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

DATA ACQUISITION AND PROCESSING REPORT

Type of Survey **Navigable Area**

Project Nos. **S-D920-BHII-10**

Time Frame **June 2010 – July 2010**

LOCALITY

State/Territory **Delaware River, Pennsylvania & New Jersey**

General Locality **Marcus Hook to the Tacony-Palmyra Bridge**

2010

CHIEF OF PARTY
LTjg Megan Guberski, NOAA

15 August 2010

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A. EQUIPMENT

A.1 SURVEY PLATFORMS

Data for project S-D920-BHII-10, Sheet F00594 was collected on the 16.46m long R/V *Bay Hydro II* (S5401).

R/V Bay Hydro II

Figure 1: *R/V Bay Hydro II*

Table 1: Survey Vessel Characteristics, *R/V Bay Hydro II*

LOA (ft)	Beam (ft)	Draft (ft)	Max Speed	Displacement
54’	20’ 9”	5’ 9”	18 knots	42.0 tons

The *R/V Bay Hydro II* collected Multibeam Echosounder (MBES) data, and sound velocity profile data. The multibeam sonar is mounted to a pole arm and deployed through a moon pool located centerline, and aft of the house.

Figure 2: *R/V Bay Hydro II Multibeam arm, retracted*

A complete NGS survey of the vessel was performed in March 2008. For more details, refer to section C.3 of this document.

A.2 DATA ACQUSITION SYSTEMS

ODOM Echotrac MKIII Vertical Beam Echosounder.

The Odom Echotrac MKIII is a dual frequency digital recording echosounder, mounted to the hull of *R/V Bay Hydro II*. The low frequency channel is set to 28 kHz, with a pulse width of 357µsec, and the high frequency channel is set to 100 kHz, with a pulse width of 200µsec. The ping rate for both low and high frequency is set to auto, allowing the sonar to ping as rapidly as possible.

Bathymetric data from the ODOM Echotrac is used to provide generalized bathymetry across the survey area. The accuracy of the sonar's soundings was checked against a lead line on 25 May 2010 (DN145) and found to be within NOAA standards. Quality was further controlled during the survey by the collection of crosslines.

This echosounder was not used during data collection for project S-D920-BHII-10, F00594.

RESON SeaBat 7125 Multibeam Echosounder

The RESON SeaBat 7125 system is a single-frequency, digital recording Multibeam echosounder, pole mounted aboard the *R/V Bay Hydro II*. The integrated system includes a 400 kHz Projector unit, a Receiver unit, a Link Control unit (LCU), and a topside 7-P Sonar

Processor Unit (TPU). The projector and receiver are set up in a Mills Cross configuration, and the pole arm is deployed through a bomb bay door located on the center line of the vessel.

The Seabat 7125 produces a 128° across track swath, that is resolved into 512 discreet equidistance beams by the receive array. Each beam has a resolution of 1.0^{o} along track, and 0.5° across track. Sound velocity at the face of the transducer is provided by an integrated ODOM Hydrographic Systems Digibar Pro sound velocimeter. This system will be discussed in further detail in the Sound Velocity Equipment Section.

Ping rate, range, power, gain and pulse width all vary with the depth of the area being surveyed.

The 7-P Sonar Processor Unit has the following software versions installed:

7K Center:	Version 3.0.7.1
7K IO:	Version: 3.2.0.7
7K UI:	Version 3.5.1.4

Bathymetric data from the RESON 7125 is used to provide object detection in shallow water. Since no VBES data was collected, there was no Vertical Beam to Multibeam comparison completed. Quality for MBES data was controlled by the high degree of overlap between congruent lines and by a comparison of Mainscheam MBES lines to MBES crosslines.

Diver's Least-Depth Gauge (DLDG)

The *R/V Bay Hydro II* does not maintain a Diver's Least Depth gauge.

