

# Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of Coast Survey

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## *FOREWORD*

The purpose of this Field Procedures Manual (FPM) is to provide NOAA field units with consolidated and standardized guidelines and requirements for conducting, processing, and generating final field deliverables for Office of Coast Survey (OCS) hydrographic surveys. This manual summarizes current best practices that shall be used by NOAA field units to meet specifications set forth in the NOS Hydrographic Surveys Specifications and Deliverables.

Words used in this manual to denote mandatory or permissive actions are defined as follows:

- “Shall” or “must” means the procedure or standard is mandatory.
- “Should” means the procedure or standard is recommended.
- “May” and “need note” means that the procedure or standard is optional.
- “Will” means futurity of action only and does not indicate any degree of requirement for application of a procedure or meeting a standard.

Due to the rapid development of technology and continual improvement of operational methods, the FPM will require periodic maintenance. User input, particularly from field units, is critical to ensuring that the FPM is up to date. Recommended changes to the FPM will be reviewed by committee bi-annually for potential application to the FPM. Any new procedures put into effect between versions of the FPM will be implemented via a Hydrographic Surveys Technical Directive. Recommended changes and other comments regarding the manual can be made via the following online form: [https://docs.google.com/a/noaa.gov/spreadsheet/viewform?usp=drive\\_web&formkey=dDZ1anFweXZiLUQtNXNMYWh2SktFdlE6MA#gid=0](https://docs.google.com/a/noaa.gov/spreadsheet/viewform?usp=drive_web&formkey=dDZ1anFweXZiLUQtNXNMYWh2SktFdlE6MA#gid=0) or via email to [HSSD.FPM.updates@noaa.gov](mailto:HSSD.FPM.updates@noaa.gov).

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## SIGNIFICANT FPM CHANGES SINCE RELEASE OF 2013 VERSION

### SECTION AND DESCRIPTION OF CHANGE

#### Title Page - Foreward

Added the Field Procedures Manual and Specifications and Deliverables Feedback form weblink and email.

#### 1.3 Basic Methods and Documentation

Added reference to HiBase

##### 1.3.2 HiBase (Hydrographic Inventory Database)

Added new section regarding HiBase

##### 1.5.11.1 Reference Surface Acquisition and Processing

Added new section

##### 2.4.5.1 Local Notice to Mariners Announcement

Add new section regarding LNM submission requirements

##### 2.4.5.3 Potential for Lost or Damaged Fishing Gear

Revised existing section with more comprehensive guidance & information

##### 3.5.2.3 Water Level Data Retrieval

Removed reference to TideBot

##### 3.5.2.3.2 TideBot

Deleted entire section

##### 3.5.7 Coast Pilot Data

Revised this section

##### 4.1.1.1 HIPS and SIPS Vessel Wizard

Updated Table 4.1

##### 4.1.1.1.2 Configuration Options

General revision to section

##### 4.1.2 Creating CARIS Projects

Revised section regarding the use of the CARIS New Project Wizard

##### 4.2.3.3 Load Error Data

General revision to section

##### 4.2.3.5 Load Delayed Heave

Revised section to include reference to Delayed Heave

##### 4.2.3.7 Merge

Deleted the 'Apply Refraction' portion of this section



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## Chapter Appendices

*Please note: The Standard Operating Procedure's (SOP's) within the FPM Appendices are in the process of being transferred to the "Documents" section of the Hydroforum and the SOP's will reside in both places for the remainder of the 2014 field season.*

### Chapter 1 Appendices:

SSS Calibration Table, Sounding System Comparison Log, POS\_MV Calibration Report, MBES Calibration Report, Leadline Sounding Pole Directions, Leadline Sounding Pole Calibration Report, Hydrographic System Readiness Memo, Coordinate Systems

### Chapter 2 Appendices:

Digital Data Directory Structure, Field Unit File Structure (example), NAVMETOCCOMINST 3142A March 2007 – OCS Deviations, NAVMETOCCOMINST 3142A March 2007, Basic Waterlevel Station Equipment Checklist, Example of Fishing Gear Interaction Reimbursement Letter, Example of Lobstermen's Association Letter, Fishing Gear OGC Legal Opinion Memo, Example LNM Survey Announcements

### Chapter 3 Appendices:

Diver Least Depth Gauge Model III, HorCon\_VerCon Observation Log, Hysweep Device Setup SOP, NGS-58, Standing Project Instructions for , Coastal and Great Lakes Water Level Stations, User's Guide for GPS Observations

### Chapter 4 Appendices:

Additional Attribution Guidance, Pydro Flags, Attributing and Flagging for Automated Feature Reports, Backscatter Acquisition SOP, Backscatter Processing SOP, CARIS HVF Uncertainty Values, Combined Surface Grid Requirements, Customized Attribute Equivalencies, Ellipsoidally Referenced Equivalencies, FileVerifier++ SOP Standard Shorthand for Features, TCARI for Notebook Features SOP, TVU\_QC SOP, SSS Contacts to \$CSYMB\_SOP

### Chapter 5 Appendices:

Digital Data Submission Checklist, Hydro Survey QC Checklist, Hydro Survey Review Checklist, Fixed ATON Report

# Chapter 1

## Systems Preparation & Maintenance

NOAA's Office of Coast Survey (OCS) uses a wide array of systems, tools, and procedures to perform modern hydrographic surveys. Due to the variety of equipment and highly technological nature of operations, a consistent, well-documented program of systems preparation and maintenance is essential to ensure that NOAA's hydrographic field units are capable of producing data that will meet OCS specifications. These procedures can be broken down into two categories: Annual Systems Preparation and Periodic Quality Assurance.

### 1.1 Annual Systems Preparation

Each field unit shall schedule an adequate period of time for Annual Systems Preparation, typically during winter inport for ships, in which survey systems will undergo annual calibration, maintenance, and verification procedures as defined in this chapter. These procedures should also be performed following any significant period of inactivity and after major changes or upgrades to a field unit's hydrographic systems. Unless specifically stated otherwise or assistance is arranged from another NOAA office, Systems Preparation should be conducted and documented by field unit personnel.

As a final step in Annual Systems Preparation, prior to the start of survey data acquisition, each field unit shall perform a Hydrographic Systems Readiness Review as described in section 1.1.1. This process is simply a formal review of each hydrographic field unit's Annual Systems Preparation.

#### 1.1.1 Hydrographic Systems Readiness Review

The primary purpose of the Hydrographic Systems Readiness Review (HSRR) is to officially document and inform OCS senior-level management of a field unit's level of readiness to perform hydrographic surveys that will meet OCS specifications. This procedure also affords field units the opportunity to identify any deficiencies that will prevent optimal performance and production throughout the field season. These deficiencies may include such items as damaged or unreliable equipment, unmet training needs, and personnel shortages. Formally documenting field unit requirements will better prepare OCS to provide support and meet the needs of NOAA's hydrographic fleet. The Hydrographic Systems Readiness Review process can be broken down into four basic steps outlined below.

1. **Hydrographic Systems Review Team Organization.** A Hydrographic Systems Review Team shall be organized for each NOAA hydrographic field unit. This team shall consist of an assigned OCS Representative, typically a hydrographer from either the Atlantic Hydrographic Branch (AHB) or the Pacific Hydrographic Branch (PHB), the regional Hydrographic Systems and Technology Program (HSTP) Field Support Liaison, and the field unit's Field Operations Officer (FOO) or equivalent.
2. **Hydrographic Systems Review.** The Hydrographic Systems Review Team shall examine both physical survey systems and documentation for Annual Systems Preparation requirements outlined in this chapter.

After completion of the review, this team shall brief the Chief-of-Party on the level of field unit readiness determined, any deficiencies identified, and any recommendations that could increase the unit's data quality or general survey efficiency.

3. Hydrographic Systems Readiness Review Memo. Within ten working days of commencing survey operations, the Chief-of-Party shall notify OCS of the field unit's hydrographic systems status and level of readiness to complete its assigned OCS hydrographic survey mission. This notification shall be an email submission consisting of a digitally signed Hydrographic Systems Readiness Review Memo (see Appendix 1) that lists system deficiencies identified during the Hydrographic Systems Review and a plan to address each problem. Any modifications or restrictions in operations that will be necessary in the interim must also be identified. This digitally signed memo should be sent to [ocs.hsrr@noaa.gov](mailto:ocs.hsrr@noaa.gov). Files shall be named using the following format <UNITNAME\_HSRR\_MMDDYYYY.pdf>. For additional HSRR memos, add Adendum or Amendment <UNITNAME\_HSRR\_Adendum1\_MMDDYYYY.pdf>. This digitally signed memo should be sent to [ocs.hsrr@noaa.gov](mailto:ocs.hsrr@noaa.gov). The following people receive e-mail sent to [ocs.hsrr@noaa.gov](mailto:ocs.hsrr@noaa.gov):
  - (a) Chief and Deputy Chief, Hydrographic Surveys Division (HSD)
  - (b) Chief and Deputy Chief, Navigation Services Division (NSD)
  - (c) Chief, Hydrographic Systems and Technology Program (HSTP)
  - (d) Chief, Atlantic Hydrographic Branch (AHB)
  - (e) Chief, Pacific Hydrographic Branch (PHB)
  - (f) Chief, HSD Operations Branch
  - (g) Chief, NSD Navigation Response Branch (NRB)
4. Hydrographic Systems Readiness Acknowledgment. Within ten working days of receiving the Hydrographic Systems Readiness Review Memo, the Chief of HSD or Chief of NSD shall formally acknowledge receipt via digital memorandum to the field unit's Chief-of-Party with a copy to [ocs.hsrr@noaa.gov](mailto:ocs.hsrr@noaa.gov). This memorandum of acknowledgment shall also state OCS acceptance, qualified acceptance, or rejection of the field unit's hydrographic systems readiness. If systems readiness is partially accepted or rejected, the memorandum shall list any specific actions required by OCS for the field unit to meet data quality standards.

## **1.2 Periodic Quality Assurance**

Periodic Quality Assurance refers to any additional procedures required by OCS to maintain or verify continued data quality between annual Hydrographic Systems Reviews. These procedures vary by equipment type and are generally performed on a scheduled basis throughout a unit's field season. Specific requirements are organized by system type and defined in this chapter.

## **1.3 Basic Methods and Documentation**

To effectively manage a field unit's hydrographic systems, a comprehensive inventory must first be completed, and then continually maintained. A standard format for a Hydrographic Systems Inventory has been implemented

by OCS, as described in section 1.3.1 . OCS has further established a standardized hydrographic system database, HiBase, which may be utilized for recording this inventory as described in section 1.3.2. HiBase is intended to serve as a centralized database that retains and archives all vessels and hydrographic hardware and software used fleet-wide.

The Hydrographic Systems Inventory is a critical element of systems documentation for both Annual Systems Preparation and changes occurring throughout a unit's field season. Preparation and maintenance requirements will vary, typically by survey system category and type. While Periodic Quality Assurance procedures are relatively easy to manage, the sheer quantity and variety of tasks to be completed during Annual Systems Preparation can be daunting. OCS-recommended methods for meeting both Annual Systems Preparation and Periodic Quality Assurance requirements for standard hydrographic survey systems are described in detail in sections 1.4 of this document. However, unless stated that the field unit shall or must follow a specific procedure, these methods are not mandatory. Field units are encouraged to develop more efficient and/or accurate methods in consultation with HSD and HSTP personnel. Note: Any new procedures used must be documented with sufficient detail for the process to be recreated. Systems documentation shall meet the minimum guidelines set forth in this chapter and use digital reporting formats supplied in Appendix 1. Each of the forms provided in Appendix 1 has been designed to include essential information. The bulk of systems documentation is to be maintained by the field unit and made available for review during Hydrographic Systems Reviews and at the request of OCS. Documentation designed for continual maintenance, such as the Hydrographic Systems Inventory spreadsheet, should be used to capture changes that occur throughout a field season.

### **1.3.1 Hydrographic Systems Inventory**

Each field unit shall complete and maintain a digital Hydrographic Systems Inventory addressing the four systems categories described below. This information shall be recorded using the format provided below.

- Vessels - Include all vessels to be used for hydrographic data acquisition. For new vessels or platform types not commonly used in OCS hydrography, additional descriptive information with diagrams and/or picture should be included
- Hardware Systems - Include all hardware systems to be used to acquire hydrographic survey data.
- Software Systems - Include all software to be used to acquire or manipulate hydrographic survey data.
- Personnel Roster - Include all personnel within the field unit who will be actively involved in survey operations.

As this inventory will typically change over the course of the field season or surveying period, the Hydrographic Systems Inventory shall be updated as changes occur and submitted as Appendix I of the Data Acquisition and Processing Report (DAPR) for each project.

### **1.3.2 HiBase (Hydrographic Inventory Database)**

Field units may opt to use HiBase, a standardized hydrographic inventory database developed by the Coast Survey Development Laboratory (CSDL), for recording and maintaining their Vessel, Hardware Systems and Software Systems inventories per section 1.3.1 . Field personnel may register for a HiBase user account at <https://hibase.noaa.gov>.

## 1.4 Vessels

Vessels are the most fundamental systems in hydrography. Accurate measurement of the dimensions and dynamic parameters of these platforms is essential to obtain high quality survey data. Vessel “calibration” consists of measuring, and estimating error for, static parameters such as the physical positions of instruments and equipment on a vessel, as well as dynamic parameters such as waterline and dynamic draft. Measurement, verification, and documentation of static parameters are addressed in section 1.4.1 . Dynamic parameters are discussed in section 1.4.2 .

### 1.4.1 Vessel Static Offsets

Static offsets of a vessel and its instrumentation are measured for the purpose of establishing a local reference frame to which all soundings and positions will be tied. Thus, errors in these measurements will directly translate to errors in survey data acquired by that vessel. Because much of the equipment installed on vessels remains fixed from year to year, it may not be necessary to perform a full survey of every platform during Annual Systems Preparation.

If the results of a previous survey are available and well documented, and the vessel’s configuration has not changed, simply verifying the existing values should be sufficient. Even when instrumentation has been moved, if the reference frame is based on a network of benchmarks independent of the movable equipment, it may be possible to reposition instruments within the fixed network rather than resurvey the entire vessel. This procedure will result in a significant savings of time and effort, but it is imperative that the original survey be completely and accurately documented to be effective.

The following items shall be positioned as part of any static offset survey conducted for a NOAA hydrographic survey platform:

- Permanent benchmarks - Benchmarks shall be sufficient in number and position to maintain the vessel reference frame if instrumentation is disturbed.
- Sonar transducers - All vertical beam echosounders, multibeam echosounders, and hull mounted side scan sonars that may be used to acquire hydrographic survey data shall be positioned. Transducers mounted on poles, levers, or other movable mounts should be surveyed in their fully deployed position. Offsets shall be measured to the transducer’s phase center, or the origin of the sonar’s local reference frame. OCS recommends also documenting measurements to a nearby permanent mounting point, for reference if the sonar head must be removed or replaced. Consult the corresponding manufacturer’s documentation for further guidance on the location of transducer phase centers.
- GPS antennae - All survey system GPS antennas shall be positioned. This includes any GPS antennas that are integrated with differential beacon receivers and typically only used for differential corrections but could potentially be used to acquire complete survey position data. Antennas capable of receiving differential correctors only do not need to be surveyed. Offsets shall be measured to the phase center of each antenna, a point which may be located inside the antenna’s housing. Consult the corresponding manufacturer’s documentation to determine the phase center location of a specific antenna type. OCS recommends also documenting measurements to the permanent mounting post for reference if the antenna must be removed or replaced.
- Inertial Measurement Unit (IMU) - For all vessels equipped with a POS/MV system, measurements shall be made to the origin of the POS/MV IMU’s local reference frame. The manufacturer’s documentation will define the IMU’s local reference frame and identify its origin.

