LIST OF FIGURES AND TABLES

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DIGITAL SEPERATES

HVFs, DeviceModel, SeaCat config files, DLDG cal file, SAND1 (Trimble field data), and Sound Speed DQA data.

INTRODUCTION

This hydrographic project was completed as specified by Hydrographic Survey Letter Instructions OPR-P183-FA, signed May 3, 2006. This Data Acquisition and Processing Report applies to sheet B (H11580), sheet G (H11582). Both sheets have the general locality of Shumagin Islands and Vicinity in the state of Alaska.

Survey specific details will be listed in Descriptive Reports as needed. Unless otherwise noted, the acquisition and processing procedures used and deliverables produced are in accordance with the *Standing Instructions for Hydrographic Surveys (February 10, 2006)*, the *NOAA Hydrographic Survey Specifications and Deliverables (NHSSD)(March 2003)*, and the *Field Procedures Manual (FPM) v2.1 (May 2006)*. Hydrographic Surveys Technical Directives (HSTD) 2004-1 through 4, 2005-1 and 2006-1 through 5 were followed during the course of this project.

A EQUIPMENT

Detailed descriptions of the equipment and systems, including hardware and software, used for bathymetric data acquisition, horizontal and vertical control operations, shoreline acquisition, and processing are listed below.

I. Inventory

1.0 Hardware

1.1 Hardware Systems Inventory

Below are tables listing the hardware systems used by the NOAA ship FAIRWEATHER and her launches for this project. Detailed hardware information, including installation dates and serial numbers, is included in Appendix I of this report. Manufacturer's product specifications are included in Appendix II.

1.1.1 Integrated Hardware

The integrated hardware testing was completed by FAIRWEATHER personnel and is outlined in Section 3 of this report. Testing procedures and results are detailed in the individual vessel reports located in Appendix III.

Multibeam Echosounders (MBES)
Reson Seabat 8111ER
Reson Seabat 8101ER
Reson 81-P Processor
Reson SeaBat 8160

Positioning
POS/MV 320 v3 with TrueHeave
POS/MV 320 v4 with TrueHeave

Table 1: Integrated Hardware

1.1.2 Auxiliary Hardware

The calibration information and testing procedures, associated with the auxiliary hardware equipment, are discussed in the following sections.

Manual Sounding Equipment
Leadlines

Positioning
MBX-3S DGPS receiver
Trimble Backpack
Impulse LR Hand-held Laser
Ashtech Z-Extreme GPS receiver

Sound Velocity
SBE 45 Micro Thermosalinograph (TSG)
SBE 19*plus* SEACAT Profiler
Moving Vessel Profiler (MVP)

Vertical Control
Carl Zeiss NI2 333 level
Leica NA2 100 level

Table 2: Auxiliary Hardware

1.2 Echo Sounding Equipment

1.2.1 RESON 8111ER Multibeam Echosounder (MBES)

FAIRWEATHER is equipped with a RESON SeaBat 8111 MBES with the Extended Range (ER) and snippet options. The 8111ER is a 100 kHz multibeam system with swath coverage of 150°. The swath is made up of 101 discrete beams with an along-track and across-track beamwidth of 1.5°. The typical operational depth range of the 8111ER on the FAIRWEATHER is 20 to 600 meters. No calibration information was provided by the manufacturer for the system.

The 8111ER is hull-mounted within a reinforced projection that extends 27 inches below the keel. It is located 39.5" starboard of the centerline at approximately frame 29. It has a specified depth range of 3 to 1200 meters.

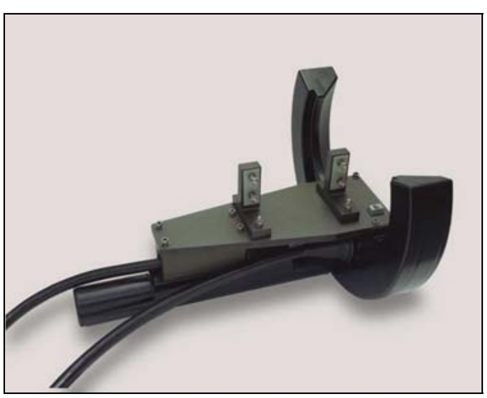

Figure 1: RESON SeaBat 8111ER MBES

Figure 2: RESON SeaBat 8111ER MBES on FAIRWEATHER

Figure 3: RESON SeaBat 8160

Figure 4: RESON SeaBat 8160 on FAIRWEATHER

1.2.2 RESON 8160 Multibeam Echosounder (MBES)

FAIRWEATHER is equipped with a RESON SeaBat 8160 MBES with the snippet option. The 8160 is a 50 kHz multibeam system with a swath coverage of 4x water depth. Each swath is made up of 126 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of 10 to 3000 meters. No calibration information was provided by the manufacture for the system.

The 8160 is hull-mounted within a reinforced projection that extends 13.6 inches below the keel. It is located 54 inches port of the centerline at approximately frame 29.

1.2.3 RESON 8101ER Multibeam Echosounder (MBES)

Survey Launches 1010 and 1018 are each equipped with a RESON SeaBat 8101 MBES with the Extended Range and snippet option. The 8101ER is a 240 kHz multibeam system with a swath coverage of 150°. The swath is made up of 101 discrete beams with an along-track and across-track beamwidth of 1.5°. It has a specified depth range of up to 500 meters. The typical operational depth range of the 8101 on launches 1010 and 1018 in 2006 was 3 to 120 meters. Under optimal conditions with a hard bottom, high power and high gain, the depth range of the 8101 ER was observed to be as deep as 350 m producing a swath of ±45º from nadir. No calibration information was provided by the manufacturer for the system.

Each system is attached to a launch using a swing mount which is to the starboard of the keel and approximately centered fore and aft (see Figures 5 & 6).

Figure 5: Launch 1010 with 8101 down

Figure 6: Launch 1010 with 8101 up

1.3 Manual Sounding Equipment – Lead Lines

Vessels 1010, 1018, 1706, and 2302 are each equipped with a lead line. Lead lines are used for depth measurements usually near shore and for echosounder depth comparison.

Leadlines were created, measured and calibrated according to Section AF.1, pages AF1-3 in the 1976 NOS Hydro Manual. Calibration was performed on December 14th, 2005. Calibration reports for the leadlines are included in Appendix V. The leadlines were not used for this project.

1.4 Positioning, Heading, and Attitude Equipment

1.4.1 TSS Positioning and Orientation System for Marine Vehicles (POS/MV)

FAIRWEATHER and her launches are equipped with a TSS POS/MV 320 v.3 and v.4, configured with TrueHeave™ and Precise Timing. The POS/MV calculates the position, heading, attitude, and vertical displacement (heave) of a vessel. It consists of a rack mounted version 2.12 POS Computer System (PCS), a strap down IMU-200 Inertial Measurement Unit (IMU), and two NovAtel GPS antennas corresponding to GPS receivers in the PCS. The port side antenna is designated as the primary receiver, and the starboard side antenna is the secondary receiver. Differential correctors are supplied to the POS MV by a CSI wireless MBX-3S Automatic Differential GPS receiver.