Lead Line

The *R/V Bay Hydro II* does not maintain a traditional lead line. In lieu of this equipment, a lead was attached to a metal measuring tape and measurements were corrected to account for the weight assembly. A lead line comparison to the Odom Echotrac VBES and RESON 7125 was performed 17 March, 2010 (DN 076).

Copies of the lead line calibration reports are included in Appendix III of this report.

KLEIN 5000 High-Speed Side Scan Sonar

The Klein High Speed, High Resolution Side Scan (SSS) Sonar system is a beam-forming acoustic imagery device that is towed behind the *R/V Bay Hydro II* via a hydraulic A-frame. The KLEIN 5500 towfish operates at a frequency of 445 kHz with a vertical beam angle of 40°, and can resolve up to 5 discreet received beams per transducer stave. The integrated system includes a KLEIN 5500 light weight towfish, a tow cable telemetry system, and a Transceiver/Processing Unit (TPU).

Positioning of the Towfish is calculated using CARIS SIPS, and is derived from the amount of cable out (a physical measurement manually entered into the acquisition program), towfish depth

(from the towfish pressure depth), the vessels Course Made Good (CMG), and the vessels heading. The calculated towfish position is then sent to the sonar data collection system in the form of a GGA NMEA string, where it is merged with the sonar data file.

Towfish altitude above the bottom is maintained between 8% and 20% of the range scale. In regions of significantly shallow water, a float is attached to the towfish to prevent the sensor from striking bottom during speed changes. The float is adjusted to keep the towfish at the altitude required by the Hydrographic Survey Specifications and Deliverables; however choppy seas can induce motion in the towfish. The resultant imagery is degraded, but remains within object detection limits.

Vessel speed is adjusted during SSS acquisition to insure that along-track coverage for object detection, as required by the NOS Specifications and Deliverables, is met. Confidence checks are performed by noting changes in linear bottom features extending to the outer edges of the digital side scan image, and by verifying aids to navigation or other known features on the side scan record.

A.3 POSITION AND ORIENTATION EQUIPMENT

APPLANIX POS/MV

The *R/V Bay Hydro II* uses a blended DGPS and inertial position orientation solution to position the vessel in space.

Position information for the vessel is acquired using a Trimble DSM212L DGPS receiver – an integrated 12-channel GPS receiver capable of receiving external RTCM correctors from a shore based reference station. The system operates at 1 Hz, with an expected accuracy of less than one meter, provided at least 5 satellites are visible. The software TSIPTalker is used to manual set the RTCM beacon, and to monitor system accuracy.

Inertial position calculations are provided by an Applanix POS/MV v4. The POS MV v4 system includes dual GPS antennas, an inertial measurement unit (IMU), and data processor (PCS). The IMU measures linear and angular accelerations corresponding to the major motions of the vessel (heave, pitch, roll, yaw) and inputs this data to the PCS, where it is combined with a GPS position (determined by carrier-phase disambiguation) to give a final position solution.

Position accuracy and quality is monitored in real time, using the MV-POSView Controller software to ensure positioning accuracy requirements in the NOS Hydrographic Surveys Specifications and Deliverables are met.

The *R/V Bay Hydro II* uses True Heave to capture long period sea swells that cannot be detected using short period heave calculations. True Heave data is acquired in a separate raw file and applied in post processing.

A.4 SOUND VELOCITY PROFILES

Sea-Bird CDT Profilers

The *R/V Bay Hydro II* uses a Sea-Bird Electronics SeaCat SBE19+ Conductivity, Temperature, and Depth (CTD) profiler to collect sound velocity profiles. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated from strain gauge pressure. CTD casts are processed using **VELOCWIN** software, and applied to MBES, SSS, and VBES data using **CARIS HIPS**.

CTD calibration reports and dates are included in Appendix III of this report.

ODOM Hydrographic Systems Digibar Pro

The Digibar Pro is a sing-around transducer, measuring the speed of sound in water by finding the time needed for a ping to travel a known distance. The *R/V Bay Hydro II* uses a Digibar Pro to acquire speed of sound at the face of the RESON 7125 transducer. Data is then sent real time to the RESON 7125 processor unit.