- Reference Point (RP) - A RP shall be established and positioned for each vessel. This point will define the origin of the local vessel reference frame to which all survey data will be tied. Note: OCS strongly recommends that a vessel's RP be established at the vessel's approximate center of motion (as defined below) and coincident with the origin of the IMU's local reference frame on vessels equipped with a POS/MV system. By collocating these three points, the number of physical offset measurements required will be reduced, thus minimizing sources of error in position and attitude data.
- Center of Motion (CM) - A CM shall be defined and positioned for each vessel. Establish this point at an approximate location at which the vessel's roll, pitch, and yaw axes intersect during static conditions and average loading. The location of a vessel's true center of motion will vary based on a combination of hull shape, loading conditions, and vessel speed; thus it is a dynamic point. However, a fairly accurate estimation can be made using the vessel's plans and empirical observation. Field units should contact NOAA's Marine Engineering Division (MED) for assistance when defining a vessel's CM.
- Towpoint - If the vessel is equipped to perform towed sonar operations, the towpoint shall be positioned. The position of the towpoint is defined as the last point of contact between the tow cable and the vessel, typically the top of a sheave over which the tow cable is led. If the sonar is towed from a movable point (J-arm, A-frame, etc.), it shall be in its fully deployed position for this measurement.

#### **1.4.1.1 Vessel Measurement Requirements & Methods**

Vessel measurement procedures vary depending on whether the intent is to complete a full survey of a vessel, conduct a partial survey to position new or disturbed instrumentation within an existing reference frame, or simply verify existing offsets when no known changes have occurred. The requirements and methods for each of these scenarios are described below.

##### **1.4.1.1.1 Full Survey**

A full survey of a hydrographic vessel is required when no prior survey exists or under any circumstances where all previous surveys are determined to be unusable. Full vessel surveys should be conducted by National Geodetic Survey (NGS) personnel or a professional geodetic surveyor. Full vessel surveys can be both time consuming and expensive; thus, proper documentation is important to preserve the value of this work.

Examples of conditions that would require full surveys include, but are not limited to, the following:

- A vessel is new or will be engaged in hydrography for the first time.
- Significant modifications have been made to the vessel since the last full survey.
- New equipment is installed or existing equipment is repositioned, and the items cannot be accurately referenced to benchmarks from a prior survey.
- New technology or techniques become available that would significantly increase the accuracy of offset measurements or error estimates for the vessel.
- Complete documentation of the previous survey, including offset values, error estimates, and procedure descriptions, is not available.

- The hydrographer discovers blunders or unexplained discrepancies when verifying the results of a previous offset survey. See section 1.4.1.1.3.
- The vessel is involved in an incident, such as a grounding, that has altered the positions of benchmarks and instrumentation, affecting the validity of the previous survey. The goal of a full survey is to establish a completely new three dimensional local vessel reference frame that is independent of any prior vessel surveys conducted. Information from existing surveys shall not be incorporated into any full survey.

## **General Considerations for Full Surveys**

*Accuracy Requirements* - OCS has not defined specific numerical values for required offset measurement accuracy. However, errors introduced in the offset measurement process will be combined with errors from other sources to produce a final Total Propagated Uncertainty (TPU) for each sounding. Measurement errors must be accurately estimated and small enough for vessel data to meet OCS survey specifications. More accurate vessel surveys will leave additional room in the error budget for other sources of error, which may allow the hydrographer to retain more data or operate under more adverse conditions than would be possible with a low accuracy survey. Note: Some integrated position and attitude sensors in use on NOAA platforms, such as the Applanix POS M/V, do have specific accuracy requirements for offset measurements between system components during installation. Hydrographers should review the manufacturer's documentation for any system-specific requirements.

*Benchmarks* - Benchmarks are permanent, known positions on the vessel used to identify the established local reference frame. They may be either existing points, such as antenna posts or well defined features of the vessel, or monuments specifically created or installed for the purpose of the survey. Examples of monuments are punch marks, scribe marks, or survey disks. Hydrographers shall avoid establishing vessel reference frames that utilize impermanent features of the vessel as benchmarks. The following two factors should be considered when selecting or installing benchmarks: (1) Permanence - Benchmarks should be permanent features fixed to the vessel's hull or superstructure. Instruments are typically not appropriate benchmarks because of their potential to be moved. If points such as sensors, antennae, or transducers are used as benchmarks, the reference frame may be invalidated if the equipment is removed, replaced, or relocated. (2) Accessibility and Location - Benchmarks should be established in locations that are protected, but can be readily accessed for future surveys. OCS strongly recommends establishing benchmarks near hydrographic instruments such as sonar heads and antennae. Doing so will allow sensors to be accurately reintegrated into the network if they are moved. Since these benchmarks are used to establish a three dimensional reference frame on the vessel, three benchmarks should be readily accessible from each instrument location to accurately position sensors, regardless of vessel attitude.

*Selection of a Reference Point* - Every benchmark network must have a defined origin (i.e., a reference point) for the local reference frame. OCS recommends locating this point at the vessel's approximate center of motion during static conditions and average loading, as discussed in section 1.4.1 *Error Estimation* - Accurate error estimates for a vessel survey are as important as the offset measurements themselves. While specific sources of error are inherent to each method of survey (see Surveying Methods below), the following common factors affect the accuracy of all vessel offset surveys.

*Setups* - This term refers to the number of individual measurements required to compute the relative position of two benchmarks, literally the number of times the surveyor's instruments must be set up to complete the measurement. Multiple setup measurements use intermediate points as temporary benchmarks between the two desired points. Physically positioning the measurement instrument on or over a benchmark or other reference point is a possible source of error, so multiple setups can increase the measurement error between two points. Hydrographers should attempt to minimize the number of setups required between benchmarks and record the number of setups for each leg of the survey.

*Redundancy* - If possible, the hydrographer should arrange the survey such that no benchmark is tied to the rest of the network by only one measurement. Ideally, each benchmark should be tied directly to multiple other benchmarks. In cases where vessel layout makes this impractical, multiple measurements along the same leg maybe useful. These additional data can be used to improve the accuracy of positions generated by the survey. While redundant positions can simply be averaged, a more accurate method of determining a final value is to combine measurements using a least squares algorithm.

*Total Error* - When estimating the total error for one leg of a vessel offset survey, individual measurement errors are combined using a “root sum squared” method, rather than simple addition. For example, in the case of a two setup measurement, the final error estimate for the leg would be computed as follows:

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}$$

where  $\sigma$  is the standard deviation of the total measurement,  $\sigma_1$  is the standard deviation of the measurement from the first benchmark to the temporary benchmark, and  $\sigma_2$  is the standard deviation of the measurement from the temporary benchmark to the second benchmark.

**Vessel Leveling** - Although it is possible to establish a vessel reference frame that is not aligned with the vessel itself, this adds an element of complication and potential error that is best avoided. The vessel surveying process is much simpler if the vessel is removed from the water and leveled relative to the earth. For ships, this may not be possible, but launches can generally be accommodated using trailers or jack stands. If a ship is to be surveyed during a dry dock period, measurements must be corrected for the slope of the vessel on the marine railway. This angle can be determined by referencing marine growth along the ship’s waterline prior to pressure washing. Subsequent offset measurements will need to be corrected for the determined angle of inclination.

#### Surveying Methods

For the purposes of this manual, offset measurement techniques are broken into the following two categories:

**“Traditional” Methods** - these methods refer to conducting a vessel offset survey using tools such as steel measuring tapes, T-squares, plumb bobs, and laser or carpenter’s levels. While these instruments can yield very exact measurements, particularly on small vessels such as launches, this technique relies on the assumption that the vessel is level and true. With this method, the surveyor uses the existing planes and axes of the vessel’s construction, such as the deck, door frames, and keel lines, to establish the local reference frame. Not only can significant error be introduced if the vessel is not actually level and true, it can also be more difficult to estimate error using traditional methods. OCS recommends using advanced survey methods if equipment and expertise are available.

**“Advanced” Methods** - these methods employ precision survey equipment such as theodolites, laser range finders, total stations, and optical levels. One advantage of using these optical techniques is that measurements are independent of the vessel’s attitude and alignment. Since the surveying instrument can be positioned anywhere convenient, measurements between benchmarks can often be accomplished with a single setup, thereby minimizing error. Detailed procedures for conducting vessel surveys using advanced methods have not been established by OCS. Field units desiring a full vessel survey using advanced methods should consult the regional HSTP Field Support Liaison before proceeding. Assistance using these techniques may also be available through the National Geodetic Survey (NGS) Geodetic Services Division.

#### **1.4.1.1.2 Partial Survey**

A partial vessel survey shall be conducted if minor changes have been made to the vessel configuration, but the most recent full survey has not been rendered obsolete. Partial surveys are typically appropriate when equipment is removed and replaced or repositioned on a vessel without disturbing the network of permanent benchmarks. In such cases, the new position of the instrument can be determined by surveying its position relative to the undisturbed benchmarks. The original survey shall then be updated and would remain valid. Partial surveys are significantly less time consuming than full surveys, but are only valid if benchmarks installed as part of the original survey remain undisturbed. When in doubt as to whether a new full survey is necessary or a partial survey is sufficient, field units shall complete a full survey of the vessel.

Partial surveys are basically identical to full surveys, but on a much smaller scale. The same rules and considerations described for full surveys apply to partial surveys. Since measurements are typically made over short distances and require few setups (assuming benchmarks have been installed near instrumentation as recommended), good accuracy can often be achieved with traditional survey methods. However, advanced methods may provide a more accurate estimate for measurement error.

#### **1.4.1.1.3 Verification Survey**

Verification surveys are conducted to check the validity of pre-existing full (or combination of full and partial) surveys when no changes to the vessel's configuration have occurred. This is the minimum survey required as part of Annual Systems Preparation and, as such, shall be conducted at least annually. The purposes of a verification survey are to review the offsets, error estimates, and documentation of the prior survey, and to check for measurement blunders, vector algebra mistakes, sign errors, etc.

Verification surveys can be viewed as a "sanity check" of the existing survey data and may be conducted using traditional methods. Typical procedures consist of pulling steel tape between benchmarks to verify the offset values and rechecking the vector algebra to confirm established values. Error estimates in the original documentation shall be reviewed for consistency and suitability for the vessel's current mission. Any discrepancies discovered during a verification survey may trigger a partial survey or a new full survey of the vessel.

#### **1.4.1.2 Periodic Quality Assurance Checks**

Periodic quality assurance checks are simply Verification Surveys, or portions thereof, performed at the discretion of the field unit. This type of check would be used if the vessel was involved in an incident, such as a grounding, that might have altered the positions of benchmarks and instrumentation, affecting the validity of the annual survey. If changes are found, a partial survey or new full survey of the vessel may be necessary.

#### **1.4.1.3 Documentation & Reporting Requirements**

The documentation required for vessel static offset surveys varies with the extent of the survey conducted. Documentation, as defined below, for static offset surveys shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Copies of documentation for all full and partial surveys shall be transmitted to HSTP. The dates, basic methodology used, and responsible professional survey agency (if applicable) for vessel static offset surveys shall be entered in the Hydrographic Systems Inventory. Any interim survey performed as a quality assurance check shall be described in the DAPR for all associated projects.

#### **1.4.1.3.1 Full and Partial Surveys**

Documentation for full and partial vessel offset surveys shall include the following:

- A full description of the equipment and technique employed, including diagrams showing the positions of setups and any pertinent technical data available for the instruments used for the survey. The survey location and description of how the vessel was leveled and immobilized, if applicable, should also be provided.
- Pictures and/or diagrams showing the general arrangement of the surveyed vessel and identifying the positions of benchmarks and instruments.
- An error analysis describing how the error values for each measurement were determined.
- Raw measurement data and a table of final results (including error estimates). A reviewer should be able to easily reconstruct the steps of data reduction from the information provided.
- A copy of Vessel Reports, generated in CARIS HIPS and SIPS Vessel Editor, for each resulting CARIS HIPS Vessel File (HVF).

#### **1.4.1.3.2 Verification Surveys**

Documentation for verification of an existing full (or combination of full and partial) vessel offset survey shall include the following:

- A simple description of the equipment and techniques used for measurements.
- A reference to the full survey or combination of full and partial surveys that were verified.
- A copy of Vessel Reports, generated in CARIS HIPS and SIPS Vessel Editor, for each HVF which will remain in effect.
- Notation of any discrepancies discovered in the prior survey(s) and how these items were resolved.

#### **1.4.2 Vessel Dynamic Offsets**

Dynamic offsets are those parameters of a vessel that are expected to change over relatively short time periods. The primary dynamic offset is vessel draft. A hydrographic survey vessel's draft and, therefore, the vertical position of the sonar transducer within the water column is affected by many factors, including the vessel's loading, weight distribution, and speed through the water. When addressed as one vessel characteristic, these effects are referred to as "Dynamic Draft." Dynamic draft is the sum of "Static Draft" and "Settlement and Squat".

Static draft is the draft of the vessel at rest, fully loaded and outfitted for surveying. This value can be affected by the amount of equipment, fuel, personnel, and other gear loaded on the vessel, and is also a function of the density of the water in which the vessel is operating.

"Settlement" is the purely vertical component of this vessel characteristic and is measured at the vessel's approximate center of motion. Although this vertical displacement is in the same direction as heave, settlement is usually filtered out of recorded heave data because its frequency is much lower than the cutoff frequency of high

pass filters typically associated with heave measurement devices. As a result, settlement must be measured and corrected for independently of heave action.

”Squat” refers to the tendency of a vessel’s stern to sink into the water as speed increases while operating in displacement mode (i.e., not on a plane). Squat typically results in a bow-up attitude, although a reverse effect may actually take place at higher speeds for some hull designs. Since echosounders are generally not mounted directly at a vessel’s center of motion, squat acts on a lever arm from the center of motion to the echosounder, causing a vertical displacement of the transducer. On vessels equipped with attitude sensors, this effect is addressed as a part of attitude measurements and corrections. For vessels without attitude sensors, squat must be measured and corrected for as a part of dynamic draft.

### **1.4.2.1 Calibration Requirements and Methods**

#### **1.4.2.1.1 Static Draft**

As part of Annual Systems Preparation, static draft shall be measured across the anticipated range of loading and buoyancy conditions. At a minimum, field units should track changes in static draft for a sufficient period of time to develop a statistically significant sample of values from which an error estimate can be produced. Depending on these results and the requirements of the survey, the frequency of draft measurements and updates of the HVF necessary during survey operations will vary. On some vessels, it may be necessary to measure static draft as often as twice a day, while annual measurements may be sufficient for others.