For all multibeam systems aboard FAIRWEATHER and her launches timing between the sonar swath, position, heading and attitude information was synchronized by utilizing the TSS POS/MV 320 v.3's (v.4 on FAIRWEATHER). A timing string was sent from the POS/MV to the RESON topside unit and to the ISIS computer recording the incoming data. In addition, vessel wiring diagrams are included in Appendix III-vessel-6.

Figure 7: POS/MV antennas mounted on 1018 (top view)

Figure 8: POS/MV antennas mounted on 1010 (side view)

1.4.2 CSI Wireless MBX-3S DGPS Receiver

FAIRWEATHER and her launches are equipped with commercial grade CSI Wireless MBX-3S DGPS Receivers that are used in conjunction with TSS POS/MV to provide vessel positioning during data acquisition. The DGPS receivers are configured in manual mode to allow reception of only one U.S. Coast Guard (USCG) differential GPS beacon station. Beacons used for a given survey will be reported in individual descriptive reports. Vessel wiring diagrams are in Appendix III-S220-6.

DGPS system checks will not be completed weekly. See correspondence included in Appendix VII.

1.4.3 Trimble Backpack

FAIRWEATHER uses two GPS Pathfinder® Pro XRS receivers in conjunction with a field computer to acquire detached and generic positions during shoreline verification in the field. Data can also be collected with a handheld TSCe data collector. FAIRWEATHER's field computers consist of three Panasonic CF-18 Toughbooks and one CF-29 Toughbook. The receivers have integrated beacon/satellite differential antennas which allow access to digital real-time sub-meter accuracy solutions. Data quality assurance testing was conducted by FAIRWEATHER personnel. The Trimble backpack GPS unit testing results are in a report in Appendix V.

Figure 9: Trimble backpack with antenna, receiver, and field device

1.4.4 Impulse LR Hand-held Laser

The Impulse Laser Rangefinder and TruPulse 200 Laser Rangefinder are used in conjunction with the Trimble Backpack GPS unit to acquire distances and heights during shoreline verification. These data are entered directly into the TerraSync shoreline acquisition software and annotated on the detached position forms. The Impulse LR and TruPulse 200 Laser Rangefinder do not function properly in low light or in choppy seas when a feature is not distinguishable from surroundings.

Data quality assurance testing was conducted on the Impulse LR on 27 February 2006 by FAIRWEATHER personnel. Comparison testing among the Laser Rangefinder, the TruPulse 200 Laser Rangefinder and the Trimble Backpack units was performed on 3 March 2006. Vertical and horizontal readings were taken with the laser level and compared to measurements taken with a fifteen meter steel tape and a graduated metric staff. Three marks were placed on the staff with SOLAS reflective tape in order to get a good fix. The laser level was set up on a bipod at 10, 20, 50 and 100 meter intervals from the staff. Three horizontal and three vertical readings were taken at each interval. The results of the testing are located in Appendix V.

Figure 10: IMPULSE LR

Figure 11: TruPulse 200

1.5 Sound Velocity Equipment

1.5.1 SBE 19*plus* SEACAT Profiler

FAIRWEATHER and her launches are equipped with three SBE 19*plus* SEACAT sound velocity profilers used to acquire conductivity, temperature, and depth (CTD) data in the water column to determine the speed of sound through water. Two of the SBE 19*plus* profilers have pressure sensors rated to 1000 meters. The third has a pressure sensor rated to 3,500 meters.

The SBE 19*plus* SEACAT sound velocity profilers were calibrated by the manufacturer and current calibration files were returned with the units. Periodic quality assurance checks will include comparison casts between CTD instruments. Data quality assurance (DQA) checks will include comparison casts between two instruments as per section 1.5.2.2 of the *FPM* for each survey.

To ensure that the CTDs continue functioning properly a stringent maintenance and calibration schedule will be followed using guidelines from the manufacturer's recommendations[2]. This will include a thorough rinsing of the instrument with distilled water after each cast. On a regular basis each CTD will be flushed with a Triton X-100 solution. On a regular basis the CTD was flushed with a 500-1000 ppm bleach solution followed by flushing with a Triton X-100 solution.

A record of the maintenance and DQA tests performed aboard the ship was kept. The *SV_Maintenance and Testing* records are included in Appendix VI.

1.5.2 SBE 45 Micro Thermosalinograph (TSG)

FAIRWEATHER is equipped with one SBE 45 MicroTSG. The SBE 45 uses continuously pumped sea water to measure conductivity and temperature near the ship's hull mounted transducers. The intake is located 9 feet below the DWL (13 ft) between frames 11 and 12.

The conductivity and temperature information is converted to sound velocity and output to the RESON 8160's and 8111's processing units. The 8160 requires sound velocity information for beam forming and pitch stabilization while the 8111 only requires it for pitch stabilization. The 8160 cannot be used to acquire data without real time sound velocity information.

Current calibration files are not available for the SBE 45. The unit will be calibrated yearly. At this time, FAIRWEATHER personnel have not developed data quality assurance testing procedures because the unit is newly installed. FAIRWEATHER personnel are investigating techniques and processes for future testing.

1.5.3 Moving Vessel Profiler 200

A Brooke Ocean Technology, Ltd. (BOT) Moving Vessel Profiler 200 (MVP200) is mounted in the aft starboard corner of the fantail (see Figure 12). The MVP200 system is a self contained sound velocity profiling system capable of sampling water column profiles to 200m depth from a vessel moving up to 12 knots. The system is configured with a Single Sensor Free Fall Fish (SSFFF) outfitted with an Applied Microsystems Ltd. Sound Velocity and Pressure Smart Sensor. Deeper profiles can be obtained by reducing the vessel speed. When the vessel is holding station, the system is capable of casts over 600m in depth.

The MVP system consists of a winch, cable, fish (the towed unit with the sound velocity sensor), support assembly, and controlling hardware and software. During ship acquisition, the fish is deployed using the on-deck controller and towed with enough cable out to keep the fish 3-5 m below the water surface. A "messenger" (a short cable-thickening sleeve) is set to allow the system to keep the appropriate amount of cable out and is reset as needed when the ship acquisition speed is altered.

During SVP acquisition, the controlling computer application, BOT MVP version 2.24 is used to control the MVP system and to acquire SVP data. MVP allows for three acquisition modes: 1) automatic continuous multiple cast freefall casting while at speed, 2) single cast freefall casting while at speed, and 3) single cast winch speed casting while stationary. The user limits the depth to which the fish will fall by setting 1) the depth-off-bottom and 2) the maximum depth. Either single, individually initiated casts can be performed at the discretion of the Hydrographer or the auto deploy function can be enabled and set with varying intervals (every 2 minutes, for example) for deployment.