Calibrations for the Digibar can be found in Appendix III of this report.

A.5 SOFTWARE

A.5.1 ACQUSITION SOFTWARE

HYPACK
Hypack is used to acquire VBES data in a *.raw format, and detached positions, in a *.tgt format. It is also used for vessel navigation during data acquisition.

HYSWEEP
Hysweep is a module for Hypack used to acquire RESON 7125 MBES data in a *.HSX format. It receives input from The Reson 7125, the Digibar Pro, and the Applanix POS/MV systems.

KLEIN SONAR PRO
Sonar Pro is used to collect SSS data in a *.sdf format.

A.5.2 DATA COLLECTION AND PROCESSING SOFTWARE

CARIS HIPS & SIPS

CARIS HIPS (Hydrographic Information Processing System) is used for the initial processing of Multibeam echosounder data. The program applies vessel offsets to the raw sonar data, corrects for tide and sound velocity, and calculates a Total Propagated Uncertainty (TPU) for each sounding. Individual soundings are then processed into CUBE (Combined Uncertainty and Bathymetry Estimator) grids.

CARIS SIPS (Side-Scan Information Processing System) is used for processing of side-scan sonar imagery, including cable layback correction, slant range correction, contact selection, tow point entry, and mosaic generation.

HSTP PYDRO

HSTP PYDRO is a program for the classification of side-scan sonar and Multibeam bathymetry contacts and for the creation of preliminary smooth sheets. Multibeam contacts (designated soundings), side-scan sonar contacts, and detached position contacts are analyzed, grouped, and assigned S-57 classifications. The bathymetric grid is imported for comparison between surveyed and charted depths, and to the side scan contacts. The sounding selection interval is dependent on the survey scale. The final product is a Preliminary Smooth Sheet file (PSS), which is delivered to the Atlantic Hydrographic Branch as part of the final submission package.

PYDRO is also used for chart comparisons, generation of chartlets, generation of Danger to Navigation reports, generation of appendices to the Descriptive Report, compilation of survey statistics, and generation of standard NOAA forms such as the Descriptive Report cover sheet.

HSTP VELOCWIN

HSTP VELOCWIN is a program used for the processing sound velocity casts. This program uses Sea-Bird Electronics SeaSoft software to convert hexadecimal SeaCat data into ASCII data, then converts the ASCII data into a depth-binned sound velocity file. The resulting .svp files are applied to MBES, SSS, and VBES data during post processing to correct for sound velocity variation within the water column.

MAPINFO Professional

MapInfo is the Geographic Information System (GIS) software package used to plan survey lines.

B. DATA PROCESSING AND QUALITY CONTROL

B.1 DATA ACQUSITION

During data acquisition the Hydrographer-In-Charge (HIC) is responsible for maintaining data quality. A HIC's primary responsibility is to monitor the quality of the incoming data; and watch

for alarms. SONARPRO and HYSWEEP show visible alarms if necessary inputs drop out, and the POS/MV alarms if positioning accuracies degrade past allowable thresholds.

B.2 DATA PROCESSING

After acquisition, all data is converted and analyzed. The following is a description of the work flow used for each type of data.

VBES Data

- Convert VBES data using CARIS HIPS;
- Scan Navigation and Attitude data, flagging erroneous data as rejected;
- Apply tide and speed of sound corrections, compute Total Propagated Uncertainty
    - Uncertainty values in the HVF follow recommendations of NOAA Field Procedures Manual (FPM), Appendix 4,
        - With the exception of MRU alignment uncertainties, which are calculated using the standard deviation of all angular biases found during a patch test;
    - For tidal zoning and speed of sound error modeling, refer to section B.2.4 of the Descriptive Report;
- Clean data using CARIS Single Beam Editor, flagging data from the water column and sub-bottom returns as rejected,
    - When definition of the true bottom is ambiguous, the full water column data can be inspected by viewing the HYPACK created .bin files using the Post Acquisition Tool;
- Create CARIS BASE Uncertainty Weighted Grids at 5 meter resolution.
    - For an in-depth discussion of how each sounding's TPU is propagated to the grid node, refer to the Bathymetric Processing section of the FPM,
- Analyze grids for features and for areas of shoaling; flag for development by a Multibeam sonar.