Factors influencing the frequency of static draft measurement include the following:

- Survey Accuracy Required - If the error associated with static draft measurement is determined to be acceptable for meeting survey accuracy requirements, a single static draft value may be sufficient. This value should be the mean of multiple observations taken over a wide range of loading and buoyancy conditions for the vessel. If survey accuracy requirements increase, more frequent static draft measurements may be necessary.
- Loading Conditions - Vessels with a wide range of loading configurations will require more frequent static draft measurements than vessels with minimal loading changes. For example, many NOAA ships conduct survey operations both with and without launches in the davits, which can create a significant difference in vessel draft. Likewise, a hydrographic survey launch’s static draft may vary noticeably with the amount of fuel loaded and the number of personnel embarked.
- Buoyancy - A vessel’s static draft will vary with the density of the water in which it floats. If the vessel will be operating in waters with a wide range of densities (most strongly influenced by salinity), more frequent observation of static draft may be necessary. Additionally, water density may change significantly with project area, making static draft determined at one location inappropriate for survey operations in another area.

##### **1.4.2.1.1.1 Static Draft Measurement Techniques**

The technique chosen to measure static draft may be influenced by the anticipated frequency of measurement required. Examples of measurement techniques include the following: Draft Marks on Hull - During the static offset measurement survey (see section 1.4.1) the vessel’s hull can be marked with vertical elevation differences from the Vessel Reference Point. If this method is used, the hull should be marked on both the port and starboard sides, in the athwartships plane of the Vessel Reference Point. Static draft is then determined by averaging the port and starboard readings. Sight Tube - A more precise method for measuring static draft is a clear plastic or glass

sight tube installed in the interior of the vessel. This method can be particularly useful on hydrographic survey launches. The lower end of the tube is connected to a through-hull fitting below the waterline (with a valve at the hull), and the top is either connected to a through-hull above the waterline or extends sufficiently high enough above the waterline to prevent flooding. The clear portion of the sight tube, where measurements will be read, should be installed directly over (or as close as possible to) the vessel RP and graduated for direct measurement of the waterline offset from the reference point. Note: The static draft information is to be placed in the 'waterline' entry in the CARIS HVF.

### **1.4.2.1.2 Dynamic Draft**

At a minimum, dynamic draft shall be measured during Annual Systems Preparation. Although dynamic draft is a function of both hull shape and weight distribution, the influence of weight distribution is typically negligible. Thus, dynamic draft can be measured annually with the vessel in an average loading configuration, and the results combined with a range of static draft measurements for a final dynamic draft determination. Vessels with ancillary trim capabilities (e.g., trim tabs, jet drives, and outboard motors) should establish operating procedures to standardize vessel trim during survey operations.

#### **1.4.2.1.2.1 Dynamic Draft Measurement Techniques**

Settlement and squat are actually two separate parameters, but they can be easily measured together. If possible, this measurement should be accomplished in a body of water at least 7 times the vessel draft, where water level, current effects, and wave conditions will be minimal for the period of the calibration. There are three common methods of determining dynamic draft values. Each method is described below.

#### **Optical Level**

This technique uses an optical level to site the height of the vessel moving at different speeds through the water, relative to a fixed position ashore. The basic procedures are as follows:

- **Set Up** - Set up an optical level on shore near a channel or fairway where the vessel will be free to maneuver. The closer the level station is to where the vessel will traverse, the more accurate the readings will be. A pier is a valid location for the level station, but the pier must be a stable structure that does not exhibit significant movement over time. Level rods should be positioned on the port and starboard sides of the vessel. If the vessel to be calibrated is equipped with an attitude sensor, the level rods should be positioned in the athwartships plane of the vessel's approximate center of motion so that only settlement is measured (squat will be measured and corrected in conjunction with vessel attitude). If the vessel does not have an attitude sensor, the level rods should be located in the athwartships plane of the sonar transducer, which will combine squat effects in the measurement.
- **Data Acquisition** - Run the vessel in opposing directions (either perpendicular to or parallel with the level station line of sight) at various speeds, ranging from dead slow ahead to slightly faster than the maximum anticipated survey speed. On each run, the vessel must be allowed sufficient time to stabilize in attitude and speed prior to the measurement point. For each speed, a rod measurement should be taken on each side of the vessel. The port and starboard values for each speed are averaged to cancel the effect of any current or vessel list. Before and after each pair of runs, the elevation values for the vessel at rest should be measured in order to correct for any change in water levels over the course of the test. The data should be recorded in tabular format, with the final dynamic draft value for each speed being the difference between the average at rest readings (before and after each pair of runs) and the average of the port and starboard underway readings.

## Post-Processed Kinematic (PPK) GPS

\*Note: The technique and analysis use depends greatly on the vessel and the area in which you are working. If you have any questions, contact your HSTP representative before proceeding.

This technique uses the vessel's POS/MV system and POSpac data acquisition and processing to measure vessel ellipsoid heights at speeds relevant to survey operations. A polynomial regression of the changes in height is used to formulate a dynamic draft table with associated uncertainties. The Pydro macro ProcSBETDynamicDraft.py may be used for the dynamic draft table data analysis. This macro reads POSpac Smoothed Best Estimate Trajectory (SBET) dynamic draft calibration data, (optionally) adjusts for tidal water levels, and outputs graphs and tables per a 3rd or 4th-order polynomial regression. The basic procedures are as follows:

- Assumptions
  - If the dynamic draft calibration test is performed in a tidally-active area, plan on performing the data analysis using the Pydro macro ProcSBETDynamicDraft.py (see below). This macro includes the ability to compensate for both discrete-zoned and TCARI water levels. Other data analysis may be used at the discretion of the field unit. A spreadsheet analysis may be used, particularly in areas with negligible tides, or during a time when water level changes due to tide will be negligible.
  - Wave conditions need to be minimal as with all dynamic draft measurements.
  - It is also assumed that the ellipsoid is relatively parallel to the water level over the area of this test. Time periods of static vessel heights at the end of each line will help to confirm this assumption. If there is evidence to the contrary once data has been acquired, another area may need to be selected or another technique may need to be used for dynamic draft measurements.

Data Acquisition - Select an area where the water depth is sufficient to remove the strong effects of squat due to shallow water. The area should be large enough that you can acquire data between 2-5 minutes at speed, enough time to allow the vessel to settle out at speed. Start acquiring POSpac data at least 5 minutes before beginning the test. While consecutive changes in speed can be used, a one to two minute "rest period" between each speed change is recommended to capture offsets due to tides, currents or geoid shape. An adequate rest period length is a function of the hydrodynamic characteristics of the particular vessel; i.e., how long it takes for the given vessel to stabilize to "static" conditions. Run lines in opposing directions taking into account current magnitudes and directions; data sampling should be balanced between lines progressing with and stemming the current. It is important to acquire lines at regular speed intervals over a range that is relevant to the multibeam survey work of the vessel; e.g., from barely maintaining steerage through 10+ knots, at an interval of 2 knots. Do NOT stop recording POSpac between lines; PPK processing performs best using uninterrupted sessions of GPS data. Record the order in which you ran the speeds and what direction you went between each of the rest periods. A complete written record of the dynamic draft calibration fieldwork may prove invaluable in troubleshooting peculiar looking results later.

- **Data Processing** - Data is processed in Applanix's POSPac software through either a SmartBase solution or a SingleBase solution. POSPac data can be processed referencing the rapid ephemeris solutions. Final ephemeris data can take up to 2 weeks to become available, and does not significantly change the calculated values. The data are processed through the GNSS-Inertial Processor in the Forwards, Backwards and Combine mode with the Roll, Pitch and Heading Initialization set to Initialize from the real time solution and the Lever Arm Standard Deviation ideally known to 3cm or better (The lever arm standard deviation should be set based on how well you actually know your lever arms). SBETs may be decimated to 1Hz to alleviate the processing load in Data Analysis, without any detrimental effects. Control station auto-adjust should never be used for processing SBETs.
- **Data Analysis** - A time series of both speed and ellipsoid heights, as well as a plot of speed versus ellipsoid heights should be examined to ensure data quality and to look for offsets. A polynomial least squares fit regression on speed versus ellipsoid height is completed with user preferred software. A minimum of a third order regression should be used. A comparison between the regression and the plotted data should be completed both through a raw plot with regression curve and through the ellipsoid height minus regression residuals. Changes in the ellipsoid height not captured by the curve should be noted and changes to the regression process may be needed. Take special care to note the zero speed crossing, as it can result in vertical offsets in the dynamic draft table. Careful examination here cannot be emphasized enough.

Once a satisfactory curve is obtained, a dynamic draft table can be created between regular speed increments and the corresponding height from the regression equation subtracting the zero speed ellipsoid height constant. Since the table for CARIS HIPS is a correction file, increases in draft with speed result in positive values in the HIPS table. Uncertainty in the dynamic draft table is obtained by calculating two standard deviations of the residual data to regression difference. If uncertainty for each speed is desired the residuals can be binned by speed and the standard deviation calculated for each bin. Care should be taken that sufficient data exists in each bin.

As mentioned previously, all of the required data analysis, from SBET to dynamic draft table—including tide compensation, can be achieved via the Pydro macro ProcSBETDynamicDraft.py. Complete details about using this macro may be found in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

### **Real-Time Kinematic (RTK) GPS**

Procedures are currently being developed for a real-time kinematic GPS determination of dynamic draft. These methods have not yet been approved by OCS and shall not be used for Annual Systems Preparation.

### **Echosounder**

This technique uses a vessel's MBES system to determine dynamic draft. A detailed procedure is described below.

- **Data Acquisition** -Data should be acquired in an area with a flat seafloor and relatively shallow water. Water depth should also be at least seven times the vessel draft to reduce attitude bias. The geographical location should be as close as possible to a water level station. If the survey time is planned to minimize currents, adequate data can typically be acquired by running in one common direction for all vessel speeds. If currents are significant, it will be necessary to acquire data in opposing directions for each speed and average the two values. As with the optical level method, vessel attitude and speed must be stable while acquiring data.
- **Line Acquisition** -Plan a survey line approximately 1000 meters in length. Establish a center reference point for three approximately 20m<sup>2</sup> reference areas located at distances of  $\frac{1}{4}$ ,  $\frac{1}{2}$ , and  $\frac{3}{4}$  along the line as shown in Figure 1.1. Acquire data along the line at various RPM intervals, ranging from the minimum to the maximum

speed anticipated for survey operations. Minimize across-track error during line navigation and establish a constant speed and heading prior to logging data. Monitor and minimize induced heave during data acquisition. Run the line in coincidental directions for redundancy. To minimize induced heave, allow time for the IMU to stabilize before reacquiring data.

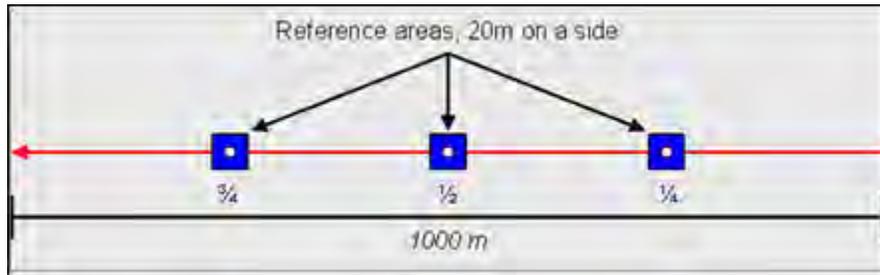


Figure 1.1: Recommended line plan for determining dynamic draft using a vessel's echosounder.

- Reference Area Acquisition - At each reference area, acquire data along the line at the lowest speed possible while maintaining heading and stable attitude to create a baseline with negligible dynamic draft. It is recommended that reference area data be acquired both before and after line acquisition to bracket and evaluate any significant water level variation. Compare these zero or at-rest settlement and squat measurements with each of the at-speed measurements to determine offsets caused by speed variation. If the seafloor is not flat, several passes may be required at each reference area to create an accurate reference surface. Conduct a sound velocity cast near the center reference point. The reference area acquisition is considered the "At rest" depth and should be the baseline to which you compare the depths acquired at speed.
- If there is concern for induced draft while moving over the targets, an alternative reference surface calculation can be made utilizing Drift Line Measurement: If the reference or drift line is run perpendicular to the analysis line it will produce a swath sufficient enough for data acquisition. If you are conducting this dynamic draft test on a vessel with a 1.5 meter draft your test should be performed in at least 10.5 meters (35 feet) of water. At that water depth the average swath width would be 36.75 meters (122.5 feet).
- Processing Soundings - If the echosounder system used for data acquisition performs real-time heave filtering, convert the data without applying true heave. Long-period heave will bias dynamic draft calculations. Random, short-period heave should cancel out during statistical averaging of reference surface depths. Filter soundings to reject all but those with the highest data quality flag.
  - A surface should contain only the drift line or reference area lines.
  - Separate surfaces should be made at each rpm interval (i.e. if lines were run at 600, 800, and 1000 rpm, create a grid for each of the 600, 800, and 1000 rpm drift lines).
- Sample all line surfaces and the reference surface soundings using an approximately 3 m x 20 m subset area at each of the three reference areas. Minimally clean subsets for gross fliers and noise. Select and query all soundings from each subset dataset and save each CARIS query window as a text file. This can be done by simply copying and pasting directly into a MS Excel spreadsheet. Import these text files into MS Excel as tab-delimited records. Sort these Excel data by line ID and calculate the median surface depth (use =MEDIAN (c#:c#) ) for each speed level at each reference area. Typical sample populations should be between 3,000 – 5,000 soundings (use =COUNTA (c#:c#) to check).

- The reference surface should be sampled first to be used as the control in the data analysis.
- Coincidental lines should be sampled together in the same surface.
- Navigation/Speed - Using the CARIS Navigation Editor, query position fixes for individual lines within each reference area subset. Save each query as a text file and import these data into Excel as tab-delimited records. Calculate the average speed for each RPM in each of the reference areas (use =average (c#:c#)).
- Offset Tables - For each reference area, subtract the median reference area depth from median depths for each RPM/speed interval to calculate relative dynamic draft offsets. Plot Speed vs. Offset for each of the 3 reference areas to evaluate data consistency. Average data from the ¼, ½ and ¾ point reference areas to calculate final dynamic draft values.
- Error Analysis -The standard deviation of each speed correction should be calculated by comparing the values derived from each surface area. The largest standard deviation value should be entered into the vessel’s HVF for dynamic draft error. Note that in CARIS, the squat and settlement is entered in as “delta draft” or the positive change in draft as the draft increases and negative as the draft decreases.

#### **1.4.2.2 Periodic Quality Assurance Checks**

Static draft shall be re-measured at whatever frequency determined necessary to meet survey specifications. However, at a minimum, static draft should be checked against previous survey values at the start of a new project and whenever a vessel will be conducting survey operations with an atypical loading configuration. Dynamic draft shall be re-measured if the vessel’s hull shape is altered, significant changes in weight distribution of the vessel have been made, or other physical alterations have been made to the vessel that may affect dynamic draft values.

