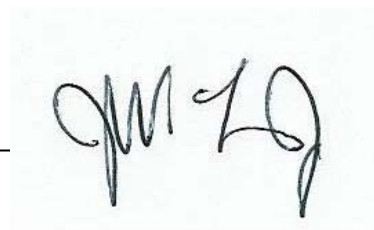
- Raw multibeam sonar sounding files in HSX, RAW, 81X formats
- Processed multibeam sounding files in CARIS HDCS format
- Raw and processed sound velocity data files
- Predicted and Verified tides correctors
- Tidal zoning prepared by NOAA CO-OPS

- XYZ files
- Sun-Illuminated GeoTiffs
- CARIS Hydrographic Vessel Files (HVF)
- CARIS Session Files
- CARIS Fieldsheets

Approval Sheet (Separate Signed Document Verifying DAPR information)
APPROVAL

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

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

Approved and Forwarded: 

John V. Lazar Jr.
ACSM Hydographer #223

APPENDIX A:

Hydrographic Hardware/Software Inventory

Hydrographic Systems Inventory Cruise# CCMA-STX-10 Hardware				
Equipment Type	Manufacturer	Model	Serial #	Firmware
Transducer	Reson	EM7183	2007011	8125-1.08-9E98
Transceiver Unit	Reson		31381	8125-2.10-A50F
Inertial GPS PCS	Applanix	POS/MV Wavemaster V4-1	3631	V5.01
IMU	Applanix	IMU-17	N/A	V5.01
DGPS	Trimble	DSM 232	225120493	N/A
Acquisition PC	N/A	N/A	N/A	N/A
Surface SVP	Teledyne Odom	Digibar Pro	98352	1.11
Profile SVP	SBE	SBE-19plus	6398	N/A

Hydrographic Systems Inventory Cruise# CCMA-STX-10 Software			
Equipment Type	Manufacturer	Model	Software Version
Acquisition	Hypack	Survey	2010
Acquisition	Hypack	Hysweep.exe	10.0.7.0
Acquisition	Hypack	Swpware.exe	10.0.7.0
Acquisition	Hypack	posmv.dll	10.0.5.4
Acquisition	Applanix	POS Controller	5.1.0.2
Processing	NOAA	Velociwin	8.96
Processing	CARIS	HIPS	7.0.1.0 SP1
Processing	Applanix	POSPAC MMS	5.3 SP1

APPENDIX B:

SBE Calibration Reports

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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: 6398
CALIBRATION DATE: 19-Aug-09