Periodic quality assurance checks include comparison casts between the MVP and one of the SBE 19*plus* SEACATs. Data quality assurance (DQA) checks include comparison casts between two instruments as per section 1.5.2.2 of the FPM for each survey. A record of the DQA tests performed aboard the ship is kept and is included in Appendix VI.

Figure 12: FAIRWEATHER's MVP200 sound velocity system

1.6 Vertical Control Equipment

1.6.1 Water Level Gauges

Three Sutron 8210 tide gauges are provided to FAIRWEATHER by the Center for Operational Oceanographic Products and Services (CO-OPS). These gauges are equipped with Paros Scientific Sensors (SDI-12) for pressure measurements. The tide gauges are checked annually by CO-OPS Field Operations Division personnel to ensure that their accuracy standards are being met.

CO-OPS does not provide calibration or quality assurance documentation to the FAIRWEATHER. FAIRWEATHER personnel are responsible for installation and removal of the water level gauges. CO-OPS is responsible for delivering final approved vertical correctors to the field unit or processing branch for application to the hydrographic data set. To ensure full functionality prior to deployment as FAIRWEATHER receives new gauges, data quality assurance checks will be conducted in a similar manner as the procedures outlined in the Vertical Control Equipment Testing document included in Appendix V.

1.6.2 Leveling Equipment

FAIRWEATHER is equipped with four universal automatic levels (two Zeiss NI2 333 and two Leica NA2 100) and graduated metric staffs to assist in leveling tide gauges.

A Kukkamaki procedure is performed prior to leveling in order to verify the collimation error. Procedures were followed as described in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations,* October 1987 and are outlined in *Kukkamaki_2006* in Appendix V along with the results of the quality assurance checks. FAIRWEATHER personnel plan to confirm the collimation error prior to or shortly after each use in the field. We are unable to follow the recommendation of confirming the collimation error immediately prior to use in the field as outlined in the User's Guide due to the roughness of terrain at the tide gauge locations.

1.7 Horizontal Control Equipment

FAIRWEATHER is equipped with one Ashtech Z-Xtreme dual-frequency GPS receiver used for the positioning of tidal benchmarks, aids to navigation and portable DGPS reference stations (Fly-Aways). The Ashtech Z-Xtreme 12 channel, L1/L2 receiver is connected to 4 Ashtech Geodetic GPS antennas.

The antennas can be equipped with an optional ground plane and mounted on fixed height Seco GPS tripods.

Data quality assurance testing of the Horizontal Control equipment was performed on 22 February 2006 (DN053) by FAIRWEATHER personnel. The Ashtech Z-Xtreme GPS receiver (SN ZE1200339016) was set up over Benchmark TIDAL in Seattle, WA using a Seco fixed height tripod. Data was collected for 2 hours 5 minutes and submitted to OPUS which returned a ultra rapid solution position the same day (see Positioning Equipment Confidence Check in Appendix V). The OPUS position was less than a centimeter off the published NGS Control Point for TIDAL (see HorCon_Equipment_Test_07MAR05 in Appendix V). Accuracy standards have been met according to NOAA Technical Memorandum NOS NGS-58.

Horizontal control equipment serial numbers and installation dates when available are located in the hardware section of Appendix I System Tracking.

To analyze a horizontal control reference station a second portable DGPS reference station is needed for comparison. FAIRWEATHER is not fully equipped to set up a portable DGPS reference station due to loss of equipment during the 2004 field season.

2.0 Software

2.1 Software Systems Inventory

An extensive software inventory with documentation, of the software systems used by the NOAA ship FAIRWEATHER, is maintained as a *Survey Software* spreadsheet and included in Appendix I. This spreadsheet includes specifics such as software applications, versions, and hotfixes, in addition to dates loaded on specific computers within the survey department.

2.2 Data Acquisition Software –

2.2.1 Isis Sonar/ BathyPro/ DelphMap/ DelphNav

The FAIRWEATHER uses the Triton Imaging Inc. software packages Isis Sonar and Sonar Suite to acquire multibeam echo sounder and backscatter data on all of its multibeam platforms. Sonar Suite has two software packages, DelphNav and DelphMap, which work together along with Isis Sonar to produce real time data planning, acquisition, and execution.

Triton Imaging BathyPro is an add-on package for Isis Sonar which processes XTF data real-time to produce DTMs supported by DelphMap. Triton Imaging DelphNav is an add-on package to DelphMap used for line planning and vessel navigation. Triton Imaging DelphMap is a stand-alone GIS program which combines georeferenced bathymetric digital terrain models and reference files such as raster charts and vector shoreline files to display real-time bathymetric bottom coverage.

See Appendix VIII for Standard Operating Procedures associated with *Configuring ISIS RT Bathy* and Appendix III-6 for vessel wiring diagrams.

2.2.2 TerraSync/ Pathfinder Office

For GPS positioning and shoreline verification FAIRWEATHER uses two Trimble Navigation Limited software programs: TerraSync 2.4.1 and GPS Pathfinder 3.00 and 3.02.

GPS Pathfinder is run on a Microsoft Windows operating system and is used to manage and process Trimble GPS data, transfer files to and from GPS receivers and handheld data collectors, and export processed data.

Trimble TerraSync 2.4.1 supports data dictionaries and georeferenced TIFF images. The georeferenced TIFF images are used for reference and navigation purposes as well as for immediate S-57 attribution of positions in the field. TerraSync is installed and configured for data collection on all of the Toughbook field computers, the ToughTab, and the TSCe handheld computer.

GPS precision masks in TerraSync using the following parameters:

- Horizontal Dilution of Precision (HDOP) ≤ 2.5
- Signal-to-Noise Ratio (SNR) ≥ 4
- Elevation Mask ≥ ~8°-15° (varies by location)

Differential GPS correction is applied in real-time, using the unit's integrated beacon as the first choice corrector, and specifying "wait for real-time" as the secondary option. Positions are filtered so that only those with a minimum of 4 satellites (3D position), and HDOP ≤ 2.5, and Positional Dilution of Precision (PDOP) ≤ 6 will be exported into shapefile format.

2.3 Data Processing Software

2.3.1 NOAA Hydrographic Systems and Technology Programs (HSTP) Software

Sound velocity data is processed with Velocwin, in-house software produced and maintained by NOAA's Hydrographic Systems and Technology Programs (HSTP) division. Velocwin creates and archives water column profiles, performs quality assurance, and processes pressure based depth data. Velocwin creates a standard file format across NOAA's hydrographic fleet for sound velocity profiles applied to shallow water multibeam and single beam data.

Pydro, another NOAA program produced and maintained by HSTP, is used to process features such as detached positions (DP), generic positions (GP), and Automated Wreck and Obstruction Information System (AWOIS) contacts. PYDRO also converts and attributes features according to S-57 standards for insertion in to CARIS Notebook.