#### **1.4.2.3 Documentation and Reporting Requirements**

Dynamic offset measurement documentation shall be broken into two separate sections, one for static draft and one for dynamic draft measurements. All information listed below should be documented. This documentation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. The dates and basic methodology used to determine dynamic offset measurements shall be reported in the DAPR for each applicable project. The actual frequency of static draft measurements, any significant changes to static draft, and any subsequent changes to dynamic draft should also be included with this documentation.

Static draft measurement documentation shall include the following:

- A complete description of the procedure used to determine draft and estimate error.
- Geographical location where measurements were made and number of observations used for draft determination.
- Raw draft measurement data in tabular format and error estimate calculations.
- Final static draft values, as applied in the CARIS HVF.
- The frequency with which draft will be measured during subsequent survey operations, with justification for this decision.

Dynamic draft measurement documentation shall include the following:

- A complete description of the procedure used to determine dynamic draft, with a chartlet identifying the geographical area where measurements were made.
- Raw data with sufficient explanation of data reduction to enable recalculation of the final dynamic draft values and error estimates.
- Final dynamic draft values, as applied in the CARIS HVF.

Note: Think carefully about the sign of the dynamic draft values placed in the Draft sensor entry in the CARIS HVF. CARIS expects the change in Z to be a positive down, so a sinking of transducer creates a shallower depth than the “true depth”, and the dynamic draft value will be positive. If the vessel rises in the water, the measured depth will be deeper than the “true depth” and the dynamic draft value will be negative.  $\text{Depth} = \text{Observed depth} - \text{Waterline} + \text{change in depth}$ .

### **1.4.3 Wiring diagrams**

All field units should maintain up-to-date wiring diagrams for each of their survey vessels. These wiring diagrams should be reviewed and updated during the Annual Systems Preparation process.

## **1.5 Hardware Systems**

Hardware systems used by NOAA field units for hydrographic survey operations consist of a variety of technologically advanced echosounders and attitude sensors and each instrument must be properly maintained and calibrated in order to provide quality data.

Calibration, maintenance, documentation, and reporting requirements established by OCS for common hardware systems used by NOAA hydrographic field units are described in sections 1.5.1 . New sensors and instruments unique to only one or two field units may not be addressed in this manual. Likewise, as NOAA’s organizational expertise with existing systems continues to grow, new and improved procedures that supersede those documented here will be developed. In such cases, this section of the FPM shall be used as a guide for the development, implementation, and documentation of new procedures. If a new procedure is used, it must be approved by HSTP and documented with sufficient detail for the process to be recreated.

### **1.5.1 Position, Attitude, and Heading Sensors**

For OCS hydrographic surveys, vessel position is typically determined using a variety of GPS based positioning methods, as described in the Hydrographic Survey Specifications and Deliverables (HSSD). Attitude sensors are often employed to measure a vessel’s roll and pitch about its RP and any purely vertical heave action affecting the vessel. The vessel’s orientation about its vertical axis (i.e., yaw) is generally determined with a heading sensor or gyroscopic compass. Attitude and heading values measured by these sensors are typically applied to sounding data during post-processing. Each of the aforementioned sensors may be stand-alone systems, or they may be integrated into a navigation system that will collectively determine vessel position, attitude, and heading.

Note: Not all NOAA hydrographic field units may be outfitted with an attitude sensor. However, this equipment will be included on any NOAA vessel used to acquire multibeam echosounder data. Vessel attitude must be measured and applied to multibeam data to produce accurate soundings. Due to the wide beam angle of vertical beam echosounders (VBES), attitude corrections are less critical for this type of data. However, CARIS HIPS is capable of applying attitude data to VBES when available.

The Applanix POS/MV (Position and Orientation System/Marine Vessel), a GPS-aided inertial navigation system, is the most common system used by NOAA hydrographic field units to measure vessel position, attitude, and heading. As such, the POS/MV calibration and reporting requirements are specifically addressed in this manual. Field units equipped with alternate position, attitude, or heading sensors shall contact the regional HSTP Field Support Liaison to develop approved calibration and maintenance requirements.

### **1.5.1.1 Applanix POS/MV**

The POS/MV navigation system will calculate survey-quality vessel position, heading, and attitude data. Primary system components consist of a processing unit, two GPS antennas, and an inertial measurement unit (IMU), which is typically installed at the vessel's RP for NOAA configurations.

#### **1.5.1.1.1 Calibration Requirements and Methods**

At a minimum, NOAA hydrographic field units shall calibrate the POS/MV during Annual Systems Preparation. Additionally, the POS/MV shall be recalibrated after any IMU or antenna installations, movements, and/or modifications. The appropriate POS/MV Installation and Operation Guide will contain comprehensive guidance on system operation and calibration.

Note: Although the POS/MV Installation and Operation Guide refers to the calibration process as "antenna installation calibration," it should be performed following any physical antenna or IMU adjustments, not just antenna installation. Additionally, all IMUs shall be turned in to the regional Electronics and Engineering Division (EED) depot every three years so that the units can be shipped to Applanix for factory service and recertification. If a field unit has been equipped with a Version 4 or higher POS/MV system, it is possible to perform an additional lever-arm calibration. However, this calibration should not be attempted without appropriate Real Time Kinematic (RTK) support. Field units should contact the regional HSTP Field Support Liaison for RTK support prior to conducting a lever-arm calibration.

##### **1.5.1.1.1.1 Offsets & Reference Frame Conventions**

Prior to calibration, POS/MV lever arm distances should be entered, as necessary, and/or verified in the POS/MV controller software. Be very careful not to enter values for offsets that will be applied to data during post-processing via the HVF. If the IMU is collocated with the vessel's RP and CM, the distance from the IMU to the primary GPS antenna (port side for OCS configurations) and the distance between GPS antennas may be the only offsets that need to be entered in the POS/MV controller software. Measured antenna separation distance must be accurate to within 5 mm, per the manufacturer's specifications. Refer to the POS/MV Installation and Operation Guide for additional measurement accuracy requirements and coordinate system conventions. Note: Be certain that offsets entered in the POS/MV controller software correspond to the local POS/MV coordinate system, which may differ from the vessel reference frame coordinate system. A summary of coordinate systems for common OCS systems and software is included in Appendix 1 (Coordinate\_Systems.pdf).

#### **1.5.1.1.1.2 Performing the Calibration**

Detailed instructions for performing a POS/MV calibration should be reviewed in the POS/MV Installation and Operation Guide. For a successful calibration, the POS/MV GPS Azimuth Measurement Subsystem (GAMS) must have data available from 7 or more satellites and a Positional Dilution of Precision (PDOP) equal to or less than 3.0. The calibration should be performed at a time when satellite geometry is good. GPS mission planning software can be used to identify an optimal calibration time, during which the PDOP will be at a minimum. Mission planning software is included on the Hydrossoft website <https://inside.nos.noaa.gov/hydrossoft/welcome.html>, or at no charge from Trimble at [www.trimble.com/planningsoftware.html](http://www.trimble.com/planningsoftware.html).

The POS/MV calibration should be performed in an open area where unrestricted maneuvering is possible and there are few vertical features likely to produce multipath signals. Set the user multipath setting to “Low” to allow the system to calibrate with the highest accuracy. It is important for heading accuracy to settle to less than the threshold set under the GAMS Installation Parameters before performing a calibration.

Note: This threshold shall always be set to 0.5 degrees or less when calibrating systems for OCS survey operations. Maneuvering the vessel in a figure eight pattern will help bring the heading accuracy within this range. Once a calibration is started, it often takes more than the 1-2 minutes on a straight course stated in the POS/MV Installation and Operation Guide for the “CAL in Progress” process to complete. After a successful calibration, save the new calibration values into non-volatile memory as described in the POS/MV Installation and Operation Guide, and save a copy of the final POS/MV configuration file for reference. A method for computing the lever arm offsets is outlined in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

#### **1.5.1.1.2 Periodic Quality Assurance Checks**

Once a high-quality POS/MV calibration has been performed, it should remain valid until system components are moved or altered. The POS/MV should operate reliably provided adequate satellite coverage and differential correctors are available. If the POS/MV becomes problematic, recalibration may be conducted at the discretion of the field unit. If a recalibration is desired, the same process used for the annual calibration should be repeated.

Note: If the POS/MV is recalibrated, a new patch test should be performed for any associated multibeam echosounder systems. (Refer to section 1.5.5.1.2 for a description of the patch test).

For each calibration conducted, system settings, procedures, and results achieved should be recorded in a POS/MV Calibration Report. A blank report form is included in Appendix 1 (POS-MV\_Cal\_Report.pdf), with sample data entered in red font. This documentation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. The dates of current POS/MV calibrations shall be reported in the Hydrographic Systems Inventory. All POS/MV calibrations conducted shall be described in the DAPR for each applicable project.

### **1.5.2 Sound Speed Measurement Instruments**

Accurate measurements of sound speed (often referred to as “sound velocity”) both through the water column and at the water’s surface are critical to hydrography, particularly if soundings are acquired using a multibeam echosounder. Two basic types of sound speed instruments are currently used by NOAA hydrographic field units, those which directly measure sound speed (commonly referred to as “velocimeters”) and those which measure conductivity, temperature and depth and then calculate sound speed (commonly referred to as “CTDs”). All field units performing OCS surveys shall proactively monitor the accuracy of sound speed measuring instruments and conduct preventative maintenance as described below.

### **1.5.2.1 Calibration Requirements and Methods**

All sound speed measuring instruments employed by NOAA hydrographic field units shall be calibrated annually and inspected by the manufacturer, unless the manufacturer recommends a different time period. Field units should turn in all sound speed measuring instruments to the regional EED depot promptly after arriving for winter inport or during another suitable period of inactivity. EED will arrange for the instruments to be returned to the manufacturer for calibration and inspection. This process takes approximately six weeks.

Note: For DigibarPro systems, only the probe needs to be returned for annual calibration. There is no need to remove the cable or display unit from the vessel unless these components require repair or replacement. Field units that can not feasibly submit sound speed measuring instruments to the regional EED depot shall contact EED to coordinate a direct submission to the manufacturer. Following annual calibrations, comparisons equivalent to the Data Quality Assurance processes described in section 1.5.2.2 shall be conducted for all sound speed measuring instruments.

### **1.5.2.2 Periodic Quality Assurance Checks**

Periodic quality assurance checks shall be performed for all sound speed measuring instruments. NOAA hydrographic platforms shall conduct these quality assurance checks on a daily or weekly basis as described below. Field units with sound speed measurement instruments not addressed in this manual should contact the regional HSTP Field Support Liaison to develop a comparable quality assurance plan.

#### **1.5.2.2.1 Daily Data Quality Assurance (Daily DQA)**

If the vessel is equipped with a surface sound speed measuring instrument (typically installed at the head of a multibeam sonar), compare a measurement from this instrument to the results of a full sound speed profile acquired at the beginning of each day the surface instrument will be used. This comparison can be performed in NOAA's Velocipy software, which is a second generation of the Velocwin, using the "Surface Sound Speed DQA" function. All discrepancies greater than 1 m/s should be noted and tracked to determine if the instrument requires repairs or recalibration. Note: NOAA hydrographic field units have experienced several failures with this type of instrument. Since surface sound speed data is critical for acquiring data with flat-faced MBES systems, these instruments must be monitored and tested each day prior to operations.

#### **1.5.2.2.2 Regular Data Quality Assurance (Regular DQA)**

A full water column profile from each sound speed profiling instrument shall be compared to an independent source at least once during each leg of survey operations or every two weeks during survey operations. This comparison should be accomplished by conducting a simultaneous cast with two profiling instruments and comparing the results using Velocipy's "Compare Two Profiles" function. Caution: If simultaneous casts are processed in Velocipy using the same vessel name, the processed file names will be identical and one will be overwritten. The user should rename the first file processed to avoid this potential problem. Data from two different types of profilers can be used for this comparison, provided both datasets have been initially processed in Velocipy. Comparison casts should be conducted in water at least as deep as typical depths for the current project.

Note: If a Digibar is to be used for a simultaneous cast, first conduct a Velocipy "Digibar DQA" comparison for the instrument using a fresh water sample.

### **1.5.2.3 General Maintenance Practices**

Velocimeters and CTDs should be rinsed with freshwater at the end of the day after use. The moving parts of the winch on the Moving Vessel Profiler (MVP) system requires weekly lubrication of its moving parts (e.g. gears and levelwind) to maintain effectiveness and to sustain its lifetime. It is also highly recommended to shift the messenger on the MVP every 24 hours of continuous use however armoring may make this more tedious. Field units should routinely do an inspection of the MVP towfish.

### **1.5.2.4 Documentation and Reporting Requirements**

Results from annual sound speed instrument calibrations, i.e., manufacturer's documentation and the corresponding digital calibration coefficient file, shall be maintained by the field unit and available for review during Hydrographic Systems Reviews or at the request of OCS. The dates of annual calibrations and any instrument problems or non-routine maintenance performed shall be reported in the Hydrographic Systems Inventory.

If using Velocipy, the results of each DQA test performed will be sorted by project number and saved to a file named <project number>.DQA, (e.g., OPR-A###-AA-YY.DQA) in the "SVfiles" directory. If Velocipy is not used for weekly data quality assessments, these comparisons shall be manually recorded. DQA records associated with each survey shall be included in Separates II of the Descriptive Report. Documentation for all calibrations or maintenance conducted shall be included in the DAPR for each applicable project.

## **1.5.3 Manual Depth Measurement Equipment**

Although no longer used as a primary means of survey, lead lines and sounding poles are invaluable for some operations. These tools can be used to take soundings in areas too shallow for echosounders or to verify least depths over dangers to navigation or shoals. The most common use of lead lines is as a calibration standard for echosounders. However, like all measuring devices, these tools have their own calibration requirements. Both lead line and sounding pole requirements are addressed in this section.

### **1.5.3.1 Calibration Requirements and Methods**

#### **1.5.3.1.1 Lead Lines**

All field units engaged in hydrographic surveys where general depths are less than 40 meters shall carry one or more marked and calibrated lead lines. Depending on the depths in which they will be used and the size of the vessel, OCS recommends that lead lines are 30m to 60m long. Each lead line shall be marked with a numerical identifier to be retained throughout the life of the lead line or until re-marking is necessary.

Traditional lead line material is mahogany-colored tiller rope with a phosphor-bronze wire center. Specifications for this material and directions for making and maintaining a traditional lead line can be found in Appendix 1 (Leadline\_Sndngpole\_Directions.pdf). Since line and tape materials have evolved significantly and lead lines are now used in special circumstances, rather than for entire surveys, it may be appropriate for alternate materials to be used when constructing a lead line. When choosing a lead line material, key properties to be considered are strength and elasticity. The line or tape must not part if deployed from a vessel underway and must not stretch significantly under tension or when wet.

