Data Acquisition and Processing Report

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OPR-N411-NRT3-06
Everett, Washington
Hydrographic Letter Instructions dated February 17, 2006
And Change No. 1 dated March 27, 2006
Team Leader: Kathryn Simmons

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This report includes descriptions of equipment used and methods employed by Navigation Response Team 3 during acquisition and processing of hydrographic survey data. It does not necessarily apply to fast-track data – a separate report will accompany data submitted directly to the Marine Chart Division.

A. EQUIPMENT

At the beginning of this survey NOAA Survey Launch S1212 was used to acquire single-beam echosounder data, side scan sonar data, and detached positions. Following completion of hydrographic data collection on May 5, 2006, the vessel underwent structural modifications to accommodate installation of a Simrad multibeam system. The refit, vessel survey and repainting were approaching completion when, in the early morning hours of July 5, a massive fire occurred at NOAA's Pacific Marine Center which destroyed the NRT office trailer, including all of the side scan data and almost all of the hydrographic data. The lost data were reacquired with the reconfigured vessel.

Launch S1212, a 27-foot, SeaArk Commander (SAMA115510000), was acquired in January 2001. In August 2004 the hull was extended to 30 feet to accommodate the weight of the two 150-horsepower Yamaha four-stroke outboards which power the vessel. The launch is eight feet wide, displaces 4.8 tons, has a static draft of 0.4 meters and is equipped with a Dell Pentium II PC for running the primary acquisition software.

Trimble backpack DGPS systems were used to position fixed aids to navigation and high water features. These positions have been submitted directly to the Marine Chart Division via Fast Track.

1. Sounding Equipment

a. Single-Beam Echosounder (SBES)

An Odom Echotrac CV vertical beam echosounder (VBES) employing a single-frequency transducer with beam width set at eight degrees is used for single beam data collection from March 30, 2006 to May 5, 2006 (DN 089 to 123). The echosounder, which is operated at 200 kHz, records both analog and digital data which may be acquired in feet, or meters. Soundings were acquired in meters with an assumed speed of sound through water of 1500 m/sec. During data collection the echosounder is controlled and the trace is monitored via an Ethernet driver connection to the HYPACK Survey program. The echosounder trace is recorded to .BIN files which were logged automatically alongside HYPACK line files during acquisition. These files were used for reference during digital data processing.

Lead line checks were performed periodically throughout the project to verify fathometer accuracy. The leadline was calibrated in June 2006; however, the report was lost in the fire at PMC. A new calibration report will be created for 2007.

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Coastal Oceanographic's HYPACK Max Survey Software is used for vessel navigation and line tracking during hydrographic data acquisition. The HYPACK software is also used to log "raw" VBES data and to record detached positions in the form of .tgt files.

b. Shallow Water Multibeam (SWMB)

In July 2006, installation of a Kongsberg Simrad EM3000 shallow water multibeam (SWMB) echosounder was completed. The system consists of a sonar head and a processing unit. The EM3000 operates at a single-frequency of 300 kHz; it has a maximum ping rate of 40 Hz and 127 beams per ping. Each beam has a fore-aft width of 1.5° and a port-starboard width of 1.5°+. Depth range from the sonar head is 1 to 150+ meters, depth resolution is 1 cm and depth accuracy is 5 cm RMS. Range sampling rate is 14 kHz.

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The sonar head is fixed-mounted to the aft hull of the vessel at the keel, directly beneath inertial measurement unit (IMU). The head contains a flat-face transducer (Mills Cross configuration) and transmitter and receiver elements all encased in an acoustically transparent medium. The transmit beam is steerable to compensate for mounting angle and vessel pitch.

Beam forming and bottom detection are performed by the processing unit which controls the sonar head with respect to gain, ping rate and transmit angle. The processing unit also contains the interfaces for all time-critical external sensors such as attitude data, position, and the pulse per second (PPS) signal.

