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NATIONAL OCEAN SERVICE

Data Acquisition & Processing Report

Type of Survey Hydrographic

Project No. OPR-N372-RA-05

Time frame March - July 2005

LOCALITY

State Washington

General Locality Approaches to Puget Sound

.....
2005
.....

CHIEF OF PARTY

..... Commander John W. Humphrey, NOAA

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DATE

Data Acquisition and Processing Report
NOAA Ship RAINIER
OPR-N372-RA-05

Approaches to Puget Sound, Washington
Hydrographic Letter Instructions dated March 23, 2005
Chief of Party: Commander John W. Humphrey, NOAA

A. EQUIPMENT

This Data Acquisition and Processing Report describes both the survey equipment used and the standard methods for acquisition applied to the equipment used. Not necessarily all equipment described within this report was used during data acquisition for all sheets of this project. Data were acquired by the following RAINIER survey launches:

<u>Hull Number</u>	<u>Vessel type</u>
1103	28 foot Munson jet drive work boat
1021	29 foot Jensen survey launch
1016	29 foot Jensen survey launch
1006	29 foot Jensen survey launch
1015	29 foot Jensen survey launch

Vessels 1021, 1016, 1006 and 1015 are used to acquire shallow-water multibeam (SWMB) data and sound velocity profiles. Vessel 1103 was used to collect vertical-beam echosounder (VBES) data and detached positions. Two unusual vessel configurations for 1006 and 1021 were applied to data due to an inappropriate projector setting of "projector-fwd" used during data acquisition. Details about these unusual vessel configurations and the data affected are explained in the appropriate descriptive reports. Vessel descriptions and offset measurements are included in the NOAA Ship RAINIER 2005 Field Season Hydrographic Systems Certification Report.

Four different categories of echosounder systems were utilized for project OPR-N372-RA-05. The individual system(s) chosen for use in a given area were decided at the discretion of the Hydrographer using the guidance stated in the Standing Project Instructions, the Hydrographic Letter Instructions, and the Field Procedures Manual, and depended upon the limitations of each system, the bottom topography, the water depth, and the ability of the platform vessel to safely navigate the area. These systems are described in the following section.

A complete description of all echosounder systems, positioning, and attitude sensors in addition to a complete inventory and list of serial numbers is located in the *2005 Hydrographic Systems Certification Report*

Sounding Equipment:

1. RESON 8101 Launch Shallow-Water Multibeam (SWMB)

Vessel 1021 is equipped with a Reson SeaBat 8101 mounted on a swing-arm which deploys the transducer from an "in transit" position recessed within the hull to a "survey" position extending beneath the hull once data collection commences. Vessel 1006 is equipped with a hull-mounted Reson SeaBat 8101. Both of these Reson SeaBat 8101s are equipped with option 033, Angle-Independent Imagery, and option 040, Extended Range Projector. The SeaBat 8101 is a 240 kHz multibeam system that measures relative water depths across a 150° swath, consisting of 101 individual 1.5° x 1.5° beams. This system was used to obtain full-

bottom coverage in depths generally from 4 meters to 200 meters, with varying range scale values dependent upon the depth of water and across-track slope.

2. RESON 8125 Launch Shallow-Water Multibeam (SWMB)

Vessel 1016 is equipped with a hull-mounted Reson SeaBat 8125, with option 033, Angle-Independent Imagery. The SeaBat 8125 is a 455 kHz multibeam system that uses high frequency focused near-field beam forming to measure relative water depths across a 120° swath, consisting of 240 individual 0.5° x 1.0° beams. This system was used to obtain full-bottom coverage in depths generally from 4 meters to 60 meters, with varying range scale values dependent upon the depth of water and across-track slope. Surface sound velocity was measured using an Odom Digibar Pro, model db1200, velocimeter and digitally input into the Seabat 8125 during acquisition.

3. ELAC 1180 Launch Shallow-Water Multibeam (SWMB)

Vessels 1016 and 1015 are equipped with a hull-mounted Elac 1180, which is a single frequency (180 kHz), multibeam echosounder system for shallow and intermediate water depths. The transducer assembly consists of two flat-faced transducers, one starboard and one port, each mounted at a 38° angle from horizontal. Echosounding is achieved using a Rotating Directional Transmission (RDT) method where sound is directed utilizing the directional gain of the complete transducer array. Sonar transmission occurs across adjacent sectors in a 3-step “subfan” process. Out of each of the 3 subfans within a sector, the receiving beamformer calculates 3 slightly overlapping beams each 1.5° wide with a spacing of 1.25°, for a total of 9 beams per sector. There are 7 fanwidth settings possible, the maximum of which (153.5°) utilizes 7 sectors, for a maximum total of 126 beams within a “virtual swath”. The Elac 1180 was generally used in depths of 50 to 100 meters with an acquisition swath width of 131°. Narrower fanwidth settings were selected at the discretion of the hydrographer in waters in between 100 and 300 meters of depth dependant upon both local conditions and the quality of the bottom trace. Surface sound velocity was measured using an Odom Digibar Pro, model db1200, velocimeter and digitally input into the Hydrostar computer during acquisition.

4. Launch Vertical-Beam Echosounder (VBES)

Vessels 817, 1101 and 1103 are equipped with a Knudsen Engineering Limited 320M, which is a dual frequency (100 kHz, 24 kHz) digital recording vertical-beam echo sounder with an analog paper record. The beam widths for the high and low frequency are 7° and 25° respectively. Soundings were acquired in meters for both frequencies, with high frequency utilized as the primary frequency in Hypack. Frequently, the low frequency was disabled in shallow water because it distorted the echosounder trace.

VBES data were collected in near shore areas to define the four-meter curve and the limit of SWMB hydrography. Data were also collected over offshore reefs and shoals, in depths generally ranging from 4 to 20 meters. Sounding lines were run perpendicular to depth contours at a line spacing sufficient to generalize the near shore contours, with splits run at a reduced line spacing to develop shoal areas that were deemed too shallow for the safe or effective use of a vessel equipped with SWMB.

5. Diver Least-Depth Gauge

A diver least-depth gauge (DLDG) was utilized to obtain least depths over selected rocks and features. The DLDG utilized by RAINIER, S/N 68332, was last calibrated in March 2005. A copy of the calibration report is included in the *2005 Hydrographic Systems Certification Report*. The depth gauge measures pressure, and is combined with a CTD profile using VelocWin software to determine depth. These depths were processed in Pydro along with the corresponding detached position (DP).

In addition to the diver least-depth gauge, Rainier can also deploy an In-Situ miniTROLL advanced. The miniTROLL features an internal data logger with a pressure/level sensor and is completely self-contained in a 316-Stainless Steel body. The integrated silicon strain-gauge pressure sensor claims an accuracy of $\pm 0.1\%$ over full pressure and temperature range, or 0.05% @ 15°C . Data is recorded at a minimum sampling rate of 0.5 seconds and saved in internal memory capable of storing 80,000 data points. This data is then downloaded with a PC using the included Win-Situ software.