SBE19plus PRESSURE CALIBRATION DATA
160 psia S/N 2945715

COEFFICIENTS:

```
PA0 =     -2.224795e-001          PTCA0 =  5.243362e+005
PA1 =      4.871932e-004          PTCA1 = -2.822874e+001
PA2 =     -4.430273e-012          PTCA2 =  3.085774e-001
PTEMPA0 = -6.745883e+001          PTCB0 =  2.500613e+001
PTEMPA1 =  5.340135e+001          PTCB1 = -7.750000e-004
PTEMPA2 = -5.458959e-001          PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE PSIA	INST OUTPUT	THERMISTOR OUTPUT	COMPUTED PRESSURE	ERROR %FSR
14.54	554155.0	1.7	14.54	-0.00
29.79	585462.0	1.7	29.79	0.00
59.78	647080.0	1.7	59.78	-0.00
94.78	719042.0	1.7	94.76	-0.01
124.77	780846.0	1.7	124.77	-0.00
159.79	853076.0	1.7	159.79	0.00
124.79	780898.0	1.7	124.79	0.00
94.80	719121.0	1.7	94.80	0.00
59.80	647170.0	1.7	59.82	0.01
14.54	554142.0	1.7	14.54	-0.00

THERMAL CORRECTION

TEMP ITS90	THERMISTOR OUTPUT	INST OUTPUT
32.50	1.91	554992.42
29.00	1.84	555053.22
24.00	1.74	555102.09
18.50	1.64	555184.49
15.00	1.57	555236.36
4.50	1.37	555461.98
1.00	1.30	555582.20

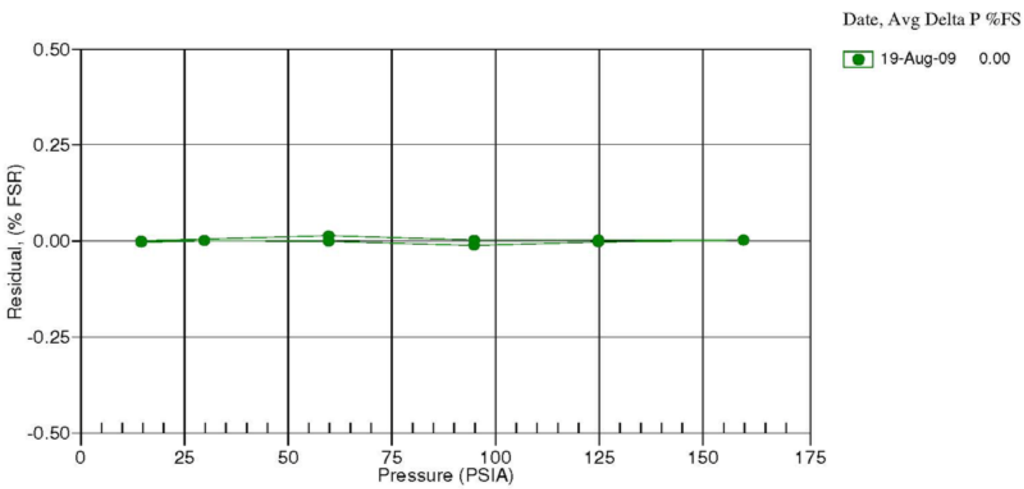
TEMP(ITS90)	SPAN(mV)
-5.00	25.01
35.00	24.98

y = thermistor output; $t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{pressure output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (psia)} = PA0 + PA1 * n + PA2 * n^2$



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: 6398
CALIBRATION DATE: 29-Aug-09

SBE19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.025470e+000
h = 1.606743e-001
i = -3.521936e-004
j = 5.130224e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

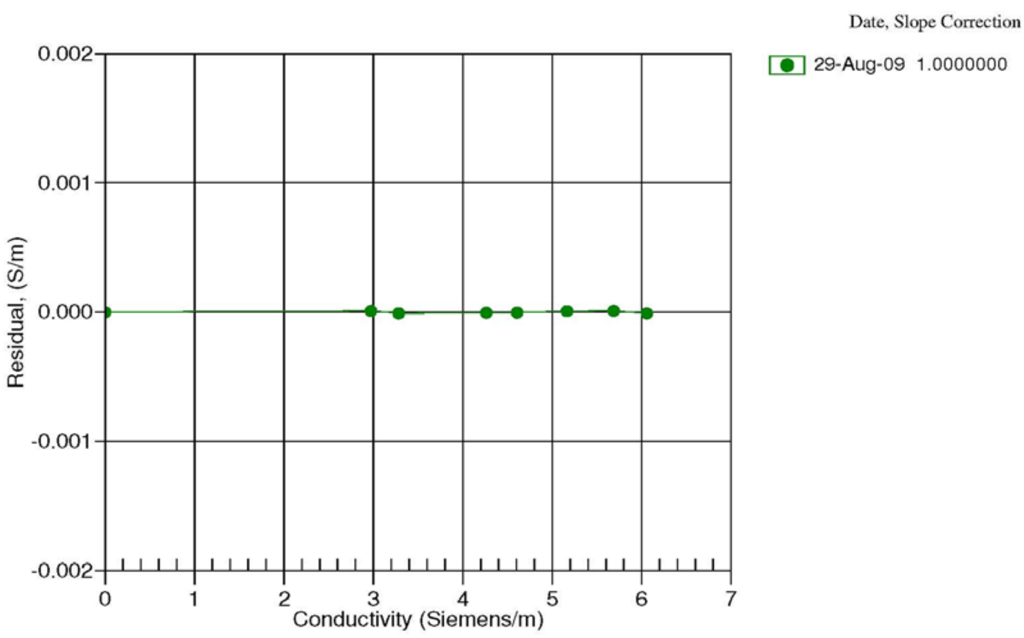
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2530.76	0.0000	0.00000
1.0000	34.7801	2.97317	4996.11	2.9732	0.00001
4.5000	34.7605	3.27998	5183.74	3.2800	-0.00001
15.0000	34.7170	4.26072	5741.88	4.2607	-0.00000
18.5000	34.7077	4.60551	5925.38	4.6055	-0.00000
24.0000	34.6976	5.16292	6210.29	5.1629	0.00001
29.0000	34.6930	5.68439	6465.18	5.6844	0.00001
32.5000	34.6922	6.05679	6641.03	6.0568	-0.00001

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 6398
CALIBRATION DATE: 29-Aug-09

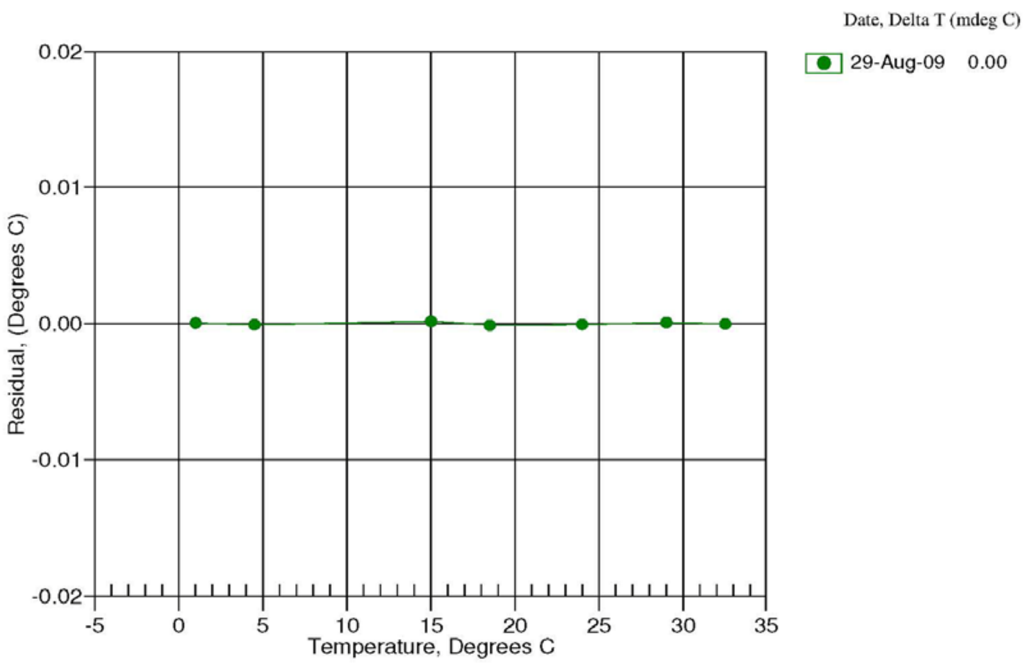
SBE19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 1.269612e-003
a1 = 2.560016e-004
a2 = 2.022456e-007
a3 = 1.284476e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT(n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	687546.254	1.0000	0.0000
4.5000	612265.864	4.4999	-0.0001
15.0000	423187.136	15.0002	0.0002
18.5000	371960.339	18.4999	-0.0001
24.0000	302166.119	23.9999	-0.0001
29.0000	248894.576	29.0001	0.0001
32.5000	216680.746	32.5000	-0.0000

MV = (n - 524288) / 1.6e+007
R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)
Temperature ITS-90 = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



APPENDIX C:

Vessel Configurations & TPE Report

Vessel Name: NPS_Osprey.hvf
Vessel created: October 13, 2010

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2010-103 00:00

Comments:
Time Correction(s) 0.000

Transduer #1:

Pitch Offset: 1.000
Roll Offset: 0.090
Azimuth Offset: 0.900

DeltaX: 1.970
DeltaY: -0.190
DeltaZ: 1.090

Manufacturer:
Model: sb8125
Serial Number:

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2010-103 01:00

Comments:
Time Correction(s) 0.000

Transduer #1:

Pitch Offset: 0.700
Roll Offset: -0.090
Azimuth Offset: -0.300

DeltaX: 1.970
DeltaY: -0.190
DeltaZ: 1.090

Manufacturer:
Model: sb8125
Serial Number:

Navigation Sensor:

Time Stamp: 2010-103 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

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

Gyro Sensor:

Time Stamp: 2010-103 00:00

Comments:
Time Correction(s) 0.000

Heave Sensor:

Time Stamp: 2010-103 00:00

Comments:
Apply Yes
Time Correction(s) 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: 2010-103 00:00

Comments:
Apply Yes
Time Correction(s) 0.000
Pitch offset: 0.000

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

Roll Sensor:

Time Stamp: 2010-103 00:00

Comments:
Apply Yes
Time Correction(s) 0.000
Roll offset: 0.000

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

TPU

Time Stamp: 2010-103 00:00

Comments: Offsets in POS
Offsets

Motion sensing unit to the transducer 1
X Head 1 0.000
Y Head 1 0.000
Z Head 1 0.000
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 0.000
Y Head 1 0.000
Z Head 1 0.000
Navigation antenna to the transducer 2
X Head 2 0.000
Y Head 2 0.000
Z Head 2 0.000

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

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.010 Pitch:0.010 Roll:0.010
Gyro measurement error: 0.030
Roll measurement error: 0.030
Pitch measurement error: 0.030
Navigation measurement error: 0.100
Transducer timing error: 0.003
Navigation timing error: 0.003
Gyro timing error: 0.003
Heave timing error: 0.003

PitchTimingStdDev: 0.003
Roll timing error: 0.003
Sound Velocity speed measurement error: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.050
Dynamic loading measurement error: 0.050
Static draft measurement error: 0.020
Delta draft measurement error: 0.050
StDev Comment: JVL

Svp Sensor:

Time Stamp: 2010-103 00:00

Comments:
Time Correction(s) 0.000

Svp #1:

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

DeltaX: 1.970
DeltaY: -0.190
DeltaZ: 1.090

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: 2010-103 01:00

Comments: (null)
Time Correction(s) 0.000

Svp #1:

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

DeltaX: 1.970
DeltaY: -0.190
DeltaZ: 1.090

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: 2010-103 00:00

Comments: (null)
Apply Yes
WaterLine 0.189

Total Propagated Error (TPE) Report

NPS RV Osprey 2010

Caris HIPS 7.0 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	0.03
Roll	0.03
Pitch	0.03
Navigation	0.10
Timing Transducer	unknown
Navigation Timing	unknown
Gyro Timing	0.003
Heave Timing	0.003
Pitch Timing	0.003
Roll Timing	0.003
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: 0.03

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

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

Roll

Error: 0.03

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

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

Pitch

Error: 0.03

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

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

Navigation

Error: 0.1

Definition: *Navigation* is the standard deviation associated with the measurement of positions for the vessel in meters.

Discussion: *Navigation* is based on POSPAC processed position errors.

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 NPS RV Osprey will use 0.05, which is consistent with other NOAA Survey vessels.

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, we will use a NOAA consistent value.

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

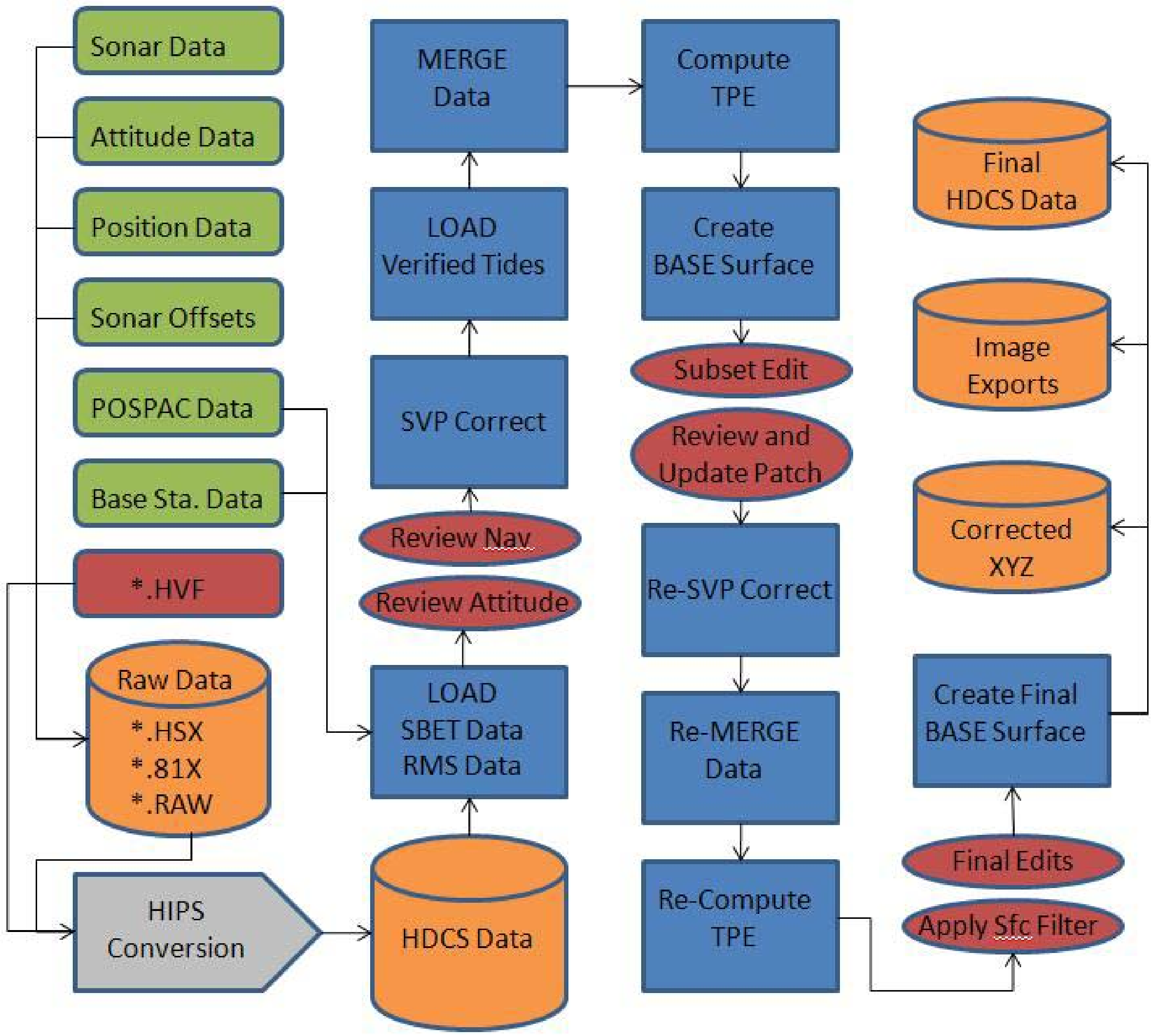
Error: 0

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.

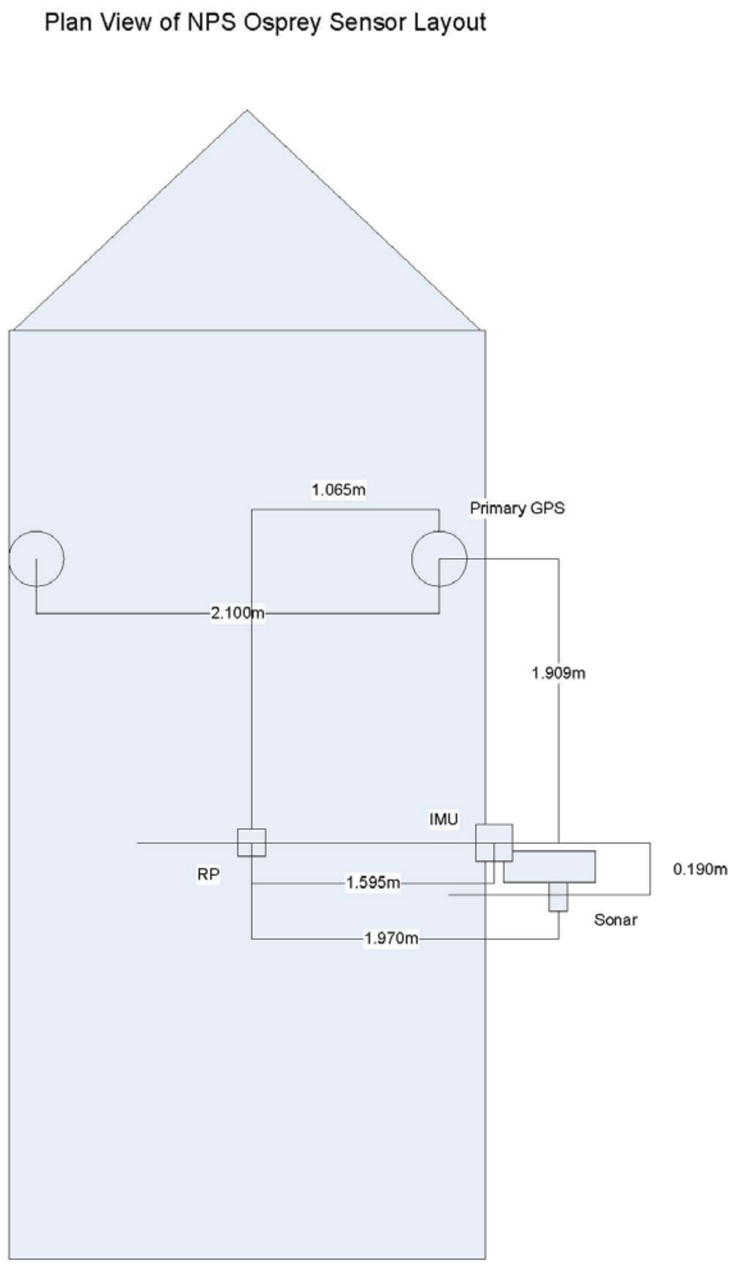
APPENDIX D:

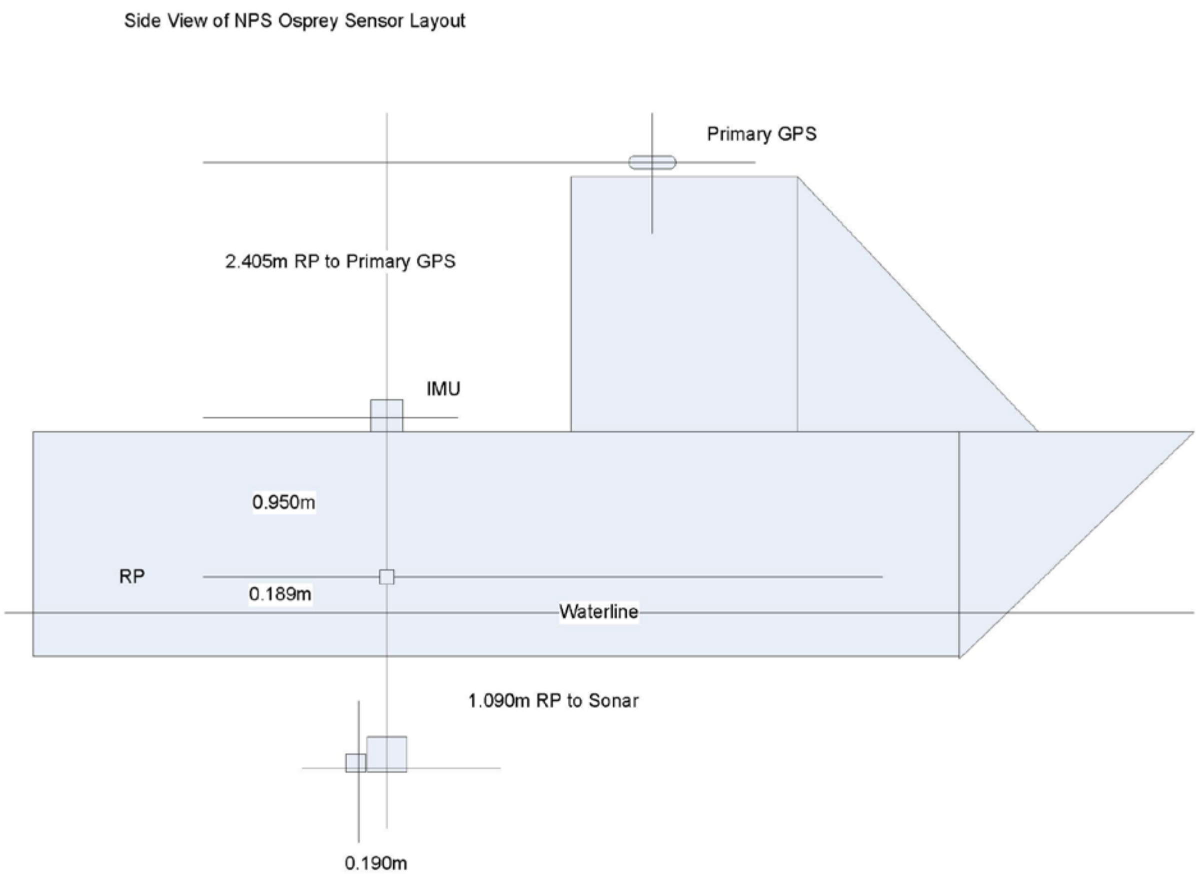
CARIS Processing Flow Chart



APPENDIX E:

NPS RV Osprey Offset Diagrams


Plan View of NPS Osprey Sensor Layout
1.065m
Primary GPS
2.100m
1.909m
IMU
RP
1.595m
0.190m
Sonar
1.970m


Side View of NPS Osprey Sensor Layout
Primary GPS
2.405m RP to Primary GPS
IMU
0.950m
RP
0.189m
Waterline
1.090m RP to Sonar
0.190m

APPENDIX F:

Multibeam Calibration Procedures & Patch Test Reports

Calibration Date: April 14 2010

Ship	
Vessel	NPS RV Osprey
Echosounder System	Reson 8125
Positioning System	POS/MV Model Wavemaster
Attitude System	POS/MV Model Wavemaster

Calibration type:

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

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

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

Pre-calibration Survey Information

Reference Frame Survey

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

Vessel reference frame defined with respect to:

[X] IMU Reference [X] Position

Reference to IMU Lever Arm

X(m)	Y(m)	Z(m)
0.0	1.595	-0.950

IMU frame w.r.t vessel reference frame

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

Reference to Sensor Lever Arm

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

[X] Measurements verified for this calibration.

[X] Reference Vessel Offset Appendix Drawing and table attached.

[X] Drawing and table included with project report/DAPR: CCMA-STX-10 DAPR

Position/Motion Sensor Calibration (for POS/MV model Wavemaster)

Calibration date: April 14, 2010

Reference to primary GPS Lever Arm

X(m)	Y(m)	Z(m)
1.909	1.065	-2.405

Heave Settings: Bandwidth 10.00 Damping Period .707

Reference to Center of Rotation Lever Arm

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

Firmware version 5.01 was used for the entire survey.

Static Draft Survey

(Vessel waterline with respect to RP)

Survey date: April 11,28, 2009

The 8125 draft was measured at the beginning of the cruise by reading the draft marks on the sonar mount pole and measuring the waterline. The draft was verified with a leadline at the beginning and end of the cruise. The initial draft measurement for the 8125 at the waterline was 0.90m. The draft determined by subtracting the recorded raw z from the initial leadline was 0.92m. The draft determined by conducting a closing leadline was 0.90m. This discrepancy of 2cm can be explained by the location of the two leadlines. The initial confidence check occurred within the marina in a very soft bottom, ultimately permitting the leadline to rest below where the sonar return penetrated. The closing check occurred within the survey area on a hard bottom.

Leadline - Raw Z = Measured Draft

Initial Check 2.20m – 1.28m + 0.0 = 0.92m
Closing Check 3.24m – 2.34m + 0.0 = 0.90m

Static Draft Correction 0.90 (meters)

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

Not performed.

Calibration Survey Information

A patch test was performed once times for the 8125. The CARIS calibration routine was used to determine the sensor mounting angle offsets.

Calibration Lines

Line	Direction	Speed	Bias Measured
2010_1041329_1	E	5.2	R1, Y1
2010_1041332_1	W	5	R2
2010_1041337_4	E	5	Y2
2010_1041340_6	W		P1
2010_1041342_6	E	5	P2

Sound Velocity Correction