Newiz 2.0 is a program produced by HSTP for recording level runs in accordance with the procedures outlined in the *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* dated October 1987. The software is run on PDAs with a Microsoft Operating System Pocket PC 2002 or Pocket PC 2003. The software records all the observations and checks for errors in the field. Newiz 2.0 produces a summary file of all runs and an abstract for submittal to CO-OPS and the Vertical and Horizontal Control Report. Paper copies of the level runs will be completed and submitted if used.

2.3.2 CARIS

CARIS HIPS™ (Hydrographic Information Processing System) is used to process all shallow water multibeam data including data conversion, filtering, sound velocity, tide correcting, merging and cleaning. CARIS HIPS also calculates the Total Propagated Error (TPE) used to produce Bathymetry Associated with Statistical Error (BASE) surfaces which assist the Hydrographer in data cleaning and analysis.

FAIRWEATHER does not use CARIS SIPS™ (Side-scan Information Processing System) as there is neither side-scan sonar equipment aboard nor requirements to use them.

CARIS Notebook™ is used to stream line the data pipeline from the field to the processing branch. Notebook was used to compile and display source shoreline, shoreline updates and S-57 features imported from Pydro for cartographic review. The .hob files created in Notebook are the current shoreline deliverables.

2.3.3 Fledermaus™

Fledermaus ™, an Interactive Visualization Systems 3D™ (IVS 3D) program, is used for data visualizations and creation of data quality control products, public relations material and reference surface comparisons.

As an additional data quality assurance check Fledermaus ™ may be used to examine the CARIS surfaces prior submission. The combined BASE surface will be exported to XYZ from CARIS. This file is then converted to a Fledermaus .sd file via the Avggrid and Dmagic programs.

2.3.4 MapInfo™

MapInfo™ is used to review tables and workspaces associated with assigned projects received from Hydrographic Survey Division (HSD). MapInfo may also be used to produce scaled plots produced for public relation purposes. HydroMI, a HSTP produced and maintained MapBasic program, is used through MapInfo to convert tide and tidal zoning files into a format that is useable in CARIS HIPS, and obtain latitude/longitude coordinates for pre-survey planning.

3.0 Vessels

3.1 Vessel Inventory

The NOAA Ship FAIRWEATHER (S220) and her survey launches 1010 and 1018 are equipped to acquire multibeam echosounder (MBES) and sound velocity profile (SVP) data. The AMBAR (2302) and Monarch (1706) will be used during shoreline verification, bottom samples, dive operations, and horizontal and vertical control operations. See Appendix I for the complete vessel inventory.

3.2 Vessel HVFs

The CARIS HIPS Vessel File (HVF) is created by FAIRWEATHER personnel and used to define a vessel's offsets and equipment uncertainty. The HVF is used for converting and processing data collected by each survey platform. For each survey platform, an *HVF Report* was produced in the

CARIS Vessel Editor. This text file lists out specific HVF entries and is included in Appendix III - *vessel*-1. The HVFs used for the current project are included with the digital separates submitted with this report.

3.3 Vessel Offsets

Sensor offsets were measured with respect to each vessel's reference point. Specific offset values were input into the POS/MV and the CARIS HIPS Vessel File (HVF).

3.3.1 Ship Offsets

A ship survey was done for the FAIRWEATHER by Westlake Consultants, Inc. A report of the results from that survey, dated September 23, 2003, was used to define the ship offset values. The Westlake document and detailed spreadsheet, which includes derivations, a description of methodology used, diagrams, and coordinate system references are located in Appendix III-S220-2.

3.3.2 Launch Offsets

Permanent control points were established on launches 1010 and 1018 in July of 2004. Sensor offsets were measured according to the procedures listed in *Measuring Launch Offsets & Installation of Benchmarks* included in Appendix VIII-1. Total stations were utilized for positioning the permanent control points. The total station specifications are located in Appendix II-7, the calibration certificates for the *Nikon DTM 310* and the *Sokkia SET 5F* are included in Appendix II. A summary of measurements, derivations, descriptions of methodology used, diagrams, and coordinate system references are included in the respective vessel's Offsets section in Appendix III-*vessel*-2.

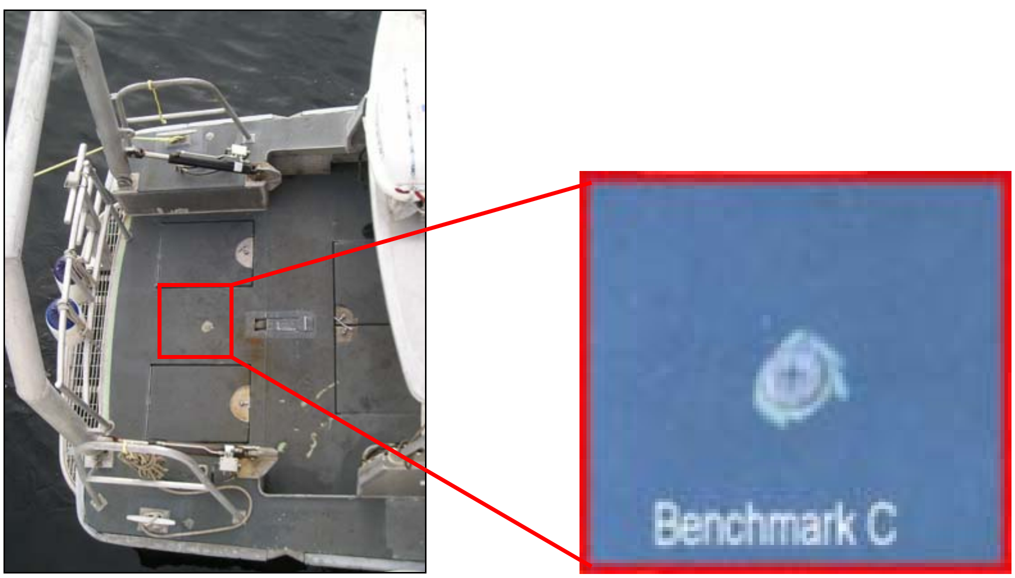

Figure 13: Permanent Control Point "Benchmark C" on launch 1018

3.4 Patch Tests

Patch tests were conducted for 1010, 1018 and FAIRWEATHER acquisition systems. The patch test procedure is located in Appendix VIII. The results of the patch tests, along with the acquisition and processing logs, are included in the individual MBES Calibration Tables in Appendix III-*vessel*.

3.5 Dynamic Draft Settlement & Squat

Dynamic Draft Settlement and Squat (DDSSM) tests were conducted for FAIRWEATHER (April 17, 2006), launch 1010 (April 10 and June 17, 2006), and launch 1018 (June 20, 2006). Results are included in the individual vessel reports. Detailed processing spreadsheets from the DDSSM are included in Appendix III-*vessel*-4.

3.6 POS/MV GAMS Calibration

GAMS calibrations were performed on each of the three POS/MV units. The GAMS calibration procedure was conducted in accordance with section 4-31 to 4-45, of the *POS/MV Version 3 Installation and Operation Manual,* dated October 2003. Results are included in the individual vessel reports and spreadsheets, with calibration details located in Appendix III-*vessel*-5.