6. Lead Line

During shoreline verification, lead lines were used to acquire depths over rocks and other features too shallow to acquire soundings using echo sounders. RAINIER personnel calibrated lead lines in March 2005. Calibration reports are included in the *2005 Hydrographic Systems Certification Report*.

Side Scan Sonar

All the SWMB systems used by the RAINIER provide a low-resolution digital SSS record of the multibeam swath. This SSS imagery is primarily used during processing of the multibeam depth data to aid in determining whether anomalous soundings are true features or noise. Reson "snippets" imagery was also recorded at acquisition and is present in the raw data, but is not processed or analyzed. Snippet data contains the amplitude data of each individual sonar beam in a swath.

Positioning Equipment:

Vessel 1103 is equipped with a Trimble DSM212L to measure and calculate position. The DSM212L is an integrated 12-channel GPS receiver and 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 DSM212L was configured in the manual mode to use only correctors from the nearest USCG beacon, to go off-line if the age of DGPS correctors exceeded 20 seconds, and to exclude satellites with an altitude below 8 degrees.

The following parameters were monitored in real-time through Trimble's TSIPTalker software to ensure position data quality:

- number of satellites used in the solution
- horizontal dilution of precision (HDOP)
- latency of correctors
- beacon signal strength

Vessels 1021, 1016, 1006, and 1015 are equipped with a TSS POS/MV Position and Orientation Sensor to measure and calculate position. The POS/MV is a GPS-aided inertial navigation system, which provides a blended position solution derived from both an Inertial Motion Unit (IMU) and an integrated GPS receiver. The IMU and GPS receiver are complementary sensors, and data from one are used to filter and constrain errors from the other. This inter-dependence results in higher position accuracy and fewer errors than either system could produce by itself. Position accuracy is displayed in real time by the POS/MV software and was monitored to ensure that positioning accuracy requirements as outlined in the NOS Hydrographic Surveys Specifications and Deliverables were not exceeded. In addition, the POS/MV software displays HDOP and number of satellites used in position computation. Data acquisition was generally halted when an

HDOP of 2.5 was exceeded or the number of satellites available dropped below four. However, because positional accuracy can be maintained by the POS/MV through short GPS outages with the help of the IMU, data acquisition was not halted during short periods of time when the HDOP and number of satellites used exceeded stated parameters.

Software:

Launches 1021, 1016, and 1006 recorded Reson 8101 and 8125 Shallow-water multibeam (SWMB) echosounder data, along with position and attitude data from the POS/MV using Triton-Elics' ISIS software and logged in the Extended Triton Format (XTF).

Launches 1016 and 1015 recorded Elac 1180 SWMB echosounder data, along with position and attitude data using Elac's Hydrostar software and logged in the Hydrostar exchange format (XSE).

All SWMB data were processed using the CARIS Hydrographic Information Processing System (HIPS) and Hydrographic Data Cleaning System (HDCS) software version 5.4 for the windows environment.

All VBES data were acquired using Coastal Oceanographic's HYPACK MAX version 02.12a, in the "RAW" format. VBES data were processed using CARIS HIPS for the windows environment.

Coastal Oceanographic's HYPACK MAX was used for vessel navigation and line tracking during acquisition of SWMB data. HYPACK MAX was also used to quick mark targets that were processed as detached positions using Pydro supplied by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP).

Sound velocity profiles were computed from raw pressure, temperature, and conductivity measurements using the program VelocWin, supplied by the NOS Hydrographic Systems and Technology Programs N/CS11 (HSTP).

A complete list of software and versions is included in the NOAA Ship RAINIER 2005 Field Season Hydrographic Systems Certification Report.

B. DATA PROCESSING AND QUALITY CONTROL

Shallow-Water Multibeam Data

Shallow-water multibeam data were monitored in real-time using the 2-D and 3-D data display windows in Isis and the on-screen display for the Reson SeaBat 8101 and 8125 sonar systems. The Elac HydroStar online bathymetry data display was monitored in real-time for Elac sonar systems. Adjustable user parameters common for all sonars are range scale, power, gain, and pulse width. In addition the swath width and bottom slope type are additional user parameters used during acquisition for the Elac 1180. These parameters were adjusted as necessary to ensure the best data quality. Additionally, vessel speed was adjusted as necessary, and in accordance with the NOS Specifications and Deliverables and Draft Standing Project Instructions, to ensure the required along-track coverage for object detection.

In an effort to combat the ever increasing volumes of data produced by modern multibeam sonar systems, CARIS has implemented the Bathymetry Associated with Statistical Error (BASE) surface in version 5.4 of CARIS HIPS and SIPS. The aim of the BASE surface is to save time cleaning data by directing cleaning efforts toward problem areas and to ignore insignificant and erroneous fliers. The BASE surface is a multi-attributed, geo-referenced, statistical representation of the seafloor. To calculate a BASE surface, the

horizontal and vertical uncertainty values of each sounding is weighed to find the value of the BASE surface at any given point. The weight of any given sounding is based on its spatial uncertainty which is determined by finding its Total Propagated Error (TPE). The TPE is an estimated value that is derived from the combination of all individual error sources. Errors such as measurement and sound velocity errors, tidal measurement and modeling errors, and data processing errors all contribute to TPE. In HIPS, errors are read from the VesselConfig.xml and the DeviceModels.xml files.

To accommodate TPE calculations, CARIS changed the structure of the CARIS Vessel Configuration File (VCF) to the HIPS Vessel File (HVF). The HVF, in addition to containing all the offsets and system biases of a VCF, now includes error estimates for tides and zoning, latency, sensor offset measurements, attitude and navigation measurements, draft measurements, and sound velocity measurements. In addition, the HVF specifies which type of sonar system the vessel is using. This, in turn, points to the DeviceModels.xml file which contains error estimates for various types of common sonar systems. Unfortunately, the default DeviceModels.xml file does not include all sonar systems in use aboard RAINIER. As a fix, the DeviceModels.xml file was edited with the specifications and accuracy parameters for each sonar in use on RAINIER and placed in the C:\CARIS\HIPS\System directory of all CARIS processing computers. This modified DeviceModels.xml file is include with the digital data submission.

Following acquisition, both Reson and Elac shallow-water multibeam data were processed using the CARIS HIPS and SIPS Batch Processor. This batch processor, running a user defined script, first converts the "raw" Reson XTF data and Elac XSE data to the HDCS data format. Next predicted tides and sound velocity files are loaded and then merged with depth, position, attitude, vessel offset, and dynamic draft correctors to compute the corrected depth and position of each sounding. TPE is then computed and filters are applied to all soundings. Soundings beyond a maximum angle of 60° off-nadir were rejected in accordance with the Draft Standing Project Instructions to reduce the noise and refraction errors possible in these outer beams. Soundings with poor quality flags, 0 for Reson, were also rejected. TPE filtering is also preformed to reject sounding outside of specific IHO order as follows:

Depth range	Depth a	Depth b	Horizontal m	Horizontal %
0-100m	0.500	0.013	5.000	5.000
Greater that 100m	1.000	0.023	5.000	5.000

As a final step of the batch process, a temporary Boat-Day BASE surface is created in the "Hxxxxx_Processing" field sheet. The naming convention for these "temporary" BASE surfaces is: "Launch Number_DnXX" (Example: "1006_Dn095"). Typically these daily BASE surfaces are created with resolutions between 2 and 10 meters dependant upon both the sonar system used and the typical water depths encountered that day.