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

Sound Velocity Measurements

Cast	Time (UTC)	Depth(m)	LAT	LONG
DN104_1	13:14	38	17 48 30.0N	64 37 00.0W

Tide Correction

Zerotide applied

Approximate distance of gauge from calibration site: NA

Water level corrections applied:

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

Data Acquisition and Processing Guidelines

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

Navigation Timing Error (NTE)

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

Transducer Pitch Offset (TPO)

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

Transducer Roll Offset (TRO)

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

Transducer Azimuth Offset (TAO or yaw)

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

Final Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
John V. Lazar Jr	0.0	0.70	-0.30	-0.09

[X] Caris ISIS [ ]

[ ] Other ____________________

Caris Vessel Configuration File

Name: NPS_Osprey.hvf

Version: 7.0.1.0 SP 1

New [X] Appended values with time [ ] tag

Evaluator: John V. Lazar Jr

APPENDIX G:

CO-OPS Tide Requirements, Tide Note and Correspondence

WATER LEVEL INSTRUCTIONS
M-I912-NCCOS-2010 St. Croix, VI
(04/12/2010 DW)

1.0. TIDES AND WATER LEVELS

1.1. Specifications

Tidal data acquisition, data processing, tidal datum computation and final tidal zoning shall be performed utilizing sound engineering and oceanographic practices as specified in National Ocean Service (NOS) Hydrographic Surveys Specifications and Deliverables (HSSD), dated April 2009, and OCS Field Procedures Manual (FPM), dated May 2009. Specifically reference Chapter 4 of the HSSD and Sections 1.5.8, 1.5.9, 2.4.3, and 3.4.2 of the FPM.

1.2. Vertical Datums

The tidal datums for this project are referenced to Chart Datum, Mean Lower Low Water (MLLW) and Mean High Water (MHW). Soundings are referenced to MLLW and heights of overhead obstructions (bridges and cables) are referenced to MHW.

The operating National Water Level Observation Network (NWLON) station at Christiansted, St. Croix (975-1364) serves as datum control for the survey area including determination at each subordinate station.

1.2.1. Water Level Data Acquisition Monitoring

The Commanding Officer (or Team Leader) and the Center for Operational Oceanographic Products and Services (CO-OPS) are jointly responsible for ensuring that valid water level data are collected during periods of hydrography. The Commanding Officer (or Team Leader) is required to monitor the pertinent water level data via the CO-OPS Web site at http://tidesandcurrents.noaa.gov/hydro.shtml, email data transmissions through TIDEBOT, or through regular communications with CO-OPS/Engineering Division (ED) 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/ED (Tom Landon, 301-713-2897 ext. 191, Email: nos.coops.oetteam@noaa.gov) to coordinate the appropriate course of action to be taken such as gauge repair and/or developing contingency plans for hydrographic survey operations. In addition, CO-OPS is required to coordinate with the Commanding Officer (or Team Leader) before interrupting the acquisition of water level data for the NWLON stations mentioned above for any reason during periods of hydrography.

1.2.2. NWLON Water Level Station Operation and Maintenance

The operating water level station at Christiansted, St. Croix (975-1364) will also provide water level reducers for this project. Therefore it is critical that it remains in operation during the survey. See Sections 1.1. and 1.2. concerning responsibilities.

No leveling is required at Christiansted, St. Croix (975-1364) by NOAA personnel.

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

1.3. Tide Reducer Stations

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

Tide Component Error Estimation

There is insufficient data with which to perform an error estimation.

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 Christiansted, St. Croix (975-1364) is the reference station for preliminary tides for hydrography in St. Croix, VI. The time and height correctors listed below for applicable zones should be applied to the preliminary data at Christiansted, St. Croix (975-1364) 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 SOAP web services at http://opendap.co-ops.nos.noaa.gov/axis/text.html.** The Commanding Officer (or Team Leader) must notify CO-OPS/ED 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**
SC001	0	x0.97	9751364
SC002	+12	x0.97	9751364
SC003	+18	x0.97	9751364

1.4.2. Polygon nodes and water level corrections referencing Christiansted, St. Croix (975-1364) are provided in CARIS® format denoted by a *.zdf extension file name.

NOTE: The tide corrector values referenced to Christiansted, St. Croix (975-1364) are provided in the zoning file "I912NCCOS2010CORP" 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, Christiansted, St. Croix (975-1364), 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 SOAP web services at http://opendap.co-ops.nos.noaa.gov/axis/text.html.**

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