EM3000 controller software, operating on the HYPACK computer and communicating via Ethernet connection, is used to control adjustable parameters such as range scale, power, gain and pulse width. Real time sound velocity measurements are acquired by a Digibar Pro sound velocity probe mounted on the transom and are transmitted by the controller software to the processing unit for initial beamforming and steering.

On September 5, 2006, a patch test was performed with the EM3000 to determine residual biases of the system. The results are included in Appendix V.

To verify proper operation of the MBES, lead line comparison tests are performed periodically.

Coastal Oceanographic's HYPACK Max Survey and Hysweep programs are used for vessel navigation and line tracking, as well as swath and coverage monitoring during SWMB data acquisition. Device parameters are monitored during acquisition with the EM3000 and POS controller software programs operating on the HYPACK computer. MBES data are logged in the HYPACK "raw" format, with files ending in the .HSX extension.

c. Side Scan Sonar (SSS)

The vessel is equipped with a Klein 3000 sonar system. The system includes:

- Dual frequency (100 kHz, 500 kHz) towfish with 300 PSI pressure sensor
- Transceiver Processing Unit (TPU)
- Workstation Display and Control Unit (WDCU)
- Thirty-five meters of Kevlar reinforced tow cable
- SonarPro software and VX Works TPU operating system

The horizontal beam widths for the low and high frequencies are 1° and 2°, respectively; vertical beam width is 40°. Maximum range scale for the Klein 3000 is 150 meters at high frequency, 500 meters at low frequency. Only the high-frequency data is recorded and stored in the data base; the low frequency image is monitored during data collection but not converted separately.

A range scale of 100 meters is maintained except in very deep water, when the scale is increased to 150 meters, or in very shallow water or during development of submerged obstructions, when the scale may be reduced to 75 or 50 meters. The towfish height above the bottom is maintained at 8 to 20 percent of the range scale whenever possible. Exceptions occur in very shallow areas or in areas where rapidly changing terrain raises the risk of hitting the towfish on the bottom.

Side scan sonar lines are spaced according to the range scale appropriate for water depth to assure overlap of at least 25 meters and to assure 200% coverage.

Vessel speed is maintained at or below five knots to ensure that an object one meter square could be detected across the sonar swath. Confidence checks are performed by observing the outer edges of the sonargram while moving alongside pier faces or known submerged targets.

All SSS data collection is controlled with SonarPro software operating in a Microsoft Windows 2000 environment on the WDCU. Signals are sent to the towfish and data is received from the towfish via the TPU. The sonar data are recorded digitally and stored on the WDCU in the Klein SDF format.

Launch S1212 is equipped with a Dynapar cable counter that logs the length of deployed towfish cable to the WDCU via the HYPACK Delph signal. The measurements are made by counting revolutions of the towing block on the J-frame. Before each use, the cable counter is calibrated by adjusting the readout to reflect the measured marking on the towfish cable at the tow point.

d. Diver Least-Depth Gauge

Deleted: A certification test of the system for object detection and positioning is included in Appendix.¶
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Not applicable

2. Positioning and Orientation Equipment

a. Trimble DSM212L

The launch is equipped with a Trimble DSM212L integrated 12-channel GPS receiver and a dual-channel DGPS beacon receiver. The beacon receiver can simultaneously monitor two independent U.S. Coast Guard (USCG) DGPS beacons. There are three modes: Auto-Range, which locks onto the beacon nearest the vessel; Auto-Power, which locks onto the beacon with the greatest signal strength; and Manual, which allows the user to select the desired beacon. Additionally, the DSM212L can accept differential correctors (RTCM messages) from an external source such as a user-established DGPS reference station.

The following parameters are monitored in real-time through Trimble's TSIP Talker software to ensure position data quality: 1) number of satellites used in the solution, 2) horizontal dilution of precision (HDOP), 3) latency of correctors, and 4) beacon signal strength. The DSM212L is configured to the auto-power mode, to go off-line if the age of DGPS correctors exceeds 20 seconds, and to exclude satellites with an altitude below eight degrees.