3.7 Uncertainty Modeling

An understanding of the errors inherent in the multibeam systems and ancillary equipment is required for the proper use of CARIS HIPS & SIPS 6.0. These values are used to generate an uncertainty model needed to compute the Total Propagated Error (TPE) estimation and for the creation of Bathymetry Associated with Statistical Error (BASE) surface. Uncertainty information for FAIRWEATHER has been entered into the HIPS Vessel File (HVF). The uncertainty information entered reflects the statistical accuracy to which equipment can measure a value or to which a value was measured in the case of offsets.

Error estimates for FAIRWEATHER and associated survey launches were compiled from manufacturer specification sheets for each sensor (Heave, Pitch, Roll, Position, and Heading) and calculated for instrument reading uncertainty for static measurements (Draft and Offset measurements).

In instances where uncertainty information was unavailable or unknown the best estimation of the uncertainty was used.

The TPE values for FAIRWEATHER and her launches, referencing original source information, are entered into an Excel spreadsheet and included in Appendix IV.

3.8 Static Draft and Loading

Static draft (*Waterline Height* in the HVF) for launch 1010 and 1018 was calculated based on measurements from the top of the gas cap, a known reference point to the waterline using a steel tape. The bow and stern draft marks were used to measure the FAIRWEATHER (S220) static draft. The values and calculations are listed in Offsets Measurement spreadsheets for each vessel located in Appendix III-*vessel*-2.

Static draft tubes have been installed in launch 1010 and 1018 however the tubes have not yet been calibrated, nor have procedures for the determination of loading been developed at this time. Once procedures are established values for the Waterline can be entered into the HVF's of the launches, allowing for long-period changes in the launches draft to be followed. The static draft tubes will also be used for refining the values of Loading, Draft and Delta Draft in the TPE section of the HVF and listed in the FA_TPE_Values_2006 spreadsheet in Appendix IV.

Calibration of the static draft tubes and creation of procedures to determine loading was not completed.

The average of the bow and stern draft marks were used to measure the FAIRWEATHER (S220) static draft. The values and calculations are listed in Offsets Measurement spreadsheet located in Appendix III-S220-2.

3.9 True Heave

FAIRWEATHER and her launches are equipped with the POS/MV TrueHeave™ option. True Heave™ is a 'delayed' heave corrector as opposed to 'real time' heave corrector (*See Figure 14*). The IMU records the vertical acceleration of the vessel. By performing a double integration of this acceleration, it is possible to determine the vertical position of the vessel at a point in time. The system calculates the integrated solution prior to the point and after the point, which improves heave estimates by using a more accurate solution. This solution is made possible because the data contains time stamps with attitude, position, acceleration and rotation information.

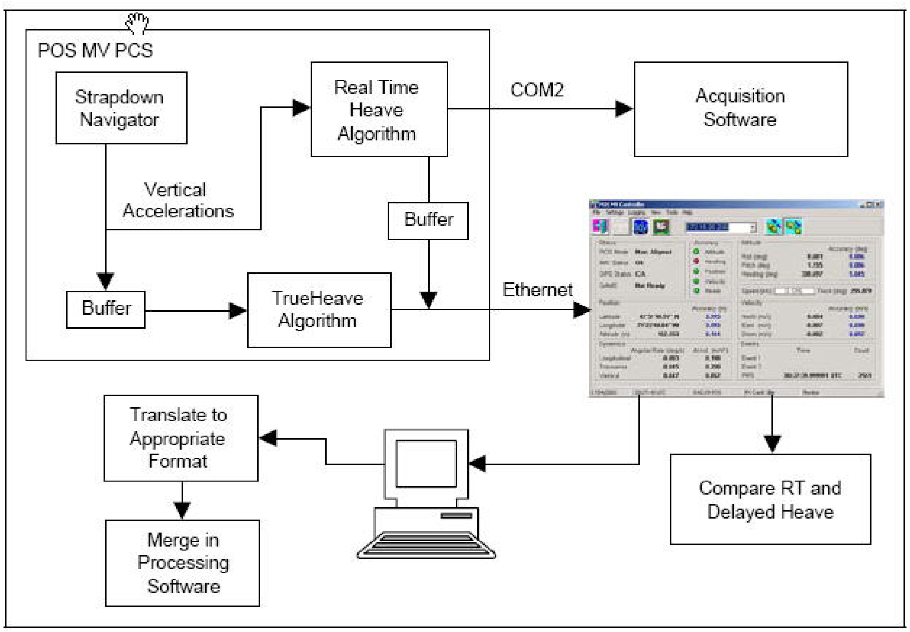

Figure 14: TrueHeave Functional Block diagram[1]

3.10 Noise Analysis

The FAIRWEATHER sonar system RESON 8111ER underwent noise analysis testing on October 11, 2004. The results are used during acquisition to enhance data quality and are included in Appendix III-S220-7. The Standard Operating Procedure for Survey Speeds to be run while acquiring data with the RESON 8111ER is included in Appendix VIII.

[1] POS MV V3 Installation and Operation Guide Applanix Corporation, 2003

4.0 Personnel

A detailed listing of personnel aboard the NOAA Ship FAIRWEATHER is provided in the FA_Vessel_Hardware_Computer and Personnel Inventories spreadsheet in Appendix I.

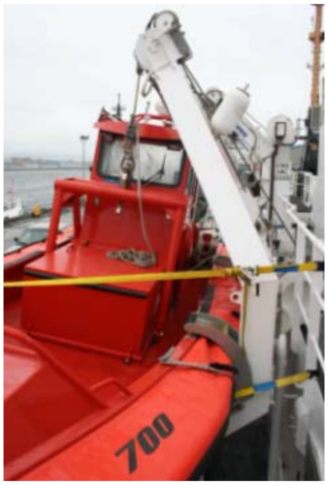

Figure 15: Vest Davit

Figure 16: Skagit Aft Crane

5.0 Deployment Equipment

5.1 WelinLambie Davits

There are four WelinLambie twin pivot davit systems, labeled number 3, 4, 5 and 6, used on the FAIRWEATHER which deploy the two hydrographic survey launches. Each davit arm has a two part tackle and block to which hooks are attached. The davit arms are connected to the deck with a pivot arm and a hydraulic cylinder inboard. The main boat winch has a gear box mounted to each side attached to an electric motor and a main brake is released by a hydraulic cylinder during power operation. The display is a touch screen that acts as an interface to control the system.

5.2 VestDavit System Davits

Two VestDavit System Davits (see Figure 15) are used on FAIRWEATHER to deploy the AMBAR 2303 and the Fast Rescue Boat 2301. The AMBAR is used extensively for shoreline verification, tide gauge operations, and other activities.