1.4.3 Zoning Diagram(s)

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

1.4.4 Final Zoning

Upon completion of project M-I912-NCCOS-2010, submit a Pydro generated request for final tides, with times of hydrography abstract and mid/mif tracklines attached. Forward this request to

Final.Tides@noaa.gov . Provide the project number, as well as a sheet number, in the subject line of the email.
CO-OPS will review the times of hydrography, final tracklines, and six-minute water level data from all applicable water level gauges. After review, CO-OPS will send a notice indicating that the tidal zoning scheme sent with the project instructions has been approved for final zoning. If there are any discrepancies, CO-OPS will make the appropriate adjustments and forward a revised tidal zoning scheme to the field group and project manager for final processing.

1.5 TideBot

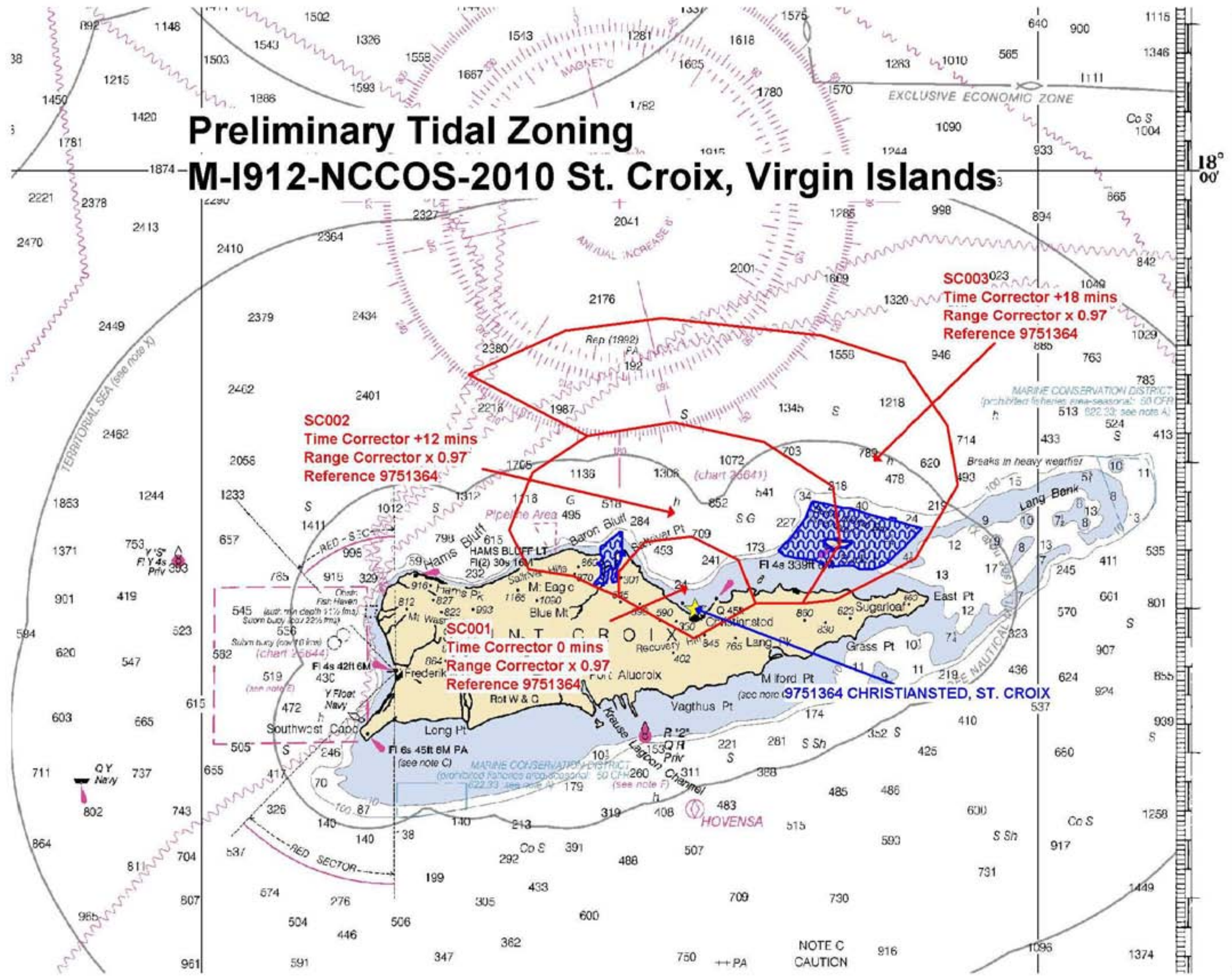
Preliminary and verified six minute water level time series data may be retrieved from the CO-OPS database via TideBot application. TideBot delivers timely preliminary/verified tidal and Great Lakes six minute water level observations via email to users on a scheduled, recurring basis. To access TideBot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

1.6 Water Level Records

Submit water level data and required station documentation as specified in the latest version of the NOS Hydrographic Surveys Specifications and Deliverables (HSSD) document. For projects where the water level data is not transmitted via GOES satellite, please submit data on a monthly basis.

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

NOAA/National Ocean Service/CO-OPS
Chief, Engineering Division
N/OPS1 - SSMC4, Station 6531
1305 East-West Highway
Silver Spring, MD 20910



Preliminary Tidal Zoning
M-I912-NCCOS-2010 St. Croix, Virgin Islands
SC002
Time Corrector +12 mins
Range Corrector x 0.97
Reference 9751364
SC003
Time Corrector +18 mins
Range Corrector x 0.97
Reference 9751364
SC001
Time Corrector 0 mins
Range Corrector x 0.97
Reference 9751364
9751364 CHRISTIANSTED, ST. CROIX
EXCLUSIVE ECONOMIC ZONE
MARINE CONSERVATION DISTRICT
HOVENSA
NOTE C
CAUTION

APPENDIX H:

CARIS Quality Control Reports

BASE Surface QC Report

Date and Time: 10/7/2010 2:20:53 PM
Surface: J:\Buck_Island\Fieldsheets\RV_Osprey\jay_review\1m_swath_recal.csar
Holiday Search Radius: 2
Holiday Minimum Number of Nodes: 6
Holiday layer created: No
Error values from: Standard Deviation

Number of nodes processed: 25464918
Number of nodes populated: 19873821 (78.04%)
Number of holidays detected: 0
IHO S-44 Special Order:
    Range: 0.000 to 30.000
    Number of nodes considered: 19475422
    Number of nodes within: 18969599 (97.40%)
    Residual mean: -0.193
S-44 Order 1a:
    Range: 0.000 to 30.000
    Number of nodes considered: 19475422
    Number of nodes within: 19412126 (99.67%)
    Residual mean: -0.453
S-44 Order 1b:
    Range: 0.000 to 100.000
    Number of nodes considered: 19873821
    Number of nodes within: 19808898 (99.67%)
    Residual mean: -0.455
S-44 Order 2:
    Range: 100.000 to 5000.000
    No depths within the specified range

Base Surface Compared to Selected Crosslines By Beam Number
Surface: J:\Buck_Island\Fieldsheets\RV_Osprey\jay_review\1m_swath_recal.csar

Beam Number	Count	Max (+)	Special Order (%)	Order 1 (%)	Order 2 (%)
1	39713	1.011	96.9	98.6	98.8
2	40914	0.906	97	98.6	98.7
3	41804	0.931	97	98.5	98.6
4	42412	1.253	97	98.6	98.7
5	43192	1.376	97.1	98.6	98.7
6	43514	1.217	97.2	98.6	98.7
7	43768	1.12	97.1	98.5	98.6
8	44241	0.982	97.1	98.5	98.6
9	44455	1.06	97	98.4	98.5
10	44754	1.296	96.9	98.3	98.4
11	44775	1.153	97	98.3	98.4
12	45050	1.115	97.1	98.3	98.4
13	45179	1.235	97.1	98.4	98.5
14	45413	1.58	97.1	98.4	98.5
15	45408	1.11	97.1	98.4	98.5
16	45627	1.079	97	98.3	98.4
17	45745	0.86	97.2	98.4	98.4
18	45775	0.874	97.1	98.3	98.4
19	45816	1.292	97.2	98.4	98.4
20	45999	1.177	97.1	98.3	98.4
21	46037	0.785	97.1	98.3	98.4
22	46183	0.78	97.1	98.2	98.3
23	46277	0.936	97.2	98.2	98.3
24	46287	0.87	97.1	98.2	98.3
25	46399	0.881	97.2	98.2	98.3
26	46419	0.822	97.1	98.2	98.3
27	46605	0.935	97	98.2	98.3
28	46597	0.914	97	98.2	98.3
29	46503	1.042	97.1	98.2	98.3
30	46600	1.091	97	98.1	98.2
31	46584	0.914	97	98.1	98.2
32	46678	1.118	97	98.1	98.2
33	46719	1.098	97	98.1	98.2
34	46698	1.096	97.1	98.1	98.2
35	46840	1.057	97.1	98.1	98.2
36	46799	1.024	97	98	98.2
37	46866	1.167	97	98	98.1
38	46937	1.033	97	98	98.2

39	46931	1.069	97	98	98.1
40	46972	1.104	96.9	98	98.1
41	46910	1.095	96.9	98	98.1
42	47035	1.065	96.9	97.9	98
43	46997	1.016	96.8	97.9	98
44	46980	0.934	96.9	97.9	98
45	46990	1.113	96.8	97.9	98.1
46	47020	1.054	96.9	97.9	98
47	47069	1.519	96.9	97.9	98
48	47108	1.477	96.9	97.9	98
49	47054	1.404	97	98	98.1
50	47042	1.341	96.9	97.9	98
51	47037	0.973	96.8	97.9	98
52	47057	1.273	96.8	97.8	98
53	47124	1.194	96.8	97.8	97.9
54	47096	1.424	96.8	97.8	97.9
55	47089	1.366	96.7	97.8	97.9
56	47103	1.284	96.7	97.8	97.9
57	47176	1.226	96.9	97.9	98
58	47070	1.219	97	97.9	98
59	47063	1.14	97	97.9	98
60	47081	1.126	96.8	97.8	97.9
61	47120	1.133	96.9	97.8	97.9