All lead lines used for OCS hydrographic surveys shall be graduated to at least the decimeter level. Any convenient system of marking that will minimize reading errors may be used, provided each whole meter of line is marked and identified with a clearly written numerical depth value.

Lead lines shall be calibrated by comparison with a known standard during Annual Systems Preparation and prior to each day's use if constructed with non-traditional material. The testing standard should be a survey quality metal tape, pre-measured graduation marks on deck or ashore, or similar item. If the mean correction exceeds 0.1m the lead line must be re-marked.

#### **1.5.3.1.2 Sounding Poles**

When surveying in depths too shallow for an echosounder, it may be prudent to use a sounding pole if the area is flat and the waters are protected. Sounding poles shall not be used in depths greater than 4 meters and are typically not used in depths greater than 2 meters.

A traditional sounding pole is made from a meter length of 1.5 inch (3.81 cm) round lumber capped with a weighted metal shoe at each end to hasten sinking. Shorter poles may be used, depending on the depth conditions. Directions for making and maintaining a traditional sounding pole can be found in Appendix 1 (Leadline\_Sndngpole\_Directions.pdf). Since modern pole, pipe, and stick materials are readily available and sounding poles are now used in special circumstances, rather than for entire surveys, it may be appropriate for alternate materials to be used when constructing a sounding pole. When choosing a sounding pole material, key properties to be considered are strength, weight, and bluntness. The pole must not significantly bend if deployed from a vessel underway or weaken when wet. Additionally, it must not be so buoyant or sink so rapidly that it becomes difficult to handle and must not penetrate the seafloor to an extent that would generate erroneous soundings.

All sounding poles used for OCS hydrographic surveys shall be graduated in meters to at least the decimeter level. Any convenient system of marking that will minimize reading errors may be used.

Any sounding pole maintained aboard a NOAA hydrographic vessel shall be calibrated during Annual Systems Preparation. Calibration shall be against a known standard, such as a survey quality metal tape, to ensure that depth markings are unambiguous and accurate. Sounding poles created between Annual Systems Preparation events shall be calibrated prior to use on an OCS hydrographic survey.

#### **1.5.3.2 Periodic Quality Assurance Checks**

Due to the static nature and infrequent use of manual depth measurement equipment, there are no requirements for accuracy checks, other than annual calibrations, if traditional lead lines or a regularly maintained sounding pole is being used. As previously stated, lead lines constructed with non-traditional material shall be calibrated prior to each day's use, and sounding poles created on-the-fly for special circumstances encountered shall be calibrated prior to use on any OCS hydrographic survey.

#### **1.5.3.3 Documentation and Reporting Requirements**

A Lead Line and Sounding Pole Calibration Report shall be completed each time a lead line or sounding pole is made or compared to a standard. A report form is provided in Appendix 1 (Leadline\_SndngPole\_Cal\_Report.pdf), with sample data in red font. Reports for calibrations conducted during Annual Systems Preparation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of

OCS. The dates of current calibrations shall be reported in the Hydrographic Systems Inventory. Documentation for calibrations shall be included in the DAPR for each applicable project.

In addition to the above reporting requirements, a full Sounding System Comparison shall be completed each year as a part of Annual Systems Preparation, following calibration of all sounding systems. A lead line shall be used to manually acquire a standard for comparison to calculated depths from each of the field unit's vertical beam echosounders, multibeam echosounders, and diver least depth gauges. This process shall be documented according to the example provided in Appendix 1 (Sndng\_Sys\_Comparison\_Log.pdf) and included in the DAPR for each applicable project.

#### **1.5.4 Vertical Beam Echosounder (VBES) Systems**

NOAA hydrographic field units may use VBES systems for water depth measurement and/or to confirm depths measured by other systems, such as multibeam echosounders. The consistency and accuracy of VBES soundings are directly related to the care with which these instruments are calibrated, maintained, and operated. It is critical that field units both ensure these systems are properly calibrated and educate operators about the effects of manually adjusting the transceiver controls such as power, gain, and sensitivity.

Vertical beam echosounders are typically either dual frequency or single frequency. Users should operate each echosounder in accordance with its manufacturer's documentation. When used for OCS hydrographic surveys, VBES systems shall be set with an assumed speed of sound through water of 1500 m/s. Recorded sounding data shall be corrected for actual sound speed, determined with a sound speed profiling instrument, during data post-processing.

##### **1.5.4.1 Calibration Requirements and Methods**

The field unit shall verify, during Annual Systems Preparation, that VBES sounding data are accurate and that each system is in proper working order. While a lead line comparison is the minimum VBES calibration requirement, a simultaneous comparison of lead line, VBES, multibeam echosounder, and diver least depth gauge (DLDG) data is also required by OCS during Annual Systems Preparation. (Refer to section 1.5.3.3 for details on Sounding System Comparison.) If the VBES unit is found to be out of calibration, it should be sent to the regional EED depot, which will return it to the manufacturer for repair. Field units that can not feasibly submit VBES systems to the regional EED depot shall contact EED to coordinate a direct submission to the manufacturer.

When performing sounding system comparisons, the vessel should, ideally, be anchored in an area with a flat sandy bottom and calm sea conditions. If comparisons will also be made to DLDG data, the water depth should be between 10 and 20 meters. The lead line depth should be measured from a location close to the transducer and timed as near as possible to slack water to minimize any effect from current on the lead line. If the vessel has a known list or is large enough that a level platform can not be accurately determined, simultaneous lead line readings should be taken from each side of the vessel and averaged.

##### **1.5.4.1.0.1 HYPACK Latency Test**

The following HYPACK latency test procedures should be performed for vessels operating a single beam echosounder and no POS/MV or motion compensator. This test is used to solve for the delay in time between the GPS "time tag" and the HYPACK PC time stamp.

- Run reciprocal lines perpendicular to a slope of a feature and determine the timing

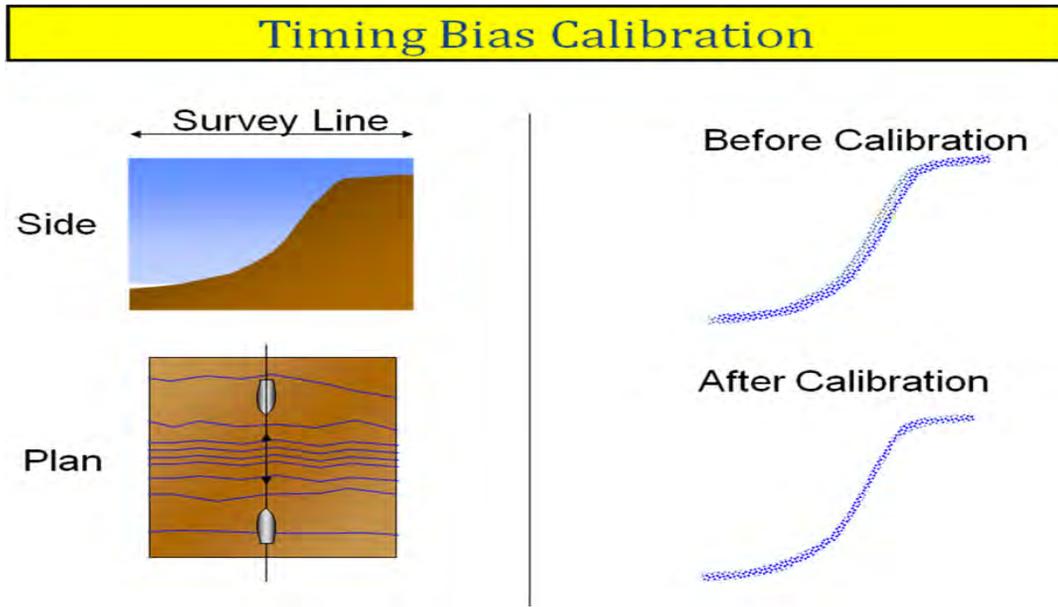


Figure 1.2: HYPACK Timing Bias Calibration

- The Latency Test for the Single Beam Echosounder is found in the utilities menu of HYPACK
- Open the two lines acquired in the latency test program
- Review Cross Section

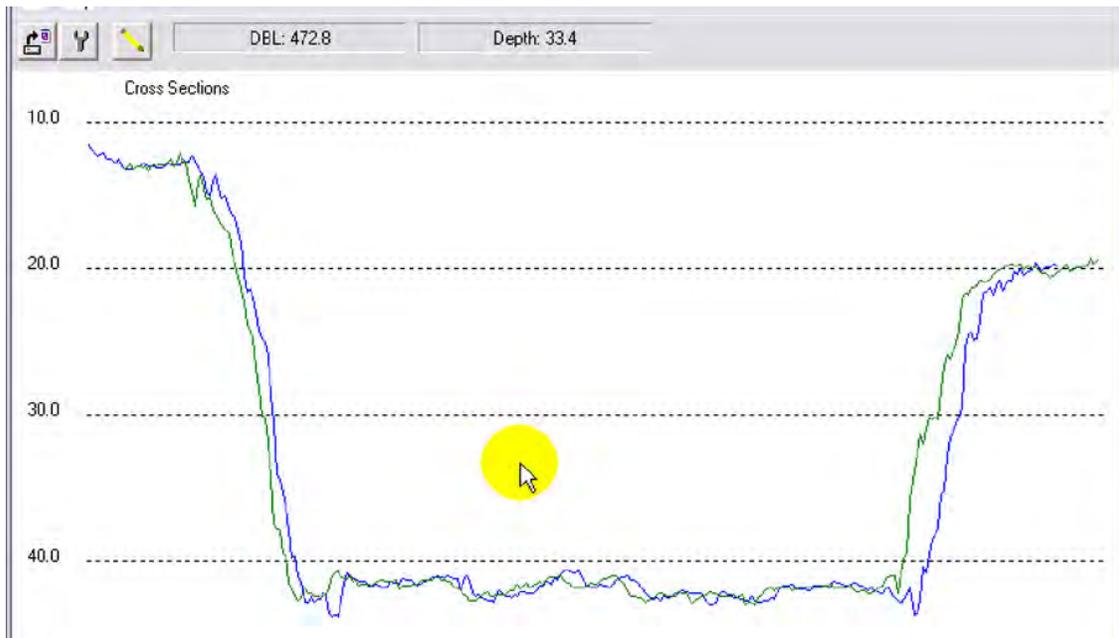


Figure 1.3: HYPACK Review Cross Section Window

- Open the Adjustment window and perform the automatic latency calculation

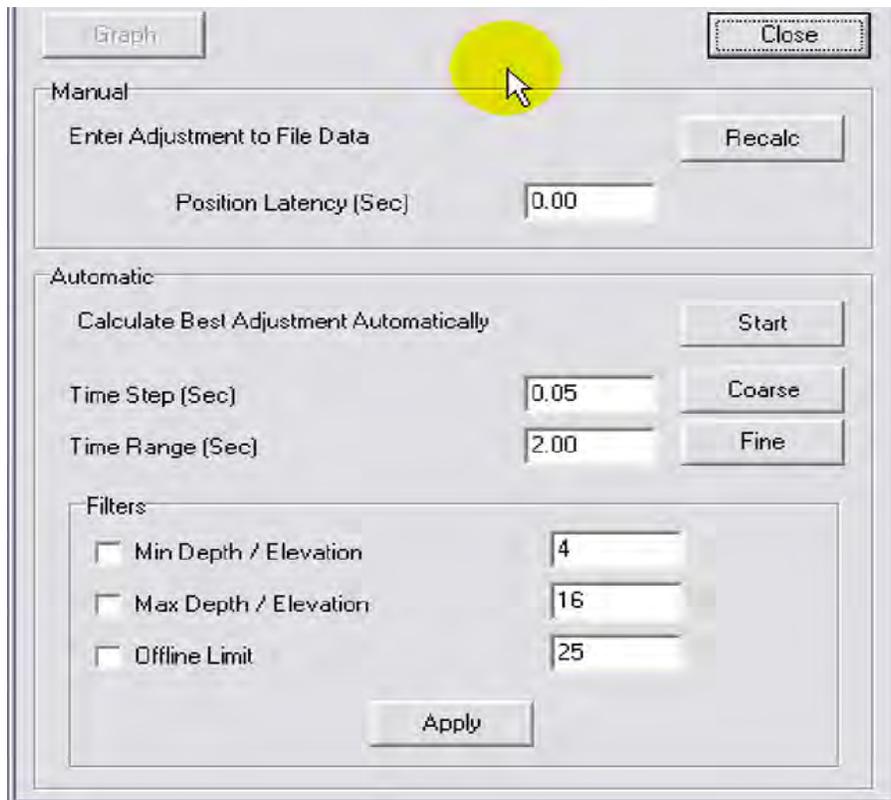


Figure 1.4: HYPACK Adjustments window

- Perform three separate tests and use the average of the results

Once the user has determined the final latency value, it can be entered in the offsets menu on the HYPACK device parameters or it can be added to the navigation timing lever arm correction in the CARIS HVF file. (\*note only add the offset in once!)

#### 1.5.4.2 Periodic Quality Assurance Checks

For modern digital VBES systems, instrument errors are generally small, fixed in magnitude, and independent observed depths. However, to ensure that echosounders continue to operate properly, periodic confidence checks should be conducted. A confidence check can be accomplished by comparing VBES soundings to lead line readings, nadir multibeam echosounder depths, or DLDG data. As when performing a calibration, routine comparisons should be conducted in an area with a relatively flat and hard bottom, when sea conditions are calm.

Confidence checks shall be conducted at least once per week for all surveys performed with VBES systems. Any discrepancies identified between sounding systems that are greater than the allowable depth error for the corresponding survey must be investigated to determine if the equipment is in need of repairs.

#### 1.5.4.3 Documentation and Reporting Requirements

Results of VBES calibrations and confidence checks shall be recorded in a Sounding System Comparison Log to be maintained by the field unit. A comparison log is included in Appendix 1 (Snding\_Sys\_Comparison.

pdf) with sample data in red font. Calibration records for each VBES used for hydrographic surveying shall be available for review during Hydrographic Systems Reviews and at the request of OCS. Sounding System Comparison Logs shall be included in the DAPR for all applicable surveys.

### **1.5.5 Multibeam Echosounder (MBES) Systems**

NOAA's hydrographic survey units use MBES systems to acquire full- and partial- bottom bathymetric coverage throughout a survey area, to determine least depths over critical items such as wrecks, obstructions, and dangers-to-navigation, and for general object detection. Field personnel should refer to section 5.2 of the HSSD.

Proper calibration of MBES systems is critical for maintaining a high level of accuracy and meeting OCS hydrographic survey specifications. Various models of swath-type multibeam sonars are used for NOAA hydrographic survey operations. For the purposes of this document these MBES systems will be treated as equivalent units unless otherwise specified.

#### **1.5.5.1 Calibration Requirements and Methods**

MBES performance is largely a function of the original system specifications. To ensure that MBES systems used for OCS surveys continue to perform adequately, all systems should be maintained and serviced in accordance with manufacturers specifications.

##### **1.5.5.1.1 Offset Measurement and Verification**

Offsets for MBES systems shall be measured and/or verified as part of the vessel static offsets survey described in section 1.4.1. OCS typically uses two types of MBES configurations, hull-mounted and pole- or lever mounted. Particular attention must be paid to the alignment of the sonar head with respect to the keel of the survey vessel, as a very small alignment error can introduce significant positioning errors in the data.