5.3 Skagit Aft Crane

FAIRWEATHER has a Skagit Aft Crane (see Figure 16) for deploying the MonArk skiff (1706) and other general lifting operations. The MonArk is used for shoreline verification, tide gauge operations, Horcon operations and other work boat activities.

5.4 A Frame

FAIRWEATHER has a stern A-Frame which can be used in conjunction with the aft capstan to deploy the MonArk (1706).

B DATA ACQUISITION

1.0 Multibeam Echosounder Acquisition and Monitoring Procedures

Methods of acquisition took into consideration system performance limitations, the bottom topography, water depth, and the ability of the vessel to safely navigate the area.

All multibeam data were acquired in Triton Elic's extended transfer format (XTF) and monitored in real-time using the 2-D and 3-D data display windows and the on-screen displays for the RESON SeaBat 8101ER and 8111ER. Adjustable parameters that were used to control the RESON from the ISIS software include range scale, power, gain, and pulse width. These parameters were adjusted as necessary to ensure best data quality. Additionally, vessel speed was adjusted as necessary to ensure the required along-track coverage for object detection in accordance with the *NHSSD* and *Standing Project Instructions (10 February 2006)*. The *RESON 81XX SOP* (standard operating procedure) and the *TEI_RT_Bathy SOP* detail the settings and procedures used during acquisition of data on the RESON systems and in Isis aboard the FAIRWEATHER. Both are included in Appendix VIII.

Mainscheme multibeam sounding lines using the RESON SeaBat 8111ER were generally run parallel to the contours at a line spacing approximately three to four times the water depth. For discrete item developments, line spacing was reduced to 2 times water depth to ensure least-depth determination by multibeam near-nadir beams. Triton Elic's DelphMap Real Time Bathy was used in lieu of planned line files. The Real Time Bathy displayed the acquired multibeam swath during acquisition and was monitored to ensure overlap and full bottom coverage. If coverage was not adequate, additional lines were run while still in the area.

2.0 Shoreline Verification

FAIRWEATHER personnel conducted field shoreline verification at times near predicted low water, in accordance with the Standing Project Instructions and the *FPM v2.1*, section 3.4.6. Pertinent standard operating procedures such as *Shoreline_Presurvey_v3, OIU aka Importing Shapefiles in Notebook, Trimble_Pathfinder_Setup*, and *Shoreline_Trimble_Acquisition* are included in Appendix VIII.

CARIS Notebook 2.2 was used to consolidate and review shoreline sources. Cartographic Feature Files (CFF) submitted by the Remote Sensing Division (RSD) were imported into Notebook according to S57 object class and inserted into a composite source shoreline .hob file (HXXXXX_Composite_Source.HOB), retaining all relevant S57 attribution. Due to their submittal as line features instead of point or area features, CFF items classified as WEDKLP and LOGPON were imported into Notebook as VEGATN and OBSTRN_L, respectively. The VEGATN and OBSTRN classes do not properly represent the features as defined by S57, however, an exception was made to include the items on the Notebook shoreline Plot.

The SORIND and SORDAT S57 attribute fields for CFF source shoreline were propagated with the name and date of the photogrammetric survey from which it was compiled.

Charted shoreline, when needed for reference purposes or when source data were not available or adequate, was digitized in Notebook into the composite source shoreline file using the correct S57 object class and attribution for each feature. The SORIND and SORDAT S57 attribute fields were propagated with the number (17404 or 17406) and edition date of the chart from which the features were digitized.

Lidar shoreline features were submitted as source and investigation files from a prior survey conducted by Tenix LADS. Lidar files defined as source features were imported into Notebook and added to the composite source shoreline layer. Lidar files defined as investigation features were imported into Notebook into a separate non-deliverable HOB file (HXXXXX_Lidar_Investigation.HOB). The separation of Lidar investigation files from the composite source was done primarily to distinguish investigation features from Lidar source features on the shoreline boatsheets. Following shoreline acquisition, the Lidar investigation features were inserted into the composite source shoreline deliverable file.

The SORIND and SORDAT attribute fields for Lidar features were propagated with the survey name (H11208_KRL) and the end date of the survey. Contractor notes accompanying the Lidar features were inserted into the Remarks attribute field.

AWOIS and Chart Evaluation File (CEF) investigations were imported into Notebook as individual .hob files. CEF investigations were included in the Notebook Shoreline session for reference purposes only and for addition to shoreline boat sheets. AWOIS items are primarily inserted into Pydro where all updates and reporting will be completed; however, they were added to Notebook for inclusion on the shoreline boat sheets and for assistance in survey planning.

Prior survey features compiled by Hydrographic Surveys Division and submitted with the project data were not included in the composite source shoreline file. A significant position offset between the prior survey files and other source features was visible when all features were added to the Notebook Session. It is believed the offset was related to errors associated with the projection of the prior survey files.

After all source, reference, and investigation features were added to the Notebook shoreline session, boat sheets were produced and geo-referenced images (tif/tfw) were created for use in Trimble TerraSync during shoreline verification.

Detached positions (DPs) and generic positions (GPs) acquired during shoreline verification indicate new features, revisions to features, or features not found in the field. They were recorded in the shoreline acquisition software TerraSync using a Trimble Backpack and on DP forms, and then processed through GPS Pathfinder. Scanned copies of the DP forms are included in the digital Separates folder and hard copies are submitted with the Separates to be included with Survey Data. In addition, annotations describing shoreline were recorded on hard copy plots of the digital shoreline, referred to as boat sheets which are also submitted with the individual survey as Separates.

Terminology used during shoreline verification is as follows. The term “Noted” indicates that the feature has been visually addressed and is within accuracy of the source. The term “Verified” is used when the existence of the feature is confirmed in close proximity and a detached position has been taken to address the feature.

3.0 Shoreline Data Processing

During shoreline verification, detached (DP) and generic (GP) positions were acquired with TerraSync 2.41. Data were reviewed, edited and exported as a Microsoft Access Database file or as ESRI shape files (.shp) in GPS Pathfinder 3.02. The exported files include the S-57 field attributed positions and were organized by object type.

Pydro and CARIS Notebook 2.2 were used exclusively in the shoreline processing pipeline, from the field to the processing branch.

All comments written on the boat sheets from observations made in the field, including Hydrographer notes regarding verification of features, were added directly to the “remrks” field of the H#####_Composite_Source.hob file for source shoreline features in CARIS Notebook. When necessary, marker text was used to add comments to features for display purposes, such as when the “remrks” field does not display correctly or to highlight an item that was not verified. Notes for shoreline investigation files and new DP/GP features were added to the “remarks” field in Pydro.

Following shoreline acquisition, notes accompanying source shoreline were superseded by Hydrographer notes. In cases when the source notes were retained, they follow the Hydrographer notes, separated by a hyphen.