Two weighting schemes are available when creating the BASE surface. Swath angle weighting is based on a beam's intersection angle with the seafloor whereas uncertainty weighting is based on depth uncertainty. Uncertainty weighting was used exclusively in BASE surface generation because a swath angle-weighted grid does not contain an estimate of statistical error as does an uncertainty-weighted BASE surface.

Each day the launch crew conducts preliminary cleaning of data based on the Boat-Day BASE surface. "Directed Editing" is preformed with the careful analysis of shaded depth models and standard deviation surfaces. Based on this analysis the most appropriate cleaning method is selected as follows:

- Subset Mode is the default tool selected due to its ability to quickly compare large numbers of questionable soundings with adjacent or overlapping data for confirmation or rejection. Subset mode also excels with the assessment possible features, disagreement between overlapping lines, and crossline comparison. The image designer can be used to visually enhance patterns and anomalies in base surfaces, especially the standard deviation base surface.

- Swath Editor is useful for burst noise, multipath, and other "gross fliers" which are specific to a particular line or lines, and most easily removed in this mode. Additionally, when it was felt that the quality of the data was reduced due to environmental conditions such as rough seas or extreme variance in sound velocity, data were filtered on a line by line basis to a lesser swath width to ensure data quality.
- Both modes (but particularly Swath Editor) are used as a training aid to help novices learn how the various sonars operate, and provide feedback to the acquisition process.

After initial cleaning by the launch crew is complete, the Boat-Day BASE Surface is reviewed by the sheet OIC and the sheet mentor. The sheet mentor is an experienced hydrographer whose task is to provide both guidance and review to the sheet OIC. At no point does the launch crew re-compute the Boat-Day BASE surface which could result in obscuring rejected soundings behind a now "smooth" BASE surface. Final review is left to the sheet mentor who inspects areas with questionable shaded depth models and/or high standard deviation to ensure that no actual features were cleaned out. The use of large tiles is encouraged to track coverage of problems areas without the need to re-compute the BASE Surface. The sheet OIC is responsible for accepting the data and adding it to the appropriate production BASE surface in the "HXXXXX" Field Sheet. Specific data quality factors are discussed in the Descriptive Report for each survey.

The production BASE surface is used to ensure bottom coverage and plan additional lines. In addition the production BASE surface is used to compare adjacent lines and crosslines, for systematic errors such as tide or sound velocity errors, sensor error (stuck heave, pitch, etc), sonar errors (consistent bad beams), vessel configuration problems, and noise. Any irregular patterns or problems are reported immediately to the FOO and the sheet OIC so that remedies can be found and applied before more data are acquired.

As the last step to finalize survey data, multiple BASE surfaces are gridded using different resolutions for different depth ranges in accordance with the Field Procedures Manual. Under ideal circumstances, gridding should be done at the finest resolution that the data density will allow. Typically deeper areas are gridded at a coarser resolution than shoaler areas where the data density is greater.

On occasion, the resolution of the BASE surface may not be sufficient to capture the high point of a bathy feature. Although this may occur on irregular shoals or rock pinnacles, man-made features such as piles and wrecks are of particular concern. These features have very slender high points that extend far above the surrounding seafloor as well as the BASE surface. To ensure that these features are properly represented, the shoalest point is flagged "designated" in CARIS. During the "finalization" process, the BASE surface is forced to honor all soundings which have been flagged "designated". In the case of a survey where the high points of many features are not being captured by the BASE surface, (i.e. a boulder field), the hydrographer may decide to tighten up the BASE surface's resolution to ensure that these features are being honored. Any such deviations from the Field Procedures Manual will be noted in that survey's Descriptive Report.

Unfortunately at the time this document was generated, no tools existed in CARIS easily vary grid resolution by depth in a single BASE surface. The individual grids generated must be "cookie cut" and then reassembled to create the final BASE surface from which depths are derived. This step can occur only after navigationally significant cultural features such as piles and wrecks have been flagged as "designated" so that the BASE surface will honor that sounding when the surface is finalized. If final approved water levels have not been received and applied to the data prior to submission, it is necessary for the field unit to submit both a finalized and un-finalized copy of each BASE surface. This dual submission is required since CARIS does not allow tides to be applied to BASE surfaces that have already been finalized and thus PHB would not be able to apply final approved water levels.

Another shortcoming exists in CARIS, which limits BASE surfaces to a maximum of approximately 25 million nodes. Beyond this node limit processing becomes very slow and inefficient, even on fast computers

with abundant memory. This node limit is generally not a problem at the coarser resolutions, but 1m & ½ m resolution surfaces often require multiple BASE surfaces in order to keep each surface at less than 25 million nodes.

In order to maximize efficiency, a field sheet is created (Hxxxxx) that encloses the entire sheet. It is important to make this field sheet as small as possible because when computing a BASE surface, CARIS will allocate memory for every grid cell, even those where there is no data. This field sheet will contain both finalized and un-finalized (if required) versions of BASE surfaces that cover the entire sheet as well as the final combined BASE surface from which the final depths are derived. If multiple BASE surfaces are required at the finer resolutions, individual field sheets are created in the number necessary to keep each surface less than 25 million nodes. Every effort is made to minimize the number of field sheets required with strategic placement and sizing of the sheets to correspond with the appropriate depth range. Some overlap (approximately 100m in most cases) is allowed between adjoining surfaces.

Each resolution-specific field sheet and its BASE surface will share a unique name, according to the following convention:

H<registry #>_<resolution in meters>M_<letter designation, if necessary>

(EX: “H12345_2M” refers to the two-meter resolution surface of survey H12345 and “H54321_1M_C” would be the third field sheet necessary to cover the area of H54321 at one-meter resolution.)

Once the collection of field sheets accurately represent the surveyed bottom and it is certain that no further edits will be made, each BASE surface is finalized using the resolution and depth ranges specified in the Preliminary Field Procedures Manual (see table 1). All BASE surfaces are then combined at the coarsest resolution used to create the final combined BASE surface. The final, combined BASE surface should be named Hxxxxx_Final_Combined_Xm and be created in the survey wide field sheet Hxxxxx.

Depth Range Filtering	Final BASE Surface Resolution
0 - 15 m	0.5 m
14 - 30 m	1 m
29 - 60 m	2 m
59 - 150 m	5 m
149 m +	10 m

Table 1 Depth range vs. BASE surface resolution

The BASE surfaces generated are sun-illuminated from different angles and examined for coverage and to further check for systematic errors such as tide, sound velocity, or attitude and/or timing errors. The final BASE surface submitted in the fieldsheet serves to demonstrate that both SWMB coverage requirements are met and that systematic errors have been examined for quality-assurance purposes.