Prior to multibeam installation, the Trimble DSM212L supplied the position data to the HYPACK system; it currently supplies only DGPS correctors.

b. Applanix Position and Orientation System for Marine Vessels (POS MV)

The POS MV includes the following components which work together to provide position and attitude information to the data acquisition systems on S1212:

- POS MV rack mount POS Computer System (PCS)
- Inertial Measurement Unit (IMU)
- Two Identical Trimble Zephyr GPS Antennas

The PCS contains the two GPS receivers, primary and secondary, along with interface cards to communicate with and process the IMU and GPS data.

The primary GPS receiver is a 24-channel Trimble BD950 which receives differential (RTCM) correctors through the PCS and provides position and velocity information. The secondary receiver provides the information necessary to compute heading using carrier phase differential measurements between the two receivers. Two Trimble Zephyr antennas, corresponding to the two receiver cards, are mounted 1.90 meters apart atop the launch cabin. The port side antenna is the primary antenna.

The IMU comprises three solid-state linear accelerometers and three solid state gyros which work together with electronics to provide digital measurements of acceleration in three directions and motion measurements around all three axes of the IMU.

The POS MV is operated and monitored with the POS MV Controller software operating on the HYPACK computer and sends position and orientation data through the Simrad EM3000 processing unit to the HYPACK data files.

Tables listing data acquisition hardware and software are included in Appendix I.

B. DATA PROCESSING AND QUALITY CONTROL

1. SBES and SWMB Data

Both SBES and SWMB raw data are converted from HYPACK to the CARIS HDCS format using the CARIS HIPS conversion wizard. Navigation and attitude data are examined using CARIS HIPS attitude and navigation editors. Evident fliers are rejected and the track line between good navigation points is either interpolated or rejected. The digital SBES depths are compared with the trace recorded in the echosounder .Bin files. The digital record is edited when warranted to ensure that peaks of shoals and abrupt changes in slope are properly depicted. SWMB swath data are examined and edited when necessary in Subset Editor and in Swath Editor.

Corrections to soundings (see Section C below) are applied during the final merge process in HIPS.

2. Side Scan Sonar (SSS) Data

Raw SSS data are also converted to the CARIS HDCS format using the CARIS HIPS conversion wizard and then reviewed with the attitude and navigation editors in the same manner as the sounding data. The

CARIS Sensor Layout tool is used to examine the values of the active sensors, cleaning where necessary. Towfish navigation is recomputed, bottom tracking (fish height) is corrected if necessary, and the sonargram is slant-range corrected. The sonargram is then examined for significant contacts (shadow height of 1.0 meter or greater). Contacts selected for development are exported to Mapinfo, where the HydroMI program is used to generate HYPACK target and line files. Assurance that adequate side scan coverage has been acquired is achieved through the generation of mosaics in a CARIS field sheet – one mosaic for the first 100% and one for the second 100%.

3. Processing Software

CARIS HIPS and SIPS software is used to convert, edit and analyze all sounding and side scan data and to apply vertical and horizontal correctors,

NOAA's Pydro software supplied by the Hydrographic Systems and Technology Program (HSTP) is used for analyzing sounding data and SSS contacts, for processing and editing detached positions, and for decimating data in the creation of preliminary smooth sheet (PSS) files.

HSTP's HydroMI Mapbasic program is used in combination with MapInfo software for a number of Pre and Post-Survey applications.

HSTP's VelocWin program is used to process sound velocity data obtained with a Seacat SBE-19 CTD, and an Odom Digibar profiler.

4. Data Decimation and Field Sheet Production

SWMB data acquired for H11556 were compiled into one Field Sheet containing five CARIS BASE surfaces. See Section B4 in the Descriptive Report for this survey.