Positions acquired with Terrasync during shoreline verification operations were exported in database or shape file format from GPS Pathfinder. The Generic GPs/DPs Import tool or database import function was utilized to retain the S-57 attribution during import into Pydro. The DPs and GPs indicate new features, revisions to features, or features not found during shoreline verification. Once the features were in Pydro, short descriptive comments along with investigation or survey methods were listed under the Remarks tab in Pydro. Features were flagged as Primary, unless there were multiple detached (DPs) or generic (GPs) positions taken on the same feature. In that case, the most important DP was marked Primary and the associated DPs/GPs were flagged Secondary. All features were S57 attributed. Items for particular surveys, that were associated with a DP or GP that needed further discussion, were flagged Report in Pydro. Along with the hydrographer notes and investigation methods provided in the Remarks tab, the Hydrographer included recommendations to the cartographer in the Recommendations tab when warranted. All features were flagged according to section 4.4.4 of the FPM.

Photos labeled and associated with a DP/GP number were included in the Pydro PSS session and stored in with the PSS. Photos not associated with a DP/GP were given a descriptive label, and were included in a marker note of the associated feature in CARIS Notebook, and also stored in the PSS folder.

The HDCS_DATA lines associated with DPs required further processing in CARIS HIPS & SIPS to correct for tide and sound velocity when necessary. GPs do not have heights associated with them and required no additional processing.

All primary and accepted DPs and GPs were exported from Pydro as an .xml to CARIS Notebook 2.2. Two separate stand alone .hob files were created from the Pydro .xml files. The files are named H#####_Updates.hob and H#####_Disprovals.hob. UserID, remarks and recommendations from Pydro were imported to the “userID”, “remrks” and “recomd” fields associated with each feature in CARIS Notebook.

AWOIS investigation items were inserted into Pydro for processing. If the investigation items were noted by the Hydrographer but not positioned, the original feature was flagged Primary and included with the H#####_Updates.hob. If the investigation item was positioned in the field, the DP/GP was marked Primary and included in the H#####_Updates.hob, the original investigation item was marked as Secondary. Any investigation items disproved were included in the H#####_Disprovals.hob, with either the original item flagged as Primary or the DP/GP position taken during the field investigation flagged as Primary.

An original composite source file (H#####_Original_Composite_Source.hob) was saved prior to being edited and will be submitted with the survey. New HW/MLLW features and any changes to the source shoreline, such as ledges or reefs, were digitized with S57 attribution into the H#####_Composite_Source.hob. For new and modified items, the SORIND and SORDAT fields were updated to denote the current survey. Features to be retained as depicted by the source shoreline file were left with their original SORIND value. One exception is when only small sections of the source item was edited, rather then update the entire items SORIND field, marker notes were used to indicate the section of the item that was modified by the current survey. Source items from the Cartographic Feature File (CFF), Lidar, or charted items that were disproved have been removed from the composite source file.

The CARIS Notebook files along with CARIS HIPS BASE surface(s) were viewed to compare soundings and features simultaneously.

4.0 Bottom Sample Acquisition

Bottom samples were conducted according to section 7.1 of the *NHSSD*.

5.0 Horizontal Control

A complete description of horizontal control for the project can be found in the *OPR-P183-FA-06 Horizontal and Vertical Control Report (HVCR)*, submitted under separate cover.

The horizontal datum for this project is the North American Datum of 1983 (NAD83). Differential GPS (DGPS) was the sole method of positioning. Differential corrections came from the U.S. Coast Guard beacon at Cold Bay (289 kHz).

System Checks were not performed during this project. Based on correspondence between personnel from the Hydrographic Systems and Technology Program and FAIRWEATHER, system checks were deemed unnecessary at this time. Refer to correspondence included in Appendix VII.

C QUALITY CONTROL

I. Data Processing

The FAIRWEATHER has numerous standard operating procedures (SOPs) that are followed by personnel throughout the survey to ensure consistent high quality data and products. A detailed *Data Processing Work Flow, Shoreline Processing Flowchart* and several key SOPs that differ from the *FPM* or are specific only to FAIRWEATHER are included for reference in Appendix VIII.

1.0 Multibeam Echosounder Data Processing

Raw XTF multibeam data were converted to HDCS format in Caris HIPS & SIPS 5.4. After conversion, TrueHeave™ was loaded prior to sound velocity correction in HIPS. Tide corrections, dynamic draft correctors, sensor lever arm information, bias information and timing errors, and attitude correctors were applied to the data during “Merge”. Once lines are merged, the Total Propagated Error (TPE) was computed in HIPS to determine the quality of the multibeam data.

The TPE takes into account uncertainties in the measurements coming from each sensor (Heave, Pitch, Roll, Position, Heading, Sound Velocity, and Tide) and uncertainties in static measurements (Draft and Latency) to calculate the total uncertainty associated with each sounding. Caris HIPS & SIPS 6.0 uses the vertical uncertainty from TPE to produce a Bathymetry Associated with Statistical Error (BASE) surface. These BASE surfaces and child layers (Depth, Uncertainty, Density, Standard Deviation, Mean, Shoal, and Deep) were used for directed data editing, to demonstrate coverage, and to check for systematic errors such as tide, sound velocity, or attitude and timing errors.

Vessel heading, attitude, and navigation data were only reviewed and/or edited in navigation editor and attitude editor as deemed necessary by the Hydrographer. When necessary, fliers or gaps in heading, attitude, or navigation data were manually rejected or interpolated for small periods of time. The multibeam data were reviewed and edited in HIPS swath editor and subset mode as needed.

The CUBE surfaces, produced as deliverables, have resolutions and depth ranges that are between 10 and 20 percent of the depth as specified in chapter 5 of the *NHSSD*. Overlap is adjusted as necessary for the survey topography. Table 3 lists the general resolution and depth ranges used by FAIRWEATHER. A detailed listing of the actual resolutions and depth ranges used during the processing of each survey, along with the corresponding fieldsheet(s), will be provided in the descriptive report of that survey.

FAIRWEATHER			
Depth Ranges			Resolutions
Lo (m)	Hi (m)	Overlap (m)	Res. (m)
0	40		2
30	70	10	5
50	120	20	10
100	200	20	20
180	350+	20	35

Table 3: Resolutions and Depth Ranges

In areas of navigational significance where the CUBE surface did not depict the desired depth for the given area, a designated sounding was selected. Designated soundings were selected as outlined in section 8.2 of the *NHSSD*.

1.1 Data Standards and Processing Guidelines

Bathymetry processing followed section 4.2 of the *FPM* unless otherwise noted. CUBE surface processing was in accordance with *HSTD 2004-3*.

The bathymetric data acquired during this project for H11580 have been verified to meet or exceed the specifications defined in the *NHSSD*. In accordance with the *NHSSD* the vertical accuracy standards are S-44 IHO Order 1 for water 100 meters or less in depth and IHO Order 2 for depths greater than 100 meters.