MBES Data

- Convert MBES data using CARIS HIPS,
- Apply True Heave; correct for tide and speed of sound; compute Total Propagated Error
    - Uncertainty values in the HVF follow recommendations of FPM, Appendix 4,

        - With the exception of MRU alignment uncertainties, which are calculated using the standard deviation of all angular biases found during a patch test;

    - For tidal zoning and speed of sound error modeling, refer to section B.4.1 of the Descriptive Report;

- Scan Navigation and Attitude data, flagging erroneous data as rejected;

- Initial data cleaning using Swath Editor to reject gross flyers;

- Create CUBE grids. Grid resolution is dictated by the type of coverage required (Complete Coverage vs. Object Detection) and the depth of the water. Compliance with HSSD gridding requirements is strictly observed,

    - For an in-depth discussion of how the CUBE algorithm creates and disambiguates depth hypothesis, refer to the Bathymetry Processing section of the FPM,

    - For a discussion of disambiguation method used, refer to section B.4.2 of the Descriptive Report;

- Review the CUBE grids for holidays,

    - Create an initial holiday line plan;

- Review the uncertainty layer of the each CUBE grid. Address each area where uncertainly falls outside of the standards set by HSSD;

- Review the density layer of each CUBE grid for compliance with HSSD specified density requirements,

    - Add areas of rarefaction to the holiday line plan;

- Examine all surfaces for erroneous surface designation and evidence of systematic errors, for features, and for evidence shoaling,

    - Significant features are flagged ‘designated’, forcing the CUBE algorithm honor the depth of the sounding.

SSS Data

- Convert SSS data using CARIS SIPS;

- Scan Navigation and Attitude data, flagging erroneous data as rejected;

- Re-Compute towfish navigation. This is when tow point offsets and horizontal layback is applied to the data;

- Slant Range correct each line of data;

- A primary reviewer scans each line for significant contacts,

- A secondary reviewer makes an independent check-scan of all lines, verifying contacts and checking for missed contacts;

- If the Project Instructions call for 200% Side Scan coverage, the scanners check for correlation of contacts between 100% and 200% coverage,

    - Correlation is also used to reveal systematic errors, particularly if a contact shows up on lines collected in opposite or orthogonal directions;

- Create individual mosaics for 100% and 200% coverage. Examine for coverage,

    - If necessary, create a holiday line plan;

- Check each contact to ensure that it has Object Detection level Multibeam data over the feature.

B.3 FEATURE CLASSIFICATION AND ANALYSIS

Once all bathymetric and imagery data have been examined for quality and coverage, all designated soundings and SSS contacts are inserted into PYDRO. The hydrographer then examines each individual contact, grouping together multiple contacts that define an individual feature.

When a single feature has more than one associated contact, one of the contacts is made primary. The following criteria are used to classify contacts:

- MBES contacts will be classified as primary contacts over SSS, DP, and GP contacts;

- If there are two or more MBES contacts for the same feature, the MBES contact of least depth is classified as the primary contact;

- If there is no bathymetry contact for a feature, then the SSS position will be classified as primary contact over DP and GP contacts;

- If there are two or more SSS contacts for the same feature, then the SSS contact that best represents the feature is classified as the primary contact;

- If there are no bathymetry or imagery contacts, then the DP contact that best represents the feature is classified as the primary contact.