62	47089	1.134	96.8	97.8	97.9
63	47099	1.097	96.8	97.7	97.8
64	47186	1.187	96.7	97.8	97.9
65	47217	1.163	96.8	97.7	97.8
66	47219	1.124	96.8	97.7	97.8
67	47238	1.083	96.7	97.7	97.8
68	47176	0.955	96.7	97.6	97.8
69	47183	0.87	96.7	97.6	97.7
70	47308	0.865	96.7	97.6	97.7
71	47267	0.878	96.6	97.6	97.7
72	47205	1.029	96.6	97.6	97.7
73	47266	0.974	96.7	97.6	97.7
74	47287	0.951	96.7	97.6	97.7
75	47308	1.006	96.6	97.6	97.7
76	47275	1.063	96.7	97.6	97.7
77	47277	1.09	96.6	97.5	97.6
78	47284	1.306	96.4	97.4	97.5
79	47283	1.046	96.5	97.5	97.6
80	47396	0.927	96.4	97.4	97.5
81	47360	1.27	96.4	97.3	97.4

82	47391	1.266	96.3	97.3	97.4
83	47370	1.048	96.3	97.3	97.4
84	47383	1.009	96.3	97.3	97.4
85	47412	1.027	96.3	97.3	97.4
86	47434	1.032	96.4	97.3	97.5
87	47412	1.08	96.4	97.4	97.5
88	47417	1.01	96.3	97.3	97.4
89	47431	1.292	96.4	97.3	97.4
90	47401	1.001	96.4	97.2	97.4
91	47522	0.963	96.2	97.2	97.3
92	47512	1.49	96.2	97.1	97.2
93	47486	1.451	96.2	97.1	97.2
94	47488	1.423	96.2	97.1	97.2
95	47478	1.229	96.1	97	97.1
96	47489	1.264	96.1	97	97.1
97	47564	1.322	96.1	96.9	97
98	47481	1.088	96.1	96.9	97
99	47504	1.084	96.1	96.9	97
100	47478	1.057	95.9	96.8	96.9
101	47466	0.948	95.9	96.9	97
102	47421	1.128	96	96.9	97
103	47405	1.203	95.9	96.8	96.9
104	47459	0.796	96	96.9	97
105	47506	0.917	96	96.9	97
106	47392	0.903	96.1	96.9	97
107	47380	0.821	96.1	97	97.1
108	47447	1.22	96	96.9	97
109	47456	1.229	96.1	96.9	97
110	47433	1.421	96.1	96.9	97.1
111	47423	1.046	96.1	96.9	97.1
112	47381	1.477	96	96.9	97.1
113	47423	0.989	96	96.9	97
114	47399	0.922	96	96.8	96.9
115	47360	1.265	96	96.8	96.9
116	47378	1.165	96	96.8	96.9
117	47353	1.306	95.9	96.7	96.9
118	47345	1.284	95.9	96.7	96.9
119	47341	1.259	96	96.7	96.9

APPENDIX I:

Statement of Work

STATEMENT OF WORK

Data Acquisition 2010
Shallow-water Acoustic Mapping for Seafloor Characterization of St. Croix, USVI
NOAA/NOS/NCCOS/CCMA Biogeography Branch
Prepared 11/24/09

I. Introduction/Background

This project serves to acquire and produce critical baseline benthic habitat information for the Buck Island Reef National Monument (BUIS) and/or Salt River Bay National Historical Park and Ecological Reserve (SARI), St Croix, USVI. While NOAA and NPS have collaboratively conducted extensive habitat mapping and biological monitoring within and outside BUIS and SARI, funding and vessel access has never afforded the opportunity to conduct a complete bathymetric survey and seafloor characterization within the MPA's. The Biogeographic Branch proposes to conduct small boat operations using acoustic systems which are ideally suited to map the remaining shallow areas and to produce an integrated shallow to deep water bathymetric and habitat map within the MPA's. Mutlibeam backscatter and bathymetry data will be collected for two MPA regions of St. Croix (Figures 1) using the NPS Vessel R/V Opsrey, 25' Challenger Boston Whaler from April 9 to April 30, 2010. The objective of this project is to collect an acoustic bathymetric data set with 100% seafloor coverage, along with multibeam backscatter. Data will be acquired to conform to IHO Order 1 accuracy standards in depths shoaler than 40 m.

The Period of Performance of this work is three months from April 1, 2010 to June 30, 2010.

II. Work Specifications

The Contractor shall submit a cost and technical proposal in accordance with the following task descriptions. The Contractor shall provide experienced personnel to perform duties which include, but are not limited to the following tasks, listed below.

Tasks
1. Survey Planning
2. Data Acquisition and Processing
3. Data Deliverables
4. Documentation

All software and source code remains the property of NOAA-NOS. The Contractor shall provide detailed written electronic and analog documentation on all procedures and products, and quality assurance/control procedures.

Task Descriptions

1. Survey Planning

The Contractor will provide personnel of sufficient experience and qualifications to be responsible for conducting all planning, coordination, and implementation of pre-survey mobilization activities for a acoustic mapping cruise to be conducted aboard the R/V Osprey April 9 to April 30, 2010, with mobilization to occur as determined by the contractor. These tasks include, but are not limited to:

- Prior to mobilization, the Contractor will collect and process a test bathymetry and snippets backscatter dataset (in CARIS and Hypack, respectively) using the Reson Seabat 8125 system. This test area will be used to verify that the SoNAR is functioning properly and the acquired datasets come close to meeting IHO Order 1 standards.
- Development of a survey plan and data collection specifications. Working with NOAA Lead Scientist (LS-Tim Battista and project scientists Bryan Costa and Peter Mueller) to develop pre-survey line plans, a draft survey schedule, a draft data collection plan, and an inventory of any needed hardware or software. A number of different parties of various experience and background will be involved in data collection. The Contractor must articulate the data acquisition and processing procedures, as well as overall specifications, to other members of the survey group to ensure standardization of data collection. In coordination with the LS, develop an estimate of the number of personnel needed for shipboard acquisition along with a personnel list, assigned tasks, and work schedule.