In addition to the above alignment considerations, pole- and lever-mounted systems introduce another potential source of positioning error. Since these systems are deployed and retrieved after each use, care must be taken to insure that the sonar is both stabilized during use (via pins, guy wires, or the like) and that its deployed position does not vary. Stabilizing mechanisms should be inspected regularly for wear, stretching or general deterioration that could affect the sonar offsets or stability.

##### **1.5.5.1.2 MBES Calibration**

As part of Annual Systems Preparation, field parties shall conduct a system calibration to quantify the accuracy, precision, and alignment for each MBES system. At a minimum, the calibration shall include determination of residual biases in roll, pitch, heading, and navigation timing error. This procedure, commonly referred to as a "patch test", is performed by acquiring data that will highlight only one bias parameter at a time. The patch test should be conducted in accordance with section 5.2.4.1 of the HSSD.

Generally two lines of data must be acquired to resolve each bias. Vessel speed, direction and/or seafloor slope will be specified for each line. Figure 1.5 illustrates the most efficient line plan for conducting a patch test; however, lines for each bias may be completed in separate areas if an ideal geographical location is unavailable. Once patch test data has been acquired, system integration errors are determined by aligning slopes and targets acquired from different directions and speeds.

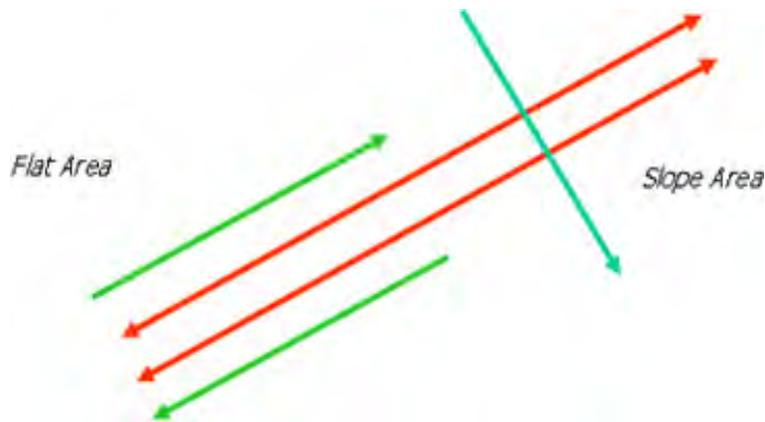


Figure 1.5: Most efficient line plan for MBES calibration testing

Once bias correctors are determined for a system, the appropriate values should be entered into the CARIS HVF for the corresponding vessel. If problems become apparent in the data or any part of the echosounder system configuration is changed or damaged, a new system calibration must be conducted.

### 1.5.5.2 Periodic Quality Assurance Checks

MBES confidence checks shall be performed in accordance with section 5.2.4.1 of the HSSD. Confidence checks shall be performed at least once during each survey conducted by multiple vessels that acquire overlapping data. Surveys conducted with only a single vessel, shall perform confidence checks at least once per week. A confidence check can be accomplished by comparing nadir MBES values to lead line readings, VBES depths, or DLDG data. These comparisons should be conducted in an area with a relatively flat and hard bottom, when sea conditions are calm. Any discrepancies identified between sounding systems that are greater than the allowable depth error for the corresponding survey must be investigated to determine if the equipment is in need of repairs.

### 1.5.5.3 Documentation and Reporting Requirements

Each patch test conducted shall be documented in a MBES Calibration Table. A copy of this table is provided in Appendix 1 (MBES\_Cal\_Table.pdf) with sample data entered in red font. In addition to a MBES Calibration Table, a chartlet showing the test area and line plan, with line numbers and headings clearly identified, shall be created for each system tested. The exact format of these chartlets is left to the discretion of the hydrographer. Calibration information shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Copies of patch test documentation shall be submitted with the DAPR for each applicable project.

Results of each MBES confidence check shall be recorded in a Sounding System Comparison Log to be maintained by the field unit. A comparison example is included in Appendix 1 (Snding\_Sys\_Comparison.pdf) with sample data in red font. Sounding System Comparison Logs shall be included in DAPR for all applicable projects.

## **1.5.6 Diver Least Depth Gauge (DLDG)**

The DLDG is a portable, self-contained, diver-deployed instrument that measures pressure in absolute pounds per square inch (PSIA). Least depth values are computed from the difference between surface pressure (pre-dive) and the pressure observed by the diver at a feature's least depth.

### **1.5.6.1 Calibration Requirements and Methods**

Each DLDG used for OCS hydrographic surveys shall be calibrated annually. These instruments should be submitted to the regional EED depot promptly after arriving for winter inport or during another suitable period of inactivity. EED will arrange for the instruments to be returned to the manufacturer for calibration and inspection. Field units that cannot feasibly submit DLDGs to the regional EED depot shall contact EED to coordinate a direct submission to the manufacturer.

Once the DLDG calibration report has been received, a copy must be forwarded to HSTP. HSTP personnel will generate, and provide to the field unit, a digital corrector file that must be loaded into Velocipy software to facilitate DLDG pressure data processing. After calibration, a Sounding System Comparison including depths computed using the DLDG shall be performed and recorded according to the example provided in Appendix 1 (Sndng\_Sys\_Comparison.pdf).

### **1.5.6.2 Periodic Quality Assurance Checks**

Velocipy software includes a DLDG DQA utility, which compares the DLDG pressure measurement in air to barometric pressure. This comparison routine should be performed daily to record a relationship between the vessel's barometer and the DLDG. The DLDG DQA should also be performed before and after each day's dive operations to provide a pre-dive and post-dive record. If inconsistencies between the barometer and calculated DLDG pressure become apparent, the DLDG may require repair or recalibration. The DLDG DQA routine in Velocipy generates a graphic display of the DLDG pressure with respect to acceptable error margins. The test passes if the new DLDG data point (red dot) lies within the two dashed lines representing the acceptable error boundaries. Prior Daily DQA results are also displayed on this graph for comparison. Each time a Daily DQA is performed, the data are appended to a digital file DIVERDAILYDQA.DAT.

### **1.5.6.3 Documentation and Reporting Requirements**

The manufacturer's DLDG calibration report, HSTP generated digital corrector file, and results of the post calibration Sounding System Comparison shall be maintained by the field unit and available for review during annual Hydrographic Systems Review and at the request of OCS. The DAILYDQA.DAT file and reports for any additional Sounding System Comparisons shall be included in the DAPR for each applicable project.

## **1.5.7 Side Scan Sonar (SSS) Systems**

NOAA hydrographic survey units use side scan sonar systems for both object detection and object recognition. Side scan sonar is typically used in conjunction with a VBES or MBES system to meet object detection coverage specifications for OCS surveys. Any SSS system used for OCS hydrography must be capable of detecting an object on the sea floor with minimum dimensions of 1 m x 1 m x 1 m, as stated in section 6.1.2.1 of the HSSD.

OCS uses both hull mounted and towed SSS system configurations. Horizontal accuracy for SSS operations will depend on the system configuration, investigation technique, water depth, and target density. However, the position of targets identified with side scan imagery must be sufficiently accurate to relocate the item for least depth and survey position determinations, usually via a MBES system. In general, side scan imagery should be capable of positioning point features to an absolute accuracy of less than 10 meters. NOAA field units use various models of side scan sonar for hydrographic survey operations. For the purposes of this document, these systems will be treated as equivalent unless otherwise specified.

### **1.5.7.1 Calibration Requirements and Methods**

Side scan sonar object detection and classification performance is largely a function of the original system specifications. To ensure that side scan sonar systems used for OCS surveys continue to perform adequately, hydrographers shall return all side scan systems to the regional EED depot for annual inspection and maintenance. If a towfish is equipped with a pressure sensor, this must be serviced and calibrated as part of the EED annual maintenance. If a towfish has been equipped with a transponder for locating the system if lost, new lithium batteries shall be installed and the system tested using an interrogator as part of annual maintenance.

#### **1.5.7.1.1 Offset Measurement and Verification**

Side scan system offsets must be measured and/or verified prior to performing a calibration. Depending upon whether the sonar configuration is hull-mounted or towed, requirements for offset measurements will vary. Offset requirements for each type of configuration are described below.

##### **1.5.7.1.1.1 Hull-Mounted SSS Configuration**

For hull-mounted configurations, the phase center of the side scan shall be precisely positioned during the vessel static offsets survey. The phase center of the towfish is considered to be at the fore and aft midpoint of the transducers and on the centerline in the athwartships and vertical axes.

When hull-mounting a SSS, particular attention must be paid to the alignment of the towfish with respect to the keel of the survey vessel, as a very small alignment error can introduce significant positioning errors in the data. For example, a heading alignment error of only 1° will add 1.75 m horizontal positioning error at the edge of the swath on a 100-m range scale. In extreme cases, it may be necessary to measure alignment error with a yaw patch test, and enter a correction in the HVF. The field unit should contact the regional HSTP Field Support Liaison for assistance with this test, if needed.

##### **1.5.7.1.1.2 Towed SSS Configuration**

For towed SSS operations, static vessel offsets should be measured to the towpoint. The actual towfish position is typically calculated using towfish depth and cable out measurements. Towfish depth may be determined by a depth sensor installed in the towfish or calculated by subtracting the towfish height (determined by a separate echosounder installed in the towfish or the first return of each sonar ping) from the depth of water (determined from a vessel echosounder). If a SSS is equipped with a pressure sensor, its accuracy should be tested annually and whenever the horizontal positioning accuracy of side scan targets is in doubt. Cable out can be estimated visually from calibrated markings on the cable or measured with an electronic cable counter. Each configuration is described below.

Note: When measuring cable out, the cable zero mark is not at its connection to the towfish, but at the phase center of the sonar.

- **Marked Cable** - Marked tow cables shall be measured using a survey grade metal tape and clearly marked. Cable markings shall be in meters and enable visual interpolation to a tenth of a meter. Since a cable jacket can stretch and slide over the conductors during use, cable measurement markings shall be verified annually, and whenever the hydrographer believes they may be in error.
- **Cable Counter** - Electronic cable counters shall be configured according to the manufacturer's instructions. The hydrographer shall verify the accuracy of the cable counter by comparing manual and electronic cable measurements at a range of cable lengths. This check shall be conducted annually, whenever the counter, cable, or sheave configuration is changed, and whenever the hydrographer believes there may be a cable measurement error. Note: For some cable counters, the serial data output being logged may be in different units than what is shown on the cable counter display. In such cases, the hydrographer may need to perform a conversion on raw cable out data either prior to logging or during post-processing.

### 1.5.7.1.2 SSS Calibration

As part of Annual Systems Preparation, the field unit shall demonstrate that all side scan sonar systems to be used for OCS hydrographic surveys are capable of meeting object detection standards set forth in section 6.1.2 of the HSSD. An operational SSS Calibration Test shall be conducted to demonstrate the system's ability to detect and accurately position seafloor targets across the system's range on both sonar channels. Test information shall be recorded in a SSS Calibration Table. An example of this table is provided in Appendix 1 (SSS\_Cal\_Table.pdf) with sample data entered in red font.

The SSS Calibration test shall consist of a minimum of 10 side scan passes on a target approximately 1 m x 1 m x 1 m. The target shall be imaged from a variety of ranges and directions, with survey speed, water depth, and weather representative of typical survey conditions. Although dedicated test targets can be used for this check, targets of opportunity, such as buoy blocks, lobster pots, and appropriately sized rocks, may be sufficient. The hydrographer should use alternate systems (e.g., MBES) to determine a high accuracy absolute position of the target for comparison with SSS detected positions.

Figure 1.6 shows the OCS recommended line plan for conducting a SSS Calibration Test. Note that this line plan balances ensonifications on the port and starboard channels, across the range scale, from different target aspects, and from different directions. This approach assists the hydrographer in differentiating systematic and random errors in detection and positioning.

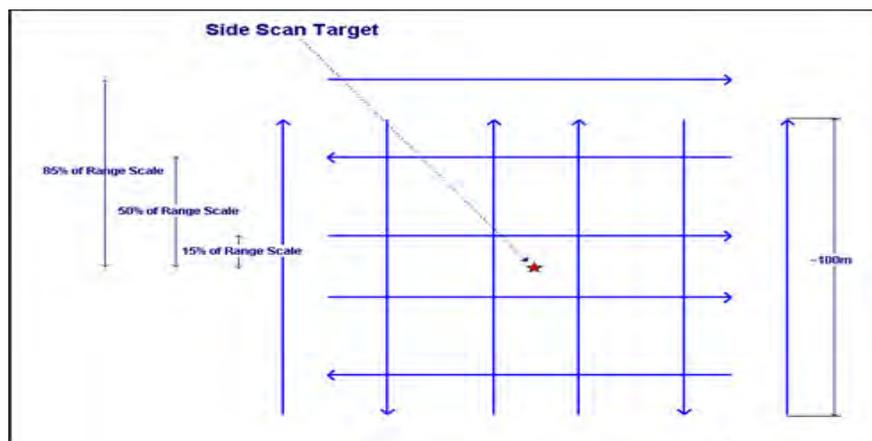


Figure 1.6: Recommended line plan for SSS calibration testing.

Test data shall be processed according to standard OCS hydrographic survey procedures and evaluated to identify any systematic problems with the sonar or vessel offsets. If the contact is not detected in more than one of the 10 passes, the SSS towfish should be carefully inspected for damage and the system re-tested. If detection remains problematic, the field unit shall contact EED and the regional HSTP Field Support Liaison for guidance.

Successful object detections shall be used to compare the mean detected position with the absolute target position and to compute the approximate 95% Confidence Radius for the system. This radius should not exceed 5 meters for hull-mounted systems and 10 meters for towed systems. Several methods can be used to estimate the 95% Confidence Radius. A simple option is to plot the detected target positions in MapInfo, and use the “Compute Statistics” function to compute the sample standard deviation of the x and y components of the detection positions (computing statistics of the Eastings and Northings yields values in meters). Assuming a normal distribution, 95% of the samples will fall within 1.96 standard deviations of the mean. If the distribution of detections is similar in x and y, the 95% Confidence Radius is roughly 1.96 times the square root of the sum of the squares of the standard deviation of detected positions in x and y.

If the distributions in x and y are not similar, it is likely that a systematic bias exists that was not canceled by ensonifying the target from multiple ranges and directions.

Similar results can be obtained by measuring the error for each detection (the distance from the absolute target position to the detected position) and computing the sample mean and standard deviation of the errors. The approximate 95% Confidence Radius is then the sample mean plus 1.96 times the standard deviation.

#### **1.5.7.2 Periodic Quality Assurance Checks**

At least one confidence check of a SSS system shall be conducted each day the system is used for data acquisition. These checks should be in accordance with section 6.1.3.1 of the HSSD and consist of detecting a discrete object at the outer range scale limits for each sonar channel (i.e., port and starboard). Confidence checks shall be annotated in the daily data acquisition records. If these confidence checks repeatedly show discrepancies with expected performance, a new System Calibration may need to be performed.