For this 1:5,000 scale survey, data were imported into a Pydro Preliminary Smooth Sheet (PSS) using shoal-biased "line-by-line" binning and a cell size of 1.5 millimeters at survey scale. The resultant thinned data were then re-excessed in Pydro using a 3-millimeter character size. Final Mapinfo data plots were created with the HydroMI Mapbasic tool.

Tables listing data processing hardware and software are included in Appendix I.

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Data processing flow diagrams are included in Appendix II.

C. CORRECTIONS TO ECHO SOUNDINGS

1. Sound Velocity

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The speed of sound through the water is determined by sound velocity casts conducted in accordance with the NOS Hydrographic Surveys Specifications and Deliverables (HSSD) Manual

From the beginning of the project through May 2006, corrections for speed of sound through the water column were computed from data obtained with an Odom Digibar Pro velocimeter. All subsequent sound velocity measurements are obtained with an SBE-19 Seacat CTD. NOAA's VelocWin software is used to process casts and generate sound velocity files for CARIS HIPS. Sound velocity correctors are applied to sounding data in CARIS HIPS using the 'nearest in time' sound velocity cast.

Calibration reports for the Odom Digibar and SBE-19 Seacat are included in Appendix IV of this report. Dates and locations of the sound velocity casts are included in Separate II of the survey descriptive report.

2. Vessel Offsets, Dynamic Draft, and True Heave Correctors

a. Static Draft

For data acquired prior to the August multibeam refit, the static draft measurements for Launch S1212 calculated on October 4, 2004 *(DN 278)* were applied. For data acquired after the August multibeam refit, static draft measurements were calculated on August 16, 6006 *(DN 228).*

The following procedure was employed: First, the depth of the transducer face from a reference mark on the hull was measured. Next, with the launch in the water, fuel tanks half full and two persons aboard, the depth from this reference mark to the waterline was measured. Combining the two measurements, a static draft of 0.4 meters was calculated.

b. Dynamic Draft

Dynamic draft measurements acquired on October 4, 2004 (DN 278) in Grays Harbor near Ocean Shores, WA, were applied to data acquired prior to multibeam installation After the multibeam refit, new dynamic draft measurements were calculated on August 16,2006 (DN 228), using the single beam echosounder and the method described in FPM 1.4.2.1. Data for the measurements were acquired over a region selected for minimum cross-track error.

Offsets measured from the reference point to the transducer, sensors and antenna were, together with static and dynamic draft correctors, incorporated into the 'vessel config' files and applied during the merge process in CARIS. Offset diagrams and CARIS vessel config files are included in Appendix III.

c. True Heave

During data collection, true heave corrections were logged through the POS MV Controller to a separate data file and applied to the hydro data during post-processing.

3. Tide Correctors

The operating National Water Level Observation Network (NWLON) station at Seattle, WA (944-7130) served as datum control for the survey area.

Verified, six-minute water levels relative to Mean Lower Low Water were downloaded from the NOAA, NOS, Center for Operational Oceanographic Products and Services (CO-OPS) web site: (http://tidesandcurrents.noaa.gov/olddata). These were imported into a text file on a local computer and appended to the CARIS tide file, 9447130.tid.

There are seven tide zones within the project limits. Time and range correctors, referenced to the tide station at Seattle, WA, are provided in the zoning file ***N411NRT32006CORP_rev.zdf*** which is included with the project data.

Using the CARIS HIPS Load Tide process, soundings are sorted into the appropriate tide zone; time and range adjustments are computed and applied to the verified tides in each zone.

All correctors are finally applied to the data using the CARIS "Merge" utility. The corrected depths are then used by Pydro for the generation of preliminary smooth sheets (PSS).

D. APPROVAL

As Chief of Party, I have ensured that standard field surveying and processing procedures were used 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 2004.

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

Approved and Forwarded: ________________________________

Kathryn Simmons
Navigation Response Team 3