- The Contractor will coordinate with the LS to ensure an adequate plan is implemented for determining real-time vertical vessel offsets due to tide levels. NOAA COOPS will perform the necessary tide zoning and provides predicted and final tide levels and zoning. The Contractor will implement PPK vertical measurements to determine real-time vessel corrections due to tidal fluctuations.
- The Contractor is responsible for the installation, maintenance, and calibration of its own pole-mounted Reson Seabat 8125, as well as the accompanying suite of necessary sensors such as a Motion Reference Unit (MRU), DGPS navigation, CTD for sound velocity profiles, and navigation, acquisition and processing software. The Contractor will provide and configure a pole-mounting system to mount the multibeam system to the vessel for the duration of the project.
- Sysetm Calibration. The Contractor will conduct the necessary planning in coordination with the LS to conduct a Patch Test of the multibeam system in the project area to determine residual biases in roll, pitch, heading, and navigation timing error. Attention should also be paid to transducer draft error and settlement and squat error. The Contractor will develop a summary of the proposed approach and location of the Patch Test prior to the survey. The results of the patch test will be used to create a CARIS vessel configuration (.hvf) file and will be documented in the NOS Patch Test Report, which should be included in the Data Acquisition and Processing Report (see Documentation section below). The Contractor will provide a summary of the Patch Test to the LS for evaluation prior to the commencement of the data acquisition portion of the cruise. The LS shall review the Patch Test Summary and provide oral Notice-to-Proceed direction to the Contractor before commencing the survey component.

The Contractor will report to the LS for the duration of the project to provide status on progress, strategize next steps, and identify any potential problems.

2. Data Acquisition and Processing

The Contractor will provide two personnel of sufficient experience and qualifications to lead the acquisition of multibeam data for the duration of the research mission. The Contractor should be experienced in managing shallow water acoustic acquisition for the purpose of seafloor characterization. This includes experience in the operation of Reson multibeam systems, POS/MV's, sound velocity correction, DGPS, data processing and cleaning, IHO standards, NOAA data collection standards, and

NOAA Biogeography standards. The Government will provide additional scientists (Bryan Costa and Peter Mueller) to assist in acquisition during the three week collection period, with the two scientists alternating during the mission.

The Contractor will manage the collection of backscatter and bathymetry data in St Croix onboard the R/V Osprey during the mission. It is anticipated that multibeam data collection will occur from 0800 to 1600 every day during that time period be may be modified due to optimum weather windows. The target IHO standard (Order 1 and 2, depending on depth) will guide all operational decisions. The maximum allowable error in measured depth includes all inaccuracies due to residual systematic and system specific instrument errors; the velocity of sound in water; static vessel draft; dynamic vessel draft; heave, roll, and pitch; and any other sources of error in the actual measurement process, including the errors associated with water level (tide) variations (both tidal measurement and zoning errors). The Contractor will confirm the correct operation of the nearest CORS station the night before data acquisition begins.

Acquisition and processing requirements include, but are not limited to, the following:

- Maximum line spacing that does not exceed 60 degrees from nadir. Line spacing shall be such that the portions of the swaths that meet the accuracy and resolution requirements overlap to ensure that no gap in coverage exists due to the uncertainty in positioning and vessel motion, ensuring 100% bathymetry and 100% backscatter coverage.
- Track lines must run parallel to each other and to the seafloor contour.
- Horizontal uncertainty (at the 95% confidence level) such that horizontal error does not exceed 5m plus 5 percent of depth.
- Vertical depth uncertainty (at the 95% confidence level) such that error does not exceed the depth dependant limits resulting from the equation $\pm\sqrt{[a^2+(b*d^2)]}$ where d=depth in meters, as specified in IHO Special Publication S-44. In depths of 0 to 100 meters a=0.5m and b=0.013, while in depths of 100+ meters a=1.0m and b=0.023.
- Usable swath width is limited to 120°, or 60 degrees to either side of nadir.