As a quality control (QC) measure, a number of cross-lines greater than 5% of mainscheme lines were run on each survey and manually compared to the mainscheme lines in CARIS subset mode. This qualitative QC comparison is discussed in the descriptive report for each survey.

Feature Data

Prior to shoreline acquisition, a shoreline reference document is prepared by the hydrographer. This reference document contains the source shoreline provided with the project instructions. In addition to this source material, charted and/or non-source features that are not covered by source shoreline are color coded and added to the shoreline reference document for field verification.

Shoreline acquisition occurs during daylight periods near MLLW. A line is run along the shore as close as is safely navigable by a survey launch. While the line run does not determine the location of the inshore limit or contour of hydrography; it does do the following things:

- It gives a general idea of how close to shore we will be able to run our mainscheme survey lines.
- It allows the opportunity to verify the accuracy of all shoreline sources, including the chart and remote sensing data (DCFF, LIDAR, etc.).
- It allows us to locate significant features at MLLW, which might not otherwise be easily detected.

As this line is run along the shore, the hydrographer is both annotating the shoreline reference document and looking for new “Navigationally Significant” features. All point features seaward of the limit contour should be verified with a DP or disproved. “Navigationally Significant” features are defined as the following:

- All features within the limits of safe hydrography.
- Features inshore of the limits of safe hydrography which are sufficiently prominent to provide a visual aid to navigation (landmarks). Note that rocks awash are almost never landmarks, but distinctive islets or other features visible at MHW can be useful for visual navigation.
- Features inshore of the limits of safe hydrography which significantly (at the resolution requirement established for the survey) deflect this limit. Common examples of these features include foul areas and large reef/ledge structures.
- All man-made permanent features connected to the natural shoreline (such piers and other mooring facilities) that are sized to be chartable at current or planned next chart edition.. Seasonal features will be evaluated by the Command
- All man-made permanent features disconnected from the shoreline, such as stakes, pilings, and platforms, regardless of size.

Terminology used for field annotation of the shoreline reference document during shoreline verification is as follows:

“Noted”

- The existence of a feature and its characteristics are confirmed from a distance, and its position appears to be correct within the scale of the chart or source.
- Appropriate for features inshore of the limit of hydrography and not navigationally significant, or are unsafe to approach to verify position within survey scale.

“Verified ”

- The feature’s position and characteristics have been acquired and recorded either by directly occupying the site, or by applying a range and bearing offset to a known position. Positioning will generally be by DGPS methods.
- Appropriate for new items within the limits of hydrography, or navigationally significant features inshore of this limit. Also appropriate for existing features with a source position not accurate at survey scale.

“Not Seen”

- The feature is present in source data (chart, DCFF, etc.) but was not visually observed in the field. Full disproval search (see below) was **not** conducted.
- Appropriate for:
 - Features above MHW, the absence of which can be proven visually from a distance.
 - Source features inshore of the limit of hydrography which are not observed, but whose presence on or absence from the survey will not affect safe navigation.
 - Any feature from source which was not seen, but for which full disproval search (see below) is impractical or unsafe.

Comment [CO1]: These features should be DPd if height is a requirement for S57, such as rocks that need vertical datum. Not worth arguing about.

Comment [CO2]: This is rarely appropriate. IF above MHW, don’t waste time looking for it. IF inshore of limit, don’t waste time looking for it. IF Offshore, must disprove using appropriate methods. If technology is not available, hydrographer must state that item should be brought forward, and recommend further search/disproval when appropriate means are available.

“Disproved”

- The feature is present in source data, but was not located after a full search. “Full Search” means SWMB, VBES, SSS, and/or Detached Position coverage of the area which conclusively shows that the item is not located at the position given to the accuracy and scale of the source document.

The primary purpose of detached positions (DP’s) is to verify and define shoreline features (ex: rocks, reefs ledges, piles), disprove charted features, position navigational aids and landmarks (ex: buoys, beacons, lights), and mark positions of bottom samples. DPs were captured in the field as quick mark targets in HYPACK by hitting the f5 key. Additional edits to the targets (range, bearing, depth and notes) were performed by editing target parameters with the f6 key in HYPACK. Concurrent with the acquisition of these DP’s, digital photographs were taken of most features which were exposed above the waterline.

Following acquisition, target files (TGT) were edited when applicable to correct magnetic bearings for local variance so that all bearing were true. Additionally, DP names were changed to the format *vvvv_ddd_nnn* where *vvvv* is the vessel’s hull number, *ddd* is the day of year and *nnn* is the position number (Ex: DP **1101_099_118** is the 118th position taken by vessel 1101 on day number 099). Finally the TGT files were saved with naming convention DP_*vvvv_ddd.tgt* for DPs and BS_*vvvv_ddd.tgt* for bottom samples.

A vessel configuration representing the majority of the targets was selected and TGT files were converted to HDCS format data using Pydro. Digital photos were renamed to match their respective DP’s fix number and moved into a single folder. Final DP attribution, correction of vessel configurations, and linkage to digital photos were the performed using Pydro. Any required application of tide and SV corrections were performed in CARIS HIPS.

S-57 Attribution

Hydrographic data become Pydro features in one of three manners:

- DPs which need to retain depth information, such as rocks and reefs, are converted to HDCS format data using Pydro. At the this point both tides and sound velocity may be applied in CARIS to produce corrected depths.
- DPs which require no depth information, such as bottom samples, are converted directly into the Pydro Preliminary Smooth Sheet (PSS) as GPs and retain only their position and attribution.
- Soundings which have been flagged as “designated” on cultural features such as wrecks or piles.

All Pydro XML features marked as “primary” were edited to have their object/attribute instances describe each feature as completely as possible. In some cases this required that multiple object classes be assigned to a single feature. Object attributes assigned to each feature conform to direction located within both the draft “S57 PYDRO guide” and the CARIS “IHO S-57/ENC Object and Attribute Catalogue”.

The Pydro S-57 editor also has carto action flags which are edited to reflect the hydrographer recommendations as follows:

- **ADD** -- A new feature was identified during survey operations. The hydrographer recommends adding the feature to the chart.
- **MODIFY** -- The feature was found to be positioned or portrayed incorrectly on the chart. Modify is also used in the case where the feature was found to be attributed incorrectly or insufficiently and is modified to reflect the additional or corrected attribution.
- **DELETE** -- The feature was disproved using approved search methods and guidelines. The hydrographer recommends removing it from the chart.
- **NONE** -- (aka Retain) The feature was found during survey operations to be positioned correctly or

was not investigated. The hydrographer recommends retaining the feature as charted.

Pydro Depth Extraction

The final, combined BASE surface is inserted into Pydro by selecting **Data > Insert > HIPS BASE/Weighted grids**. The PSS parameters **Localized Bathy-Grid Least Depth Size**, **Localized Bathy-Grid Surrounding Depth Size**, and **Localized Bathy-Grid Resolution** were left on their default values (15, 35, and 5 respectively). The resultant data is then excessed in Pydro using a 3-millimeter character size, ensuring that the largest spacing between selected soundings would not exceed 5 millimeters at survey scale. Final selected soundings were exported to MapInfo from Pydro using HP tools, and plotted in MapInfo at a 2-millimeter character size. Data processing flow diagrams are included in Appendix I of this report.