Before surveying with a SSS system that has been either reconfigured or in storage, a “rub test” should be performed. The rub test is a simple procedure wherein a hydrographer observes the SSS trace while an assistant physically rubs one transducer on the towfish and then the other while the system is pinging. As the assistant rubs the transducer, the hydrographer should see a return on the corresponding channel of the imagery. A rub test failure can indicate system errors such as incorrect gain or power settings, a faulty cable, or damaged transducers. This test should be conducted while the towfish is out of the water and dry, to avoid the possibility of electric shock.

Caution: Do not leave a SSS towfish turned on for more than 5 minutes while out of the water. These are water-cooled systems and can be damaged by excessive heat buildup if left on when not deployed.

#### **1.5.7.3 Documentation & Reporting Requirements**

In addition to a SSS Calibration Table, a chartlet showing the test area, actual target position, test line plan, positions of successful detections, and approximate 95% Confidence Radius for the target location shall be created for each system tested. The exact format of these chartlets is left to the discretion of the hydrographer. This information shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Documentation for SSS Calibration Tests conducted shall be included with the DAPR for each associated project.

There is no requirement to individually document and report SSS confidence checks required in section 1.5.7.2 above. Hydrographers shall verify that these checks were conducted, describe the results, and discuss any problems encountered in the Quality Control section of each applicable Descriptive Report.

### **1.5.8 Tide Gauges**

Tide gauges are used to measure water levels for calculating bathymetric data correctors. In any given tidal area, water level data account for the largest vertical correction to soundings. However, water levels vary due to both astronomical tides and effects from other forces such as wind, rain, barometric pressure, and freshwater runoff. Even in areas where tidal range is small, such as the Gulf of Mexico, the total water level variations can still be large enough to significantly affect sounding accuracy. If water level values are not properly measured and applied, then hydrographic error budget requirements may not be met.

#### **1.5.8.1 Calibration Requirements & Methods**

Tide gauges, batteries, GOES antennas, battery cables, regulators, and other tide gauge equipment are typically maintained and calibrated (if necessary) by the Center for Operational Oceanographic Products and Services (CO-OPS) staff on an annual basis. Field units should contact the local Operations Branch of the CO-OPS Field Operations Division immediately after the close of the field season to arrange for servicing of any gauges deployed with the unit. As the field unit prepares for the upcoming field season, the unit should discuss tide gauge requirements with FOD as soon as project assignments are known.

Field units should thoroughly test all tide gauge equipment, including that serviced by CO-OPS, as part of the Hydrographic Systems Readiness Review process.

#### **1.5.8.2 Periodic Quality Assurance Checks**

When a field unit installs a tide gauge for hydrographic surveys, it is responsible for operation and maintenance of that gauge for the duration of the survey. As such, it behooves the hydrographer to conduct a full functional check of all gauge equipment immediately prior to installation. Once the gauge is installed, the following checks should be conducted:

- The hydrographer should monitor the daily Hydro Hotlist email to ensure that gauge data are being received by CO-OPS and pass quality checks. (Note: the hydrographer must specifically request CO-OPS to add gauges to the Hydro Hotlist. See section 3.5.2.3.1 on page 86 for additional information.)
- If GOES transmissions are not possible from the tide station site, the hydrographer should visit the station every few days to ensure that data are being recorded. The hydrographer should download recorded data on these visits, check the water levels to ensure a smooth curve consistent with predictions (if available), and transmit the data to CO-OPS.
- Regardless of the status of the satellite uplink, the hydrographer should visit the station site approximately weekly to check the physical integrity of the installation. These checks should include the following:
  - Confirm that gas pressure is adequate to last until the next visit, and check for gas leaks at tubing connections (for bubbler gauges).

- Check battery voltage to confirm that the solar cells are providing adequate charging current.
- Check for physical stability of the gauge by performing a minimum of 2 hour of staff readings for comparison with recorded data.
- These station checks are particularly critical immediately before and after an extended absence from the survey area (such as a port call).

If problems are observed with water level data an on-site assessment should be conducted and field units should contact CO-OPS to determine the preferred course of action.

### **1.5.8.3 Documentation and Reporting Requirements**

Since tide gauge equipment is maintained by CO-OPS, annual field unit calibrations are not required. Tide gauges do not need to be addressed during Hydrographic Systems Reviews aside from being listed in the Hardware Systems Inventory. Any tide gauge problems encountered during survey operations shall be described, including any subsequent effects to survey data, in applicable DAPRs or DRs.

### **1.5.9 Leveling Equipment**

Geodetic leveling equipment is used to measure elevation differences between benchmark locations and to extend vertical control from established benchmarks to water level measuring equipment or a water level staff. For hydrographic survey operations, this equipment consists of a compensator leveling instrument and level rod. The quality of the vertical datum measured is partially dependent on the quality of the leveling performed between benchmarks and the water level staff or equipment. It is important to properly maintain leveling instruments and rods to ensure that they are within calibration tolerances.

It is OCS policy to follow the standards and procedures established by CO-OPS for calibrating and operating leveling equipment used to survey water level stations. These requirements are described in the NOS User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, published by CO-OPS and included on the Hydrossoft website. These requirements are summarized here, but the hydrographer should refer to the User's Guide for specific information on leveling operations.

#### **1.5.9.1 Calibration Requirements & Methods**

For OCS hydrographic survey operations, level surveys shall be conducted to at least third order accuracy standards. The minimum scale calibration standard for level rods being used for third order surveys is the manufacturer's standard. Level rods do not have a recommended time period between scale calibrations. If an error is suspected in a rod scale, the rod may be calibrated and certified by an approved laboratory.

No leveling instrument is perfectly aligned. The angle from which the line of sight departs from the actual level surface when the instrument is leveled is referred to as collimation error. To minimize collimation error, the leveling instrument shall be serviced and adjusted during Annual Systems Preparation and whenever a collimation error cannot be reduced to acceptable tolerances in the field. This service shall be performed by a qualified, manufacturer-approved technician.

The hydrographer shall verify the collimation of leveling instruments after annual calibration. Collimation shall be checked according to either of the two approved methods described in section 3 of the User's Guide. The collimation error should be no greater than  $\pm 0.05$  mm/m. If it exceeds this tolerance, the level instrument must be adjusted and another check performed. Collimation Checks shall be processed and documented on NOAA Form 75-29 (or an equivalent) according to the procedure and example in section 3 of the User's Guide.

#### **1.5.9.2 Periodic Quality Assurance Checks**

Collimation and general performance of leveling equipment shall be verified prior to each leveling survey by repeating the collimation check. If collimation error exceeds  $\pm 0.05$  mm/m, the level instrument must be adjusted and another check made until the error can be successfully reduced below this threshold.

#### **1.5.9.3 Documentation and Reporting Requirements**

Collimation check and calibration records for leveling equipment used for OCS hydrographic surveys shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Leveling equipment and dates of calibration shall be reported in the Hydrographic Systems Inventory. Documentation for any subsequent collimation checks and/or calibrations conducted shall be included in the DAPR for each applicable project.

#### **1.5.10 Horizontal & Vertical Control Equipment**

No standard calibration requirements have been implemented at this time for horizontal and vertical control equipment. This equipment's calibration requirements and quality assurance checks should be maintained per the manufacturer's recommendations until further guidance is provided.

##### **1.5.10.1 Documentation & Reporting Requirements**

Note: Calibration and quality assurance documentation for horizontal and vertical control equipment used for hydrographic surveying shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. Horizontal and vertical control equipment and dates of calibration (if applicable) shall be reported in the Hydrographic Systems Inventory. Documentation for any subsequent calibrations or quality assurance checks conducted shall be included in the DAPR for each applicable project.

#### **1.5.11 Reference Surface**

Once all sonar and ancillary instrument calibrations have been performed, field parties shall assess the combined effects of vessel offsets, patch test biases, and sonar bottom detection for each vessel-sounder combination by comparing data and grids over a known reference surface. This is a capstone of the system preparation process, as it combines the data from all constituent systems for an assessment of the final result.

In the event there is only one vessel and sensor, a comparison should be made with another field unit or data from previous years if possible. If there is no previous coverage readily available, a self-comparison of reference surfaces shall be conducted. Self-comparisons cannot be used to check for overall vertical biases, but are useful for checking for other data anomalies.

Note: this section assumes testing of multibeam echosounders. However, testing vertical beam echosounder systems over a multibeam reference surface can also provide useful results.

Field units are encouraged to collaborate in establishing and using reference surfaces. Ideally, these would be located in an area to which field units could return annually or as needed, with all datasets centrally archived for future comparison.

### **1.5.11.1 Reference Surface Acquisition and Processing**

A grid pattern (shown in Figure 1.7) should be acquired with each sonar-vessel combination for a robust comparison:

- The grid should be planned over a relatively flat area of depth appropriate for the sonar under evaluation. (It may be helpful if the test area includes a few discrete features such as wrecks or rocks, but this is not required.)
- Survey lines should be planned for at least 100% coverage in each direction, leading to ~200% coverage over the entire grid.
- The reference surface should be sized to produce a minimum of approximately five million soundings per echosounder head. This is necessary to provide a statistically significant sample size for each beam of the sonar. Larger surfaces will typically improve analysis results, but obviously at the expense of acquisition and processing time.
- Sonars should be operated (vessel speed, system settings) as they would ordinarily be for standard survey operations in the area.
- Settings (beam type-EA/ED, power, gain, pulse width, absorption, spreading) should be the same for the comparative systems, but may differ for different frequencies of the same sonar. For example, for the Reson7125, the 200kHz may have settings that differ from the 400kHz system.
- All necessary data correctors such as delayed heave, tide, sound speed, and TPU shall be acquired and applied to the data. Incorporating the techniques of Ellipsoidally-Referenced Surveys (ERS), in addition to traditional tides, can help minimize errors associated with water levels.
- Backscatter data should be acquired concurrent with bathymetry data.
- Ideally, all of a field unit's sonar-vessel combinations should be tested in reasonably quick succession to limit influence of environmental changes.

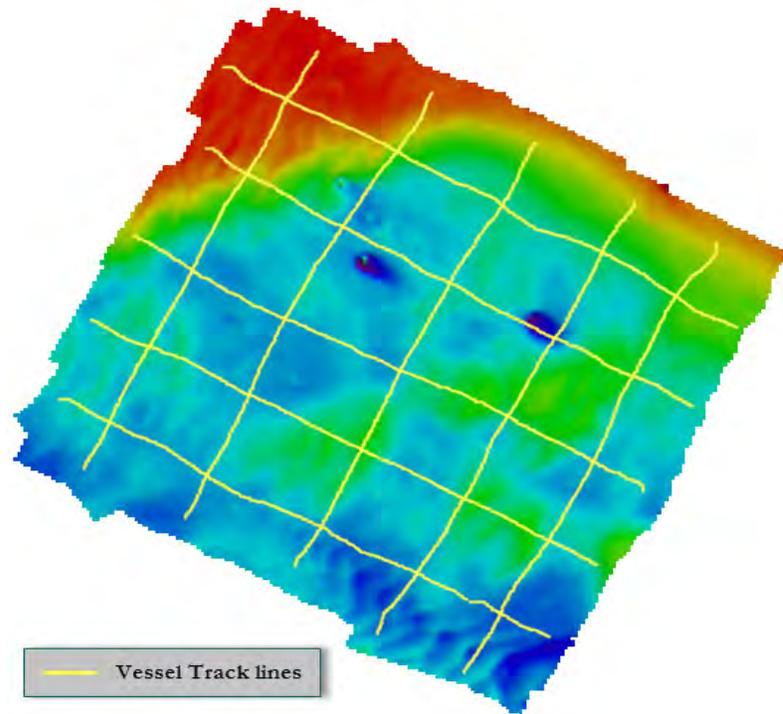


Figure 1.7 – Sample reference surface acquisition plan. A 200% coverage scheme was employed over a site which displayed a mixture of flat bottom, sand waves, and targets (buoy blocks).

Once gross fliers have been removed, the data for each unique vessel/sonar combination should be gridded using CUBE at the highest resolution at which the dataset can support a minimum of five soundings per node (ideally, twice the maximum standard required survey resolution for the depth of the test area, i.e. 2.5% water depth). In addition, the backscatter should be mosaicked at appropriate resolution. A number of tests are now advised, including:

- Visually check each surface for any data artifacts, especially those associated with offset issues, poor patch test values, timing errors, or incorrect motion stabilization application.
- Assess the computed total propagated uncertainty and standard deviation of each reference surface, comparing these uncertainty estimates to IHO thresholds.
- Compute difference surfaces to compare the surfaces of different vessel/sonar combinations acquired at roughly the same time (consider performing these differences with data referenced to both tidal and ellipsoidal reference frames). Compare the difference values with the estimated uncertainty for each of the comparison grids, and the IHO thresholds. (This tests inter-system agreement).
- Compute difference surfaces to compare each vessel/sonar combination with results from the same combination from previous years (again, consider performing these differences with data referenced to both tidal and ellipsoidal reference frames). Compare the difference values with the estimated uncertainty for each of the comparison grids, and the IHO thresholds.
- Perform a beam-by-beam statistical comparison of the processed soundings against the reference grid composed of the same data. The HIPS beam-by-beam analysis tool may be the most

appropriate method. Examine results for beam-specific biases or noise. (This tests internal-consistency of the sonar, and helps identify faulty segments of the transducer or beamformer).

- As an alternative or in addition to the beam-by-beam comparison, two separate surfaces at lower resolution (one from each 100% coverage) can be created, and differenced. (This will help assess internal consistency of the data, but will not highlight problem segments of a sonar swath).
- Backscatter analysis is more qualitative, but assessments may include visual assessment of the mosaic for any obvious artifacts which could be associated with a sonar malfunction, inter-system comparison, and year-to-year comparison of backscatter acquired with the same sonar-vessel system.

### 1.5.11.2 Periodic Qualify Assurance Checks

Reference surfaces and associated data analysis should be performed as part of any new sonar-vessel system commissioning, and at least annually as part of the Hydrographic System Readiness Review. Additional tests may be advisable after significant changes to the sonar-vessel system, or if any data qualify concerns emerge from standard survey data.

### 1.5.11.3 Reporting Requirements

As the reference surface test is a capstone of the overall Hydrographic System Readiness Review (HSRR) Process, any results which indicate concerns in the overall health of the sonar-vessel system(s) shall be discussed in the HSRR Memo.

A fuller description of reference surface process and results shall be included in the DAPR as an attachment. The exact format is left to the discretion of the hydrographer, but it should include the following:

- Description of the reference surface area in sufficient detail to allow other units to utilize the same location
- A full description of the system combination tested
- A brief description of data acquisition and processing, including discussion of any problems encountered or non-standard procedures followed
- Results and discussion of the comparison tests performed
- Any recommendations

The following is an example discussion of Reference Surfaces from NOAA Ship *Rainier*.