All features are then re-examined for significance. At this level of data analysis, significant is defined as meeting the criteria specified in HSSD (significant features are at least 1m x 1m x 1m in ≤ 20m of water, or a cube measuring 5% of the depth in > 20m of water) and being relevant at chart scale. Features that are found to be significant are flagged reportable. Features that pose a danger to navigation are further flagged as a "DTON", and a report is sent to the Marine Charting Division (MCD)

All reportable features are then given an IHO S-57 attribution. Features that already appear on the chart are assigned a keyword of 'chart', while new features are given a keyword of 'un-charted'. Each primary feature, both reportable and non-reportable, is then flagged as 'resolved'.

C. CORRECTIONS TO ECHO SOUNDINGS

C.1 SOUND SPEED CORRECTION

Speed of Sound

Sound speed values at the transducer face are applied real-time. Accuracy of the transducer is checked against the data point closest to the transducer depth on every CTD cast.

The ODOM Digibar Pro is factory calibrated annually. Calibration reports can be found in Appendix III of this report.

CTD Profiles

Sound velocity profiles are taken once per week for VBES acquisition, and once every 2 - 4 hours for MBES. Profiles are collected more frequently when transiting more than 1 nautical mile between survey areas, or when current and weather conditions warrant. Sound velocity casts are applied to all bathymetric data during post processing.

The Sea-Bird CTD is sent for factory calibration annually. Calibration reports can be found in Appendix III of this report.

C.2 WATER LEVEL CORRECTORS

During data acquisition, bathymetric data is initially reduced to Mean Lower-Low Water (MLLW) using preliminary (observed) water level data. Water level stations and zone files are assigned by the Center for Operational Oceanographic Products and Services (CO-OPS). Preliminary water levels are downloaded though the CO-OPS website in six-minute intervals and applied to the data at the end of each day.

After acquisition is complete, preliminary tide levels and zoning are examined for veracity by CO-OPS. Once the field unit receives verification that levels and zoning are accurate, all bathymetric data is then re-reduced to the verified levels.

C.3 VESSEL OFFSETS AND DYNAMIC DRAFT CORRECTORS

R/V Bay Hydro II

An NGS survey of *R/V Bay Hydro II* was performed on 23 March 2009 using optical levels. Dynamic Draft values were determined on 2 March 2010 using the echosounder technique.

All vessel offsets are included in the HIPS Vessel file reports in Appendix II.

C.3 HEAVE, PITCH, ROLL AND HEADING, INCLUDING BIASES AND NAVIGATION TIMING ERRORS

The acquisition suite of the *R/V Bay Hydro II* is configured to use "Precise Timing". This method reduces latency, thereby minimizing timing errors, by sending UTC messages to the processing units of each sonar. This allows all SSS and MBES data to be time stamped at acquisition, instead of upon arrival at the acquisition computer. For more detailed information on this setup, see the Field Procedures Manual.

Patch tests are conducted throughout the year, following any removal or replacement of the RESON 7125 transducer head. These patch tests are used to determine and correct any angular bias between the IMU reference frame, and that of the sonar. Patch tests are also used to detect any remaining latency between navigation and bathymetric data, however the precise timing setup generally leaves no latency in the system. Results of all patch tests are included in the CARIS Hips Vessel Files (HVF) reported in Appendix II. All HVFs are digitally submitted with project data.

As per the HSSD, pitch and roll are not applied to VBES soundings.

Notable Modifications:

- RESON 7125 projector, receiver, and LCU removed 22 May 2010 (DN 142)
- Projector receiver and LCU installed 15 June 2010 (DN 166)
- Patch Test on 22 June 2010 (DN 173)

D. APPROVAL

As Chief of Party, I have ensured that standard field surveying and processing procedures were utilized in accordance with the Hydrographic Manual, Fourth Edition; Hydrographic Survey Guidelines; Field Procedures Manual, and the NOS Hydrographic Surveys Specifications and Deliverables.

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

Megan R. Guberski

Digitally signed by Megan Guberski
Date: 2010.08.19 13:12:58 -04'00'

LTjg Megan R. Guberski, NOAA
OIC R/V Bay Hydro II