- Crosslines totaling 3% of mainscheme nautical miles will be run over the mainscheme lines at angles between 45° and 90°. A crossline comparison will be conducted as described in *NOS Specifications and Deliverables (June 2006 edition*) section 5.5.3. as a systems check and the results will be described and plotted in the Project Summary.
- Sound velocity profiles will be taken and applied via CTD casts at intervals not exceeding 4 hours apart, or when sea and weather conditions change in such a way that sound velocity in water is affected. See *NOS Specifications and Deliverables (June 2006 edition*) section 5.4.3.
- Resolution standards should be according to NOAA Hydrographic Surveys Specifications and Deliverables (April 2009) 5.1.1.2
- Multibeam bathymetry acquisition requirements will be balanced with backscatter quality considerations to minimize disruptive changes. Changes in pulse width, range (and thus, ping rate) should be avoided. Also, large changes in gain and power/ extreme gain and power settings should be avoided, and should be documented in the log book if and when they occur. Any other changes in the acquisition parameters (e.g., range scale) should also be noted in the log book.

3. *Data Deliverables*

The Contractor will deliver multibeam data in raw format only. A schematic and description of the hardware and software component and system settings should also be included. A complete description of PPK installation and operation should be provided. A schematic of vessel offsets and measurements methods should be provided. Only the raw digital data files are required. The digital format is specified in *NOS Specifications and Deliverables (June 2006 edition*) section 8.5. Observed echosounder depths must be corrected for all departures from true depths attributable to the method of sounding or to faults in the measuring apparatus.

Note that transit lines, and crosslines will be considered unusable and shall not be used to determine coverage, generate grids, or contribute to any exportable product.

Raw full resolution Multibeam dataset
Specified format dependant on ship software (Hysweep .HSX, Hypack .raw, Hypack .7k snippets)

Correctors
Including but not limited to sound velocity profiles (SVP), final tide levels and zoning, attitude and navigation correctors, PPK, raw and post-processed POS data and vessel configuration files.

III. Personnel Requirements

The resume of the proposed candidate shall be submitted to the Lead Scientist for prior approval. The proposed candidate shall have a B.S in earth or environmental science and extensive experience with hydrography, including specialized familiarity with operating a multibeam system.

IV. Travel and Other Direst Costs

This contract will cover all direct and indirect costs associated with the survey mission. This include but are not limited to shipping costs for all gear to and from the Maryland to St. Croix, USVI; travel costs (per diem, lodging, meals, and incidentals); rental car; vessel fuel costs; personnel costs; and equipment leasing.

V. Period of Performance

The period of performance for this task shall be for a minimum of four months with the Government reserving the right to extend the task. The Contractor shall perform off-site, and onboard the NPS vessel R/V Osprey. The principal period of performance shall be eight hours each day Monday through Friday except during Task 2 when a ten hour workday is expected.

VI. Reference Systems
The Contractor will provide all positions referenced to the North American Datum of 1983 (NAD83). This datum must be used throughout the survey project for everything that has a geographic position or for which a position is to be determined. Those documents used for comparisons, such as charts, junctional surveys, and prior surveys, must be referenced or adjusted to NAD 83. In addition, all software used on a survey must contain the correct datum parameters.

The Contractor will provide all positions referenced to Universal, Transverse Mercator Projection (UTM) Zone 20. Ellipsoidal heights will be computed in NAD83 reference frame using Geodetic Reference System 1980 (GRS80) ellipsoid.

All sounding data will be reduced to Mean Lower Low Water (MLLW).

VII. Deliverables

The Contractor shall provide the following deliverables.

Deliverables	**Due Date**
1. Survey Planning	4/1/10
2. Data Acquisition and Processing	5/17/10
3. Data Deliverables	5/31/10
4. Documentation	6/30/10

VIII. Designated Point of Contact

The Designated Point of Contact shall serve as a technical advisor and Assistant to the Contracting Officer's Technical Representative (ACOTR). The ACOTR shall assist the COTR in monitoring all technical aspects and assist in the administration of the contract. The Contractor shall refer to Section G.1.1 for specific guidance of the COTR and ACOTR responsibilities.

Lead Scientist/Point of Contact:	Timothy A. Battista
Address:	NOAA/NOS/NCCOS/CCMA 1305 East West Highway SSMC IV, 9th floor Silver Spring, MD 20910
Telephone No.	(301) 713-3028 ext 171
Email Addresses:	tim.battista@noaa.gov

Figure 1: 2010 Proposed Project Area St Croix, USVI