Pydro Processing & Reports

Pydro is capable of producing a number of different reports based on standard report templates built into the program in addition to user selected filters and feature trees. All reports generated in Pydro are saved in the Adobe Acrobat PDF format. Reports generated for inclusion with DRs include shoreline, DTON, and request for approved tides.

The shoreline report is generated by selecting the **Reports>For Descriptive Report** option. This generates a report detailing all features flagged "Report" in addition to all dangers to navigation.

Any item selected as a DTON must be classified as a feature in Pydro. For a sounding this is accomplished in the Pydro Feature Cumulative Grid by selecting the individual sounding of interest and with a right click "Make Feature". The resultant feature is then flagged Primary - Significant - Chart - DTON - Resolved. Once all selected DTONs are features a report is generated by selecting **Reports>Danger to Navigation**. This generates both a .pdf file and an .xml file with the naming convention of "Hxxxxx_DTON1.xml". In addition, the generation of this report also flags all DTONs as Submitted. Any subsequent DTONs discovered are similarly made features and flagged as previously instructed. Running **Reports>Danger to Navigation** again, with the naming convention of "Hxxxxx_DTON2.xml" for the second submission, will generate a report with DTONs not previously flagged as submitted.

Prior to the start of data collection on a sheet, the AWOIS database provided with the project instructions is edited to be sheet specific by deleting all AWOIS items which fall outside of the sheet limits. This sheet specific database is then inserted into the sheet's PSS. If a DP is taken and correlates to the AWOIS item, the DP is marked "Primary" and the corresponding AWOIS item is marked "Secondary". If an AWOIS item was found or disproved with a multibeam sounding, the sounding is made into a bathy-feature and marked "Primary" and the corresponding AWOIS item is marked "Secondary". Investigation techniques and methods are entered in the remarks tab of the AWOIS item. Any digital photo taken with a detached position is associated with the DP as usual. When applicable, MapInfo screen-grabs displaying the AWOIS search radius with the associated grid in the background were associated with the AWOIS item. With a right mouse click "add to report" any photos or screen-grabs may optionally be added to the shoreline report.

C. CORRECTIONS TO ECHO SOUNDINGS

Sound Velocity

Sound velocity profiles were acquired with SeaBird Electronics SeaCat SBE19 and SBE 19Plus Conductivity, Temperature, and Depth (CTD) profilers (S/N 219, 281, 4039, 4114, 4343, and 4443). Raw

conductivity, temperature, and pressure data were processed using the program VelocWin version 8.72 which generated sound velocity profiles for CARIS in the .SVP format. VelocWin was also used to generate sound velocity profiles for Elac acquisition in the .SVA format. Calibration reports and dates of the SeaCat profilers are included in the NOAA Ship RAINIER 2005 Field Season Hydrographic Systems Certification Report.

The speed of sound through the water was determined by a minimum of one cast for every four hours of SWMB acquisition in accordance with the Standing Project Instructions and the NOS Hydrographic Surveys Specifications and Deliverables Manual. Casts were conducted more frequently when changing survey areas, or when it was felt that conditions, such as a change in weather, tide, or current, would warrant additional sound velocity profiles. Additionally, drastic changes in the surface sound velocity indicative of the need for a new cast were determined by observation of the real-time display of the Odom Digibar Pro mounted on vessel 1016 and 1015.

The Elac 1180 SWMB system utilized on vessels 1016 and 1015 is a beam-steered flat-faced transducer system which produces the best results when SV correctors are applied to both the transducer-water interface and the water column itself. To correct SV at the face of the transducer, a real time SV value is feed directly into the HydroStar acquisition software from an Odom Digibar Pro, model db1200 velocimeter. To correct beam-steering in the water column, the .SVA file produced by VelocWin is also input into the HydroStar acquisition software and is used until replaced with another .SVA file.

Occasionally circumstances would dictate taking an SV cast after the acquisition of SWMB data to which the cast was intended to be applied. In this event the cast was manually backdated so that it would be applied to the SWMB data correctly. Sound velocity profiles for CARIS were concatenated by vessel in order of ascending time/date and saved in the same directory as the individual SVP files for each vessel. A naming convention of Hxxxxx_vvvv_SVP.SVP was used where Hxxxxx is the sheet's registry number and vvvv is the vessel's hull number (Ex: **H11292_1006_SVP.SVP** is the concatenated SVP file for hull number 1006 for sheet H11292). This concatenated file was then applied to all HDCS data collected by that particular vessel with the option **Previous in time** selected under the **Profile Selection Method**.

Vessel Offsets and Dynamic Draft Correctors

The following table shows when the vessel offsets and dynamic draft correctors used for this project were last determined:

Vessel Hull Number	Date of Static Draft and Transducer Offset Measurements	Method of Settlement and Squat Measurement	Date of Settlement and Squat Measurement	Location of Settlement and Squat Measurement
1103	February 2005	Surface analysis	April 2005	Sequim Bay, WA
1021	February 2005	Surface analysis	March 2004	Lake Washington, WA
1016	February 2005	Surface analysis	March 2005	Lake Washington, WA
1006	February 2005	Surface analysis	March 2005	Lake Washington, WA
1015	February 2005	Surface analysis	April 2005	Sequim Bay, WA

Settlement and squat observations were conducted for all launches using a surface analysis method. An area of flat topography was selected in a protected area to minimize any heave or chop. When possible observations were conducted in a lake to negate any tidal influence. A line was then run repeatedly in the same direction at different speeds while logging data. Finally data was collected at three pre-selected target areas on the same line while the launch was at rest. Settlement and squat speed curves were derived by querying these target areas using CARIS and graphing the change of apparent depth at different speeds.

Settlement and squat observations collected in Lake Washington by vessel 1021 for the 2005 field season were subsequently determined to be unusable due to improper collection procedures. As a consequence, dynamic draft values determined for 2004 operations were utilized since a re-test could not be scheduled prior to conclusion of data acquisition on OPR-N372-RA-05.

Vessel offsets and static draft were measured using both steel tapes and a LEICA laser distance meter. In most cases, measurement values obtained fell close to the historic values and these were retained. In a few cases the new measurements differed enough from the historic values and the new measurements were carried forward.

Dynamic draft and vessel offsets corrector values are stored in the HIPS Vessel Files (HVF's). Survey platforms used to collect SWMB data each have a separate HVF associated with each individual acquisition system aboard. Each of these HVFs contain sensor offset and dynamic draft correctors that pertain to this single acquisition system. Sensor offset and dynamic draft correctors were applied to SWMB data in CARIS during post-processing. Vessel offset diagrams and dynamic draft tables are included in included in the NOAA Ship RAINIER 2005 Field Season Hydrographic Systems Certification Report. The HVFs themselves are submitted with the digital HDCS data.