Data quality errors for H11582 included roll errors that were consistent with data collected on Launch 1018, especially data collected on DN 172, 175, 188, and 189 after which it was discovered that the port and starboard POS/MV antennae were switched. A new roll patch test was conducted and the edited HVF applied to the data. The error was minimal throughout the survey and affected data was marginally outside the IHO Order 1 specification. The data was examined and found to be mostly within IHO Order 1, with small areas only meeting IHO Order 2. All data is considered sufficient to supersede current sounds in the area. Data quality issues specific to individual surveys are noted in the descriptive reports.

1.2 System Certification Report Clarifications

HIPS Vessel File

The HVFs for each vessel used for this project and the Devicemodel.xml used during data processing in CARIS HIPS are located in the Separates to be included with this report.

The sensor latency value noted in the vessel reports can either be entered into each sensor (Navigation, Gyro, Heave, Pitch and Roll) Time Error field or the inverse value can be entered once into the Swath Time Error field. The Swath Time Error value for all vessels is entered as the inverse value of the Navigation Time Error reported in the vessel reports.

2.0 Reference Surface

Due to mechanical issues and time constraints a reference surface was not completed in the OPR-P183-FA-06 project area. Initial lines were only run by the NOAA Ship FAIRWEATHER (S220) RESON 8111ER and her launches using RESON 8101.

II. DATA REVIEW

Specific procedures were used on FAIRWEATHER to ensure quality control of data throughout acquisition, processing, and submission. These procedures are outlined in the *HXXXXX QC Checksheets, HXXXXX_Data_Log,* and the *Survey Management SOP* located in Appendix VIII. As detailed in *HXXXXX QC Checksheets*, the QC Check is preformed by the survey manager. The QC Review is conducted by qualified (FOO, CST, SST, or PS) survey personnel other than the survey manager, as an outside review of the survey data and deliverables. The Data Submission and Analog Submission checklists are used to ensure that all data and deliverables are complete and included upon submission. These documents are completed for every survey but only the *HXXXXX_Data_Log* is submitted with the individual survey data.

III. STANDARD OPERATING PROCEDURES

Offsets & Configurations		
Measuring Launch Offsets	Configuring ISIS RT Bathy	
PreSurvey		
TEI_RT_Bathy	Trimble_Pathfinder_Setup	Shoreline_PreSurvey_v3
Acquisition		
RESON_81XX	SOP Survey Speeds 1.0	Shoreline_Trimble_Acquisition
Processing		
Data_Processing_Work_Flow	Shoreline Processing Flowchart	
PYDRO_Shoreline_Processing	NOTEBOOK_Shoreline_Processing	OIU/Importing Shapefiles
Quality Control		
Survey Management	HXXXXX_QC_Checksheets	HXXXXX_Data_Log

Table 4: List of SOPs included in Appendix VIII

D Corrections to Echo Soundings

I. POS/MV Correctors

1.0 Position Computation

The POS/MV is used for positioning multibeam data on all FAIRWEATHER vessels. The POS/MV controller software was used to monitor position accuracy and quality during data acquisition. This ensured that positioning accuracy requirements were met, as outlined in the NOS Hydrographic Surveys Specifications and Deliverables. The POS/MV controller software provides clear visual indications whenever accuracy thresholds are exceeded.

The CSI Wireless MBX-3S DGPS Receivers are used in conjunction with TSS POS/MV to provide vessel positioning during data acquisition. The DGPS receivers are configured in manual mode to allow reception of only one U.S. Coast Guard (USCG) differential GPS beacon station.

2.0 Heading Computation

The heading computed by the POS/MV was used as a corrector for multibeam data.

3.0 Pitch and Roll Computation

The POS/MV was used for pitch and roll values.

4.0 Heave Computation

The POS/MV on FAIRWEATHER is equipped with the TrueHeave™ option. Stored TrueHeave™ data contain time stamps with attitude, position, acceleration, and rotation information. TrueHeave™ data were acquired in accordance with section 6.0 of the *POS/MV Version 3 Installation and Operation Manual,* dated June 2004. These data were loaded in CARIS HIPS & SIPS 6.0 into the simultaneously collected multibeam data to determine the vessel heave correctors.

In cases where TrueHeave™ could not be applied, real time heave correctors were used. Real time heave data were recorded in Triton Elic's Isis software, stored in the .XTF format and applied as the heave corrector for multibeam data.

Data that does not have TrueHeave™ applied will be listed in the individual Descriptive Report for the survey.

II. Sound Velocity

Within CARIS HIPS there are four different algorithms used to automatically apply sound velocity information to a profile using information stored in the concatenated sound velocity file. They are: "Previous in time," "Nearest in time," "Nearest in distance" and "Nearest in distance within time." The method used for applying sound velocity information to a line is included in the processing logs that are submitted with the data.

1.0 SBE 19*plus* SEACAT Profiler

Sound Velocity Profile (SVP) casts from the SBE 19*plus* were processed with Velocwin and the correctors were applied to echosounder data in CARIS HIPS during post processing.

2.0 Moving Vessel Profiler (MVP)

Sound velocity correction data were acquired using the Brooke Ocean Technology Moving Vessel Profiler 200 (MVP) sound velocity profile (SVP) acquisition system and subsequently converted to .svp format using Velocwin for application to multibeam data in CARIS HIPS during post processing.

MVP records cast data into files of type .001, .001c, .001d, and .001e (collectively called BOT files) where the number increments by one with each subsequent cast. The .00#c file for each cast was opened with Velocwin and converted into CARIS .svp file format. The individually taken casts were compiled into a daily .svp file which were in turn concatenated to the ship .svp file for the project and applied to multibeam data in CARIS HIPS during data processing. No individual .svp files exist for each cast taken by the MVP due to the large number of casts acquired.

III. Water Level

Predicted and unverified observed water level correctors were downloaded from the CO-OPS website when internet was available. When internet was unavailable, the ship enabled the automated Tidebot program, which would send daily observed water level correctors for selected tide stations to the ship via email. The daily water level correctors arrived in .dat file format. The files for the relevant days were collated into a tide station master file which was converted to .tid file format in Mapinfo using HydroMI. The .tid files were applied to data along with the zone definition file (.zdf) in CARIS HIPS & SIPS.

The vertical datum for this project is Mean Lower-Low Water (MLLW). The operating National Water Level Observation Network (NWLON) primary tide station at Sand Point, AK (945-9450) served as control for datum determination and as the primary source for water level reducers for this project.

CO-OPS does not provide calibration or quality assurance documentation to the FAIRWEATHER. FAIRWEATHER personnel are responsible for installation and removal of the water level gauges. CO-OPS delivered final approved water level data to the FAIRWEATHER for application to the hydrographic data set on October 2, 2006. See the Descriptive Report of specific surveys for tide application details. It will not be necessary for the Pacific Hydrographic Branch to apply the final approved water levels (smooth tides) to the survey data during final processing for the surveys in project OPR-P183-FA-06: H11580 and H11582.

A complete description of vertical control for the project can be found in the *OPR-P183-FA-06 Horizontal and Vertical Control Report (HVCR)*, submitted under separate cover.