The following table lists each HIPS Vessel File used for this project:

HVF name	Survey Vessel & System Type
1006_Reson8101_HVF	Jensen hull 1106, SWMB using hull mounted Reson 8101
1006_Reson8101_ProjFwd_HVF	Jensen hull 1106, SWMB using hull mounted Reson 8101 with beam order reversed
1015_Elac1180_HVF	Jensen hull 1015, SWMB using hull mounted Elac 1180
1016_Elac1180_HVF	Jensen hull 1016, SWMB using hull mounted Elac 1180
1016_Reson8125_hvf	Jensen hull 1016, SWMB using hull mounted Reson 8125
1021_reson8101_HVF	Jensen hull 1021, SWMB using swing-arm mounted Reson 8101
1021_reson8101_ProjFwd_HVF	
1103_Echosounder_DP	Jensen hull 1103, detached positions using echosounder
1103_Singlebeam_HVF	Jensen hull 1103, singlebeam using Knudsen 320M

Heave, Pitch, Roll and Heading, Including Biases and Navigation Timing Errors

SWMB launches (Vessels 1021, 1016, 1006 and 1015) utilized a TSS POS/MV Model 320 Position and Orientation System – Marine Vessel (POS/MV) which provides accurate navigation and attitude data to correct for the effects of heave, pitch, roll and heading. The POS generates attitude data in three axes (roll, pitch and heading) to an accuracy of 0.05° or better. Heave measurements supplied by the POS/MV maintain an accuracy of 5% of the measured vertical displacement for movements that have a period of up to 20 seconds. The POS/MV delivers heading measurements by two distinct methods. First, the Dynamic Heading Alignment determines the vessels heading by using the data supplied by the Internal Measurement Unit (IMU) and GPS receivers to achieve heading that is, at best, accurate to within 0.25°. This method suffers from drift but is relatively unaffected by noise. Second, the GPS Azimuth Measurement System (GAMS) determines the geographic vector between two GPS antennas fixed to the vessel by comparing the phase of satellite signals they receive. The error from this method is largely due to noise, but exhibits no drift. The POS/MV uses the advantages of each method to compensate for the disadvantages of the other to arrive at an optimal accuracy of 0.05°.

With a series of both software and firmware upgrades in addition to modified wiring, all Reson survey launches have been upgraded for precise timing for the 2005 field season. The objective of this upgrade is to use a single clock to time stamp all data at the point of acquisition and thus eliminate the latencies introduced by the serial and Ethernet interfaces in addition to the PC millisecond counter. Position, heading and attitude are all time stamped by the POS/MV on UTC epoch and the bathy data is time stamped in SeaBat using the POS/MV UTC serial string. This synchronization essentially eliminates timing errors and variable latencies resulting in data which is both horizontally and vertically more accurate.

Patch test procedures are modified slightly for precise timing. Pitch, roll and yaw lines are collected and processed as usual in accordance with NOS Hydrographic Specifications and Deliverables. Navigation latency is determined by examination of the roll timing error. Roll error can be determined from any single line in an area with relatively flat topography. A thin slice of the outer beams parallel to the line was examined in CARIS calibration mode. Any wavelike pattern observed in the data is assumed to be the result of roll latency. The roll latency value is determined by manually changing the value until the wave pattern disappears. The resultant latency value was also applied to navigation, heave gyro and pitch time errors since they all of these values are produced by the POS/MV.

Elac patch test procedures were modified as outlined in section 3.7.3 of the HydroStar Manuals 2.1. Since the Elac is a beam-steered flat-faced transducer system, the roll bias values must be entered directly into the HydroStar acquisition software for proper beam steering calculations. Roll bias values are not entered into the CARIS HIPS Vessel File (HVF) so as to avoid double application. The transducer alignment option in HydroStar allows for automated computation of the roll bias values based upon two pairs of reciprocal lines in an area with flat seafloor, one offset from the other to ensure an overlap of 100%. Pitch, yaw and navigation latency lines are collected and processed as usual in accordance with NOS Hydrographic Specifications and Deliverables.

All SWMB vessel offsets, dynamic draft correctors, and system bias values are contained in CARIS HIPS Vessel Files (HVF) and were created using the program Vessel Editor in CARIS. These offsets and biases are applied to the sounding data during processing in CARIS. All applicable HVFs are included with the digital HDCS data.

Water Level Correctors

Soundings were reduced to Mean Lower-Low Water (MLLW) using verified observed tide data for stations at Friday Harbor, WA (944-9880) and Port Townsend, WA (944-4900). Tide data were obtained from the Center for Operational Oceanographic Products and Services (CO-OPS) web site through TideBot. These data were used in creating the observed tide corrector tables (*.tid files) in CARIS. Raw observed water level data from these three reference stations were applied to the survey depths in CARIS using height ratio and time correctors from the CO-OPS provided zone definition file (*.zdf).

Refer to the Horizontal and Vertical Control Report for specific information on the tidal gauges used in during this project and individual Descriptive Reports for further information regarding water level correctors specific to each survey.

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 2003.

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

Approved and Forwarded:

John W. Humphrey
Commander, NOAA
Commanding Officer

In addition, the following individual was also responsible for overseeing data acquisition and processing of this project:

Field Operations Officer:

Benjamin K. Evans
Lieutenant, NOAA

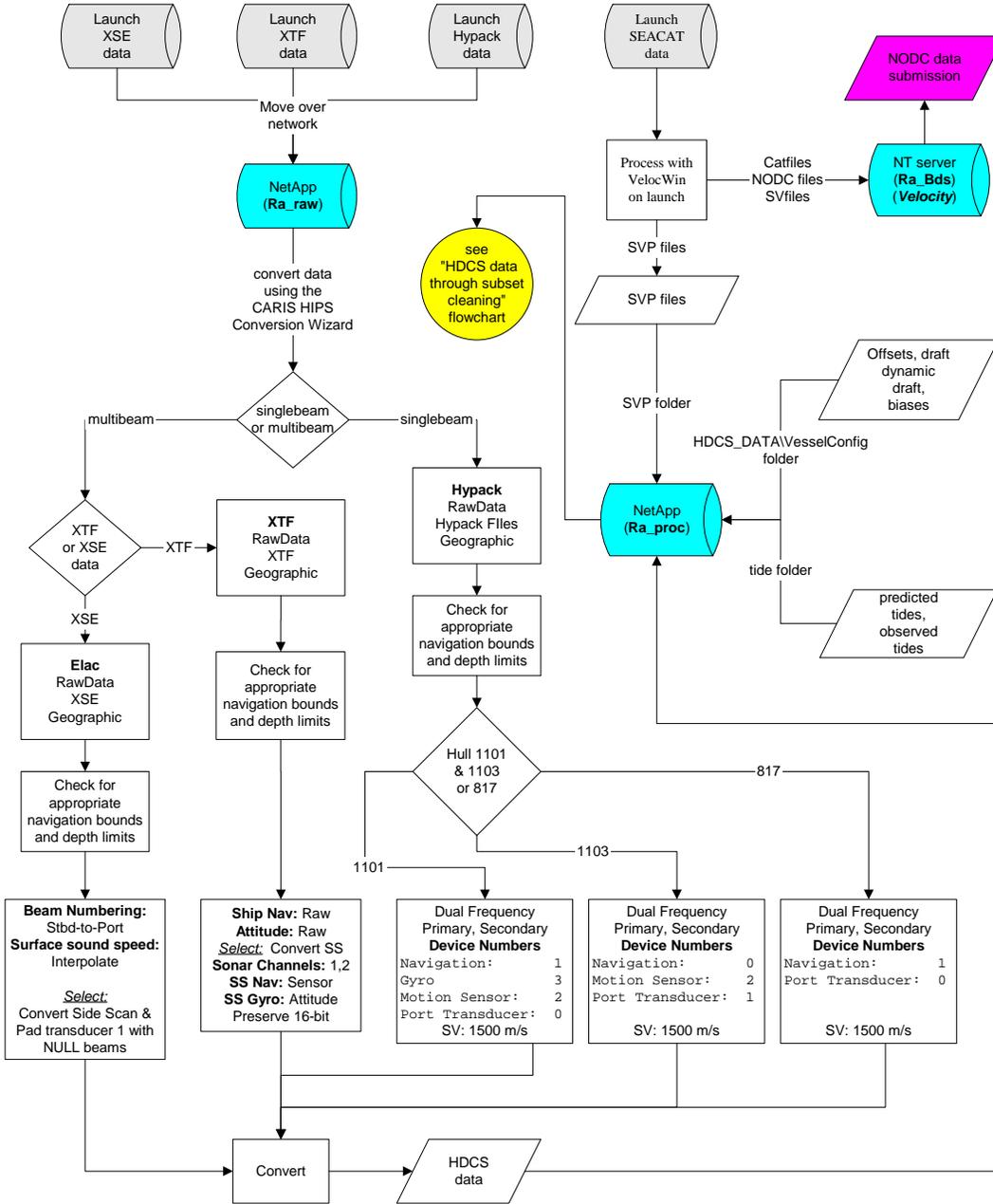
Chief Survey Technician:

James B. Jacobson
Chief Survey Technician, NOAA

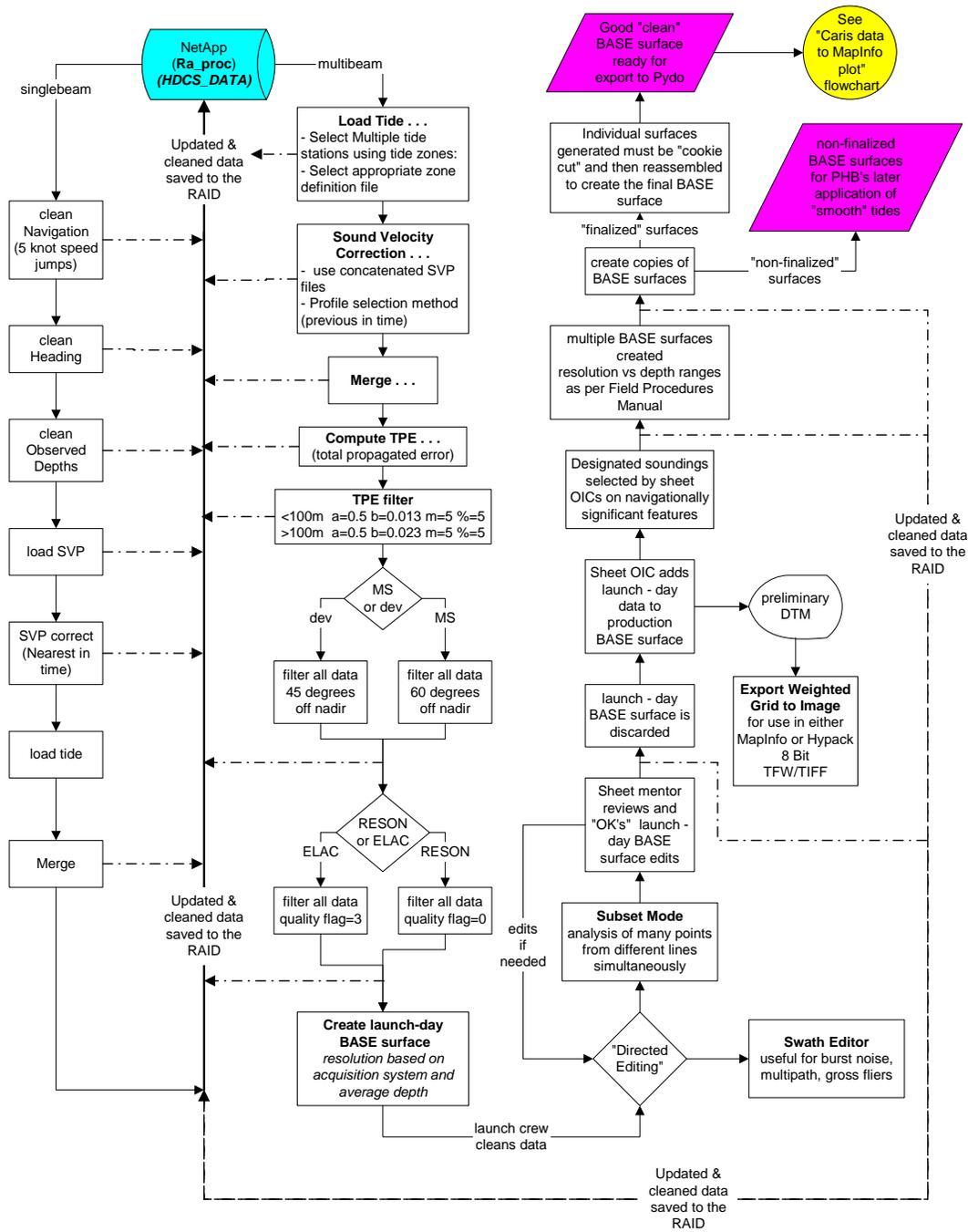
APPENDIX I

Data Processing Flow Diagrams

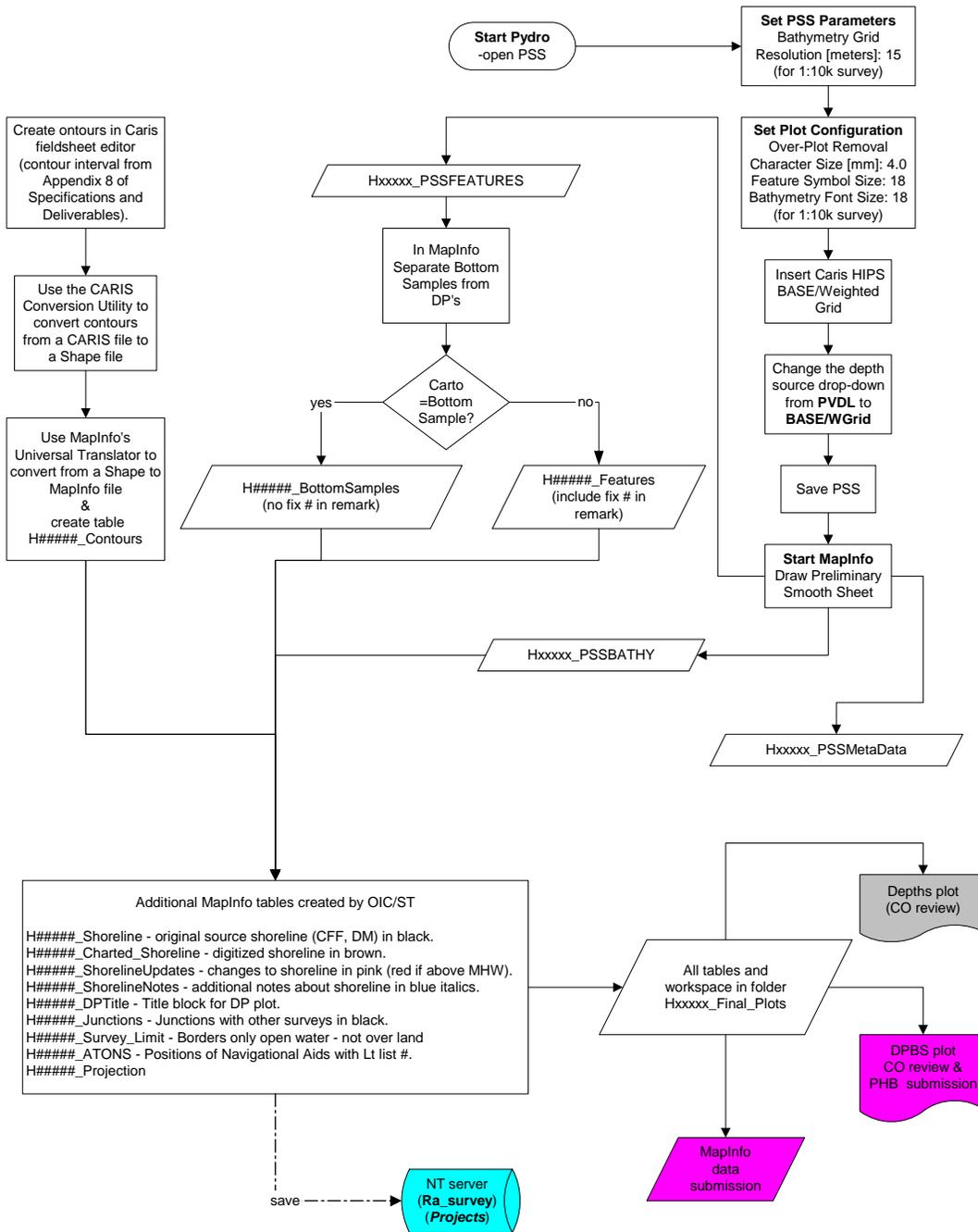
Raw sounding data to HDCS



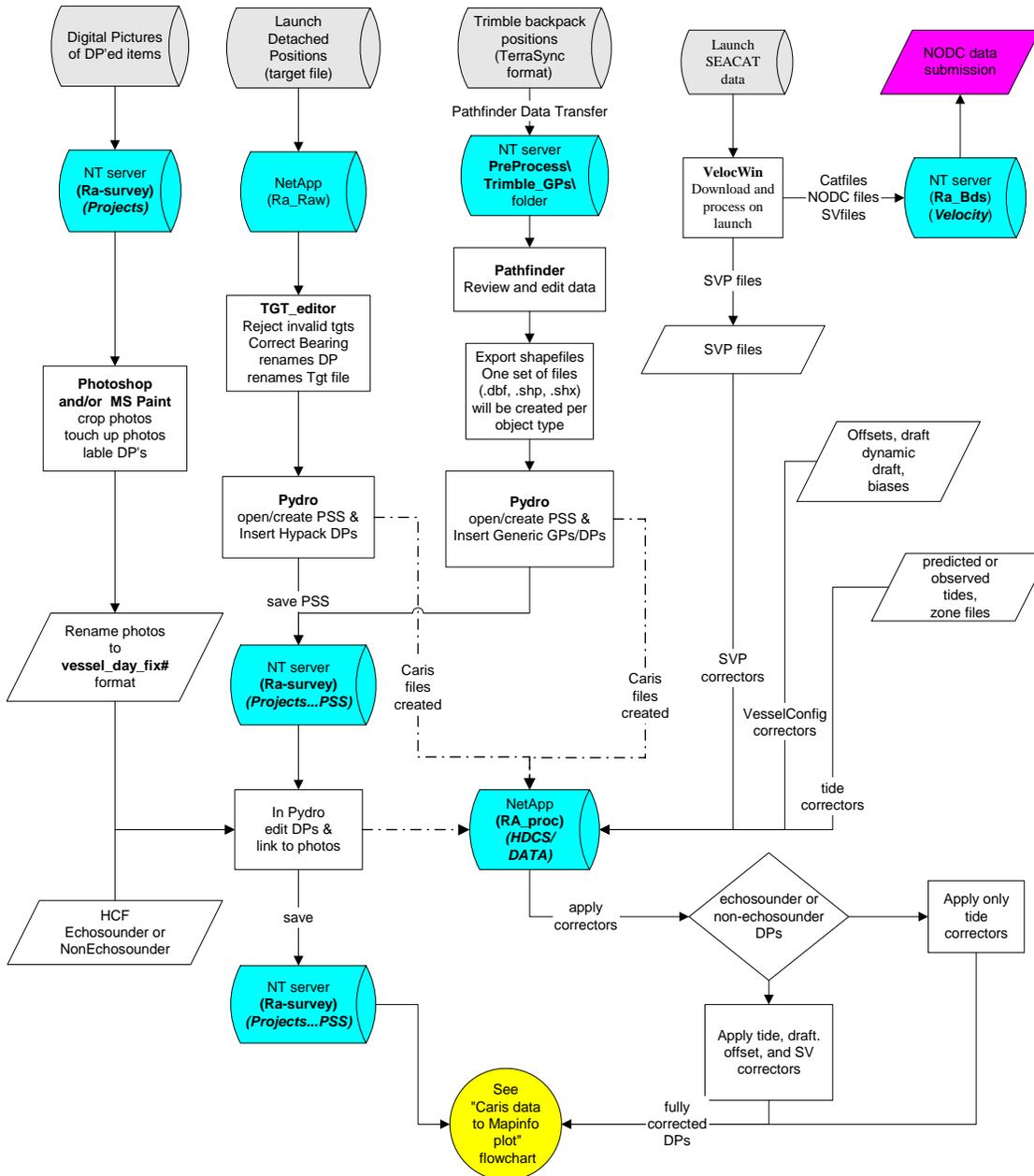
HDCS data through subset cleaning



Caris data to MapInfo plot



Detached Position processing (Raw DP's to Pydro)



Detached Position processing in Pydro