As an example, part of the *Rainier*'s HSRR process involves creating nine reference surfaces for the purposes of calibrating their four survey launches (with their nine associated transducers).” One sonar is arbitrarily declared the “baseline”, and all surfaces are then differenced from this baseline (Figure 1.8). Once these differences are known, statistics are generated, visualized and appropriately interpreted (Figure 1.9). In the example shown in Figure 1.9 all three sonars mounted to Launch 2803 (green) exhibited a 6-7cm bias as compared to the other ves-

sels (when referenced to MLLW); a bias that was mitigated when comparisons were instead made on the ellipse. This knowledge then informs the HSRR team to examine the parameters of Launch 2803 that are unique to the MLLW workflow (i.e. Dynamic Draft, Static Draft, Loading, Tides or Heave). In this case, it was an erroneous dynamic draft model due to the characteristics of the suspended 8125 sonar unique to the design of Launch 2803.

Once analysis is complete, all the systems could then be condensed into a master reference surface which can be used as the baseline in future HSRRs.

Differences Relative to 2801 HF (Baseline)		
Sensor 1	MLLW	Ellipse
2801 HF	0.00	0.00
2801 LF	0.00	0.01
2802 HF	0.00	-0.02
2802 LF	0.00	-0.01
2803 HF	-0.07	-0.01
2803 LF	-0.06	-0.02
2803 8125	-0.06	-0.03
2804 HF	0.01	0.01
2804 LF	0.01	0.01

Figure 1.8 – Tabulated differences of all sonars (2801 HF considered baseline) conducted during a single HSRR process, referenced to both MLLW and the Ellipse.

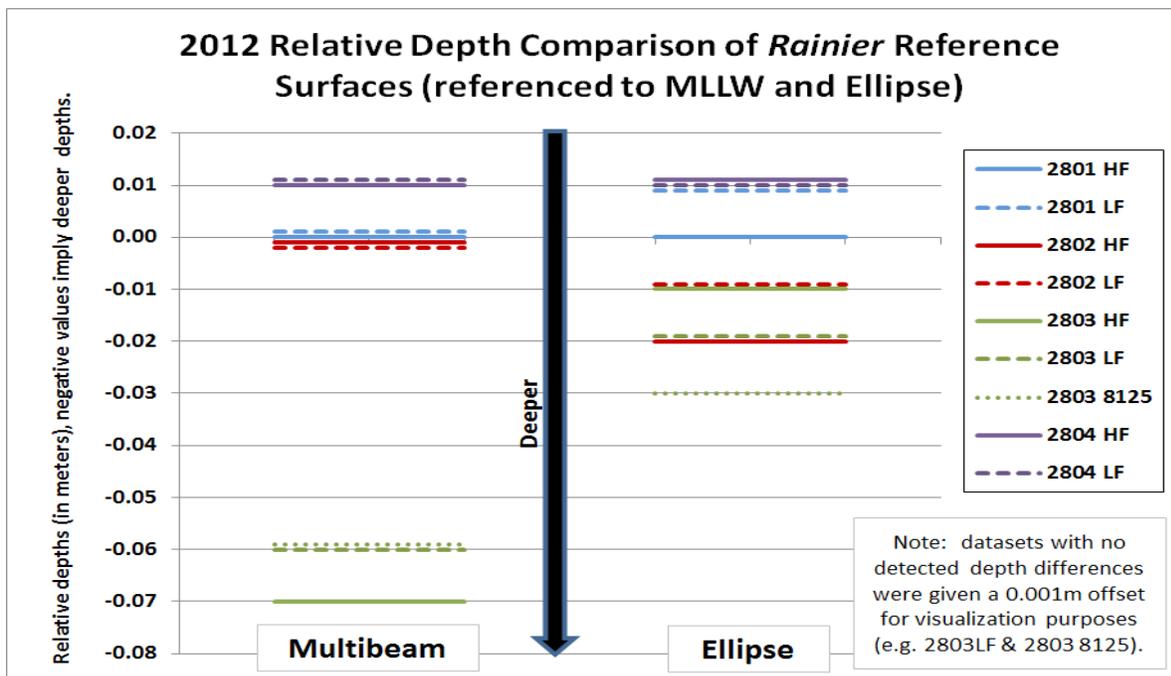


Figure 1.9 – Graphical display of the relative differences of nine sonars’ reference surfaces, referenced to both MLLW and the Ellipse.

## 1.6 Software Systems

Computer software plays an essential role in NOAA's hydrographic surveying operations and must be managed with care and attention to detail. It is important that each field unit ensure during the Annual Systems Preparation, that their systems are up-to-date with the most current approved versions of survey related software.

Field units shall operate with the most up-to-date software available; any mid-season software changes should be carefully documented so that the field unit can revert to a prior software version if problems arise. OCS has established the following basic guidelines for maintaining, updating and testing software.

All field units should incorporate adequate computer and software maintenance periods into their annual schedules. This should be planned to coincide with a period of relatively low operational activity, typically winter inport for ships. Field units should use this opportunity to install and configure software on new computer systems and conduct comprehensive rebuilds of systems to be retained. In general, "rebuilding" a system entails the following steps:

1. Back-up all storage devices attached to the system (local hard drives).
2. Reformat storage devices.
3. Complete any scheduled hardware upgrades (new drives, memory, etc.).
4. Load the latest approved version of the operating system and mission software (standardized to the greatest extent possible across the platform).
5. Restore only essential data from the back-up.

This practice has been particularly useful on Microsoft Windows-based systems with multiple users, as it enforces software and configuration standardization and limits retention of unnecessary data or software that may adversely affect system performance.

NOAA personnel seeking information on hydrographic software updates should consult HSTP. HSTP is the first point of contact for most commercial hydrographic software packages in use by NOAA hydrographic field units and is directly responsible for writing and maintaining many of the in-house programs used for OCS surveys. Prior to installing software upgrades, it should be ascertained that the new version or update has been tested and approved for use. The field unit's regional HSTP Field Support Liaison should be able to answer questions about software availability and testing.

Aboard NOAA hydrographic survey ships, EED shares responsibility for maintenance of hydrographic survey computer systems and software. Traditionally, EED has maintained computer hardware, operating systems, and data acquisition software, while OCS has been responsible for survey planning and data processing software, but these lines are often blurred. Shipboard hydrographers should, therefore, coordinate all software requests and changes with the embarked Electronics Technician, as well as with HSTP.

There will be cases where a critical software problem warrants installation of an upgrade before HSTP or EED has rigorously tested and/or verified its functionality. Hydrographers are encouraged and expected to exercise common sense in these cases. If external testing is not possible, field units should establish an internal software test program, document the procedures and results, and report their findings to HSTP and EED, so other units can benefit from their experience.

## 1.6.1 Types of Software Systems

### 1.6.1.1 Computer Operating Systems (OSS)

The operating system is a computer's most fundamental software and it affects the performance of all other programs running on a machine. Typically, NOAA's hydrographic survey computer systems use the Microsoft Windows environment. New versions or significant updates (such as Service Packs) for any OS should not be installed until the hydrographer has consulted both EED and HSTP. These groups must confirm that mission critical software has been successfully tested under the proposed new OS version prior to installation on any system used for hydrographic survey operations. OCS discourages major mid-season OS upgrades (for example, switching from Windows XP to Windows 7 ) and suggests that field units attempt to maintain a standard OS on all data acquisition and processing systems.

OCS will not notify field units of available OS upgrades unless the update is critical to maintain functionality or compatibility with hydrographic systems. However, most OS vendors have an automatic notification system for critical updates. Field units with Internet access can also check the OS vendors' websites to determine if updates are available. Complete OS upgrades should be acquired through EED (if shipboard) or via the field unit's chain of command.

### 1.6.1.2 Data Acquisition Software

Software Packages	Manufacturer	Common NOAA Uses
HypackMAX	HYPACK	VBES and MBES acquisition; survey line navigation
SonarPro	Klien	SSS acquisition
SIS	Kongsberg	MBES acquisition
POSVIEW	Trimble/Applanix	POS MV settings, lever arms and logging (POSPAC) control
Discover II	EdgeTech	SSS acquisition

Table 1.1: Common OCS Data Acquisition Software Packages.

OCS recommends that data acquisition software updates be performed during Annual Systems Preparation. Field units wishing to install updates during normal operational periods shall contact the regional HSTP Field Support Liaison to determine if the new version has been successfully tested in a controlled environment. Occasionally, it may be necessary to install a critical update without prior HSTP testing. In such cases, field units should first document the existing software version settings so that it can be reinstalled if the update causes more severe problems. The software upgrade should then be installed on a limited basis to minimize the effects of any bugs encountered. Proper testing of new software may require several days of standard field operations to fully assess its functionality. Field units should process and thoroughly examine resulting data for errors prior to making a unit-wide installation.

HSTP maintains support agreements with most manufacturers of data acquisition software packages used by OCS. Although some companies may contact individual licensees directly when updates are available, this communication is typically routed through HSTP or EED. When a period of relative inactivity suitable for computer system maintenance is approaching, field units should contact the regional HSTP Field Support Liaison and assigned EED Electronics Technician (if applicable) for any approved data acquisition software upgrades that are available.

### 1.6.1.3 Data Processing Software

Data processing software are those programs used to manipulate and analyze survey data. Common hydrographic data processing software packages used by NOAA field units are presented in Table 1.2. Downloads for software and updates can typically be found at the following HSTP maintained Hydrosoft site <https://inside.nos.noaa.gov/hydrosoft/welcome.html>

Software Package	Manufacturer	Common OCS Uses
HIPS / SIPS	CARIS	bathymetry and imagery data processing
Notebook	CARIS	survey planning and processing
MapInfo	MapInfo	survey planning; survey product creation
Fledermaus	IVS - 3D	3D survey data visualization
Pydro	NOAA	survey data analysis; report creation; TCARI tide application
Velocipy	NOAA	sound velocity profile processing; variability wedge analysis, est. sound speed uncertainty
Hydro MI	NOAA	survey line planning; tide file creation
POSPac	Trimble/Applanix	derive IAPPK solution to hydrographic data
OPUS	NGS	high accuracy positioning
Inverse 3D	NGS	PPK processing
VDatum	NOAA	conversion from different horizontal/vertical references into a common system

Table 1.2: Common OCS Data Processing Software Packages

HSTP maintains software support agreements with most data processing software manufacturers, many of which notify users directly when new updates are available. The following update procedures for specific processing software packages have been established by OCS:

- CARIS products: All NOAA hydrographic field units should be receiving weekly email from CARIS describing any new releases. Any field units not subscribed to this service should contact the regional HSTP Field Support Liaison to register.
- HSTP products (Pydro, Hydro\_MI, Velocipy): HSTP will notify field units directly when critical updates are available.
- IVS 3D: Units interested in receiving email notification of Fledermaus updates can subscribe to the IVS email list. See <http://www.qps.nl/display/fledermaus/support> for more information.
- MapInfo: All MapInfo licenses are covered under a global maintenance plan managed by HSTP. HSTP will notify field units directly when critical MapInfo updates or patches are available.
- POSPac: HSTP will notify field units directly when critical updates become available.
- OPUS: OPUS is not available as a standalone program, but can be found online at <http://www.ngs.noaa.gov/OPUS/>

- NGS INVERSE3D; NGS INVERSE3D can be used to perform the weekly position uncertainty check base stations and can be downloaded at [http://www.ngs.noaa.gov/TOOLS/Inv\\_Fwd/Inv\\_Fwd.html](http://www.ngs.noaa.gov/TOOLS/Inv_Fwd/Inv_Fwd.html).
- VDatum: VDatum software is developed jointly by the NOS Tri-Office VDatum Team. VDatum transformations utilize a combination of stepwise transformations between ellipsoidal, orthometric, and tidal datums, leveraging the best available hydrodynamic models and historical tidal and geodetic data at each step. VDatum software can be downloaded at <http://vdatum.noaa.gov/>.

#### **1.6.1.4 Support Software**

Support software includes any packages that are used as part of the hydrographic survey process, but do not directly interact with data. However, they may be used to create digital products that accompany survey data and, as such, must be compatible with systems throughout OCS. Examples of support software that may be in use by a field unit include NOAA Chart Reprojector, Paint Shop Pro or AutoCAD.

Although OCS does not notify field units of upgrades to these packages unless there is a pressing operational need, most vendors provide email update notification to registered users. Field units should coordinate with OCS to ensure that support software is in compliance with NOAA standards and compatible with survey systems.

#### **1.6.2 Software Repositories**

Once a field unit has determined that a software upgrade is approved, available, and desirable, the digital files must be acquired. While some vendors will provide these upgrades on physical media, users are often expected to download updates via File Transfer Protocol (FTP) or from Internet websites. HSTP posts both commercial and in-house software upgrades to OCS's anonymous FTP server (IP address 205.156.4.84). Note: NOAA field units can not upload data to the FTP server.

If field units are outfitted with reliable high speed Internet access, software can be easily downloaded from vendor sites or the FTP server. However, some of NOAA's hydrographic field units have limited bandwidth for accessing the Internet or for receiving email attachments; thus, an alternate means of obtaining software upgrades may be necessary. Field units should consider other connection sites, such as public libraries or Internet cafés, or contact the regional HSTP Field Support Liaison to have updates mailed on CD or other media.

#### **1.6.3 Documentation & Reporting Requirements**

Each computer used to acquire or manipulate hydrographic survey data shall be included on the Software Inventory portion of the Hydrographic Systems Inventory. Installations and updates for primary software packages shall be recorded for each computer, as shown by the sample data (red font) included on the Software Inventory spreadsheet. Additionally, a record of system settings for hydrographic data acquisition software shall be created and updated throughout the field season. If a software system has the capability to output a file identifying all configuration settings, a copy of this file will meet system settings reporting requirements. Otherwise, the field unit will need to manually generate a digital record (e.g., a spreadsheet). Software documentation shall be maintained by the field unit and available for review during Hydrographic Systems Reviews and at the request of OCS. A copy of the Software Inventory and system settings records in effect during operations shall be included in the DAPR for each respective project.

## **1.7 Personnel Rosters**

People are the most essential component of any hydrographic survey system, and training hydrographic personnel is a critical element of survey preparation for any field unit. Even if all hardware and software systems are functioning correctly, data quality and operational efficiency will suffer without properly qualified hydrographers. Guidelines for training and qualification of hydrographic personnel are described below.

For the purposes of this manual, “hydrographic personnel” are defined as those members of a field unit’s complement (permanent or temporary duty) whose normal duties include responsibility for any activities that directly affect survey planning, data acquisition, or data processing. In addition to Physical Scientists, Survey Technicians, Commissioned Officers, and others in immediate control of survey operations, this includes launch coxswains and Officers of the Deck (OODs) responsible for operating vessels during surveying; visitors who participate in data acquisition and processing without direct supervision; and the unit’s command. Support personnel, such as marine engineers, stewards, and members of the deck department not acting as launch coxswains, are not typically considered “hydrographic personnel”. However, if survey operations will be significantly impacted by any of the aforementioned groups, e.g. an insufficient number of engineers to perform planned 24-hour operations, these situations should be mentioned in the Hydrographic Systems Readiness Memo described in section 1.1.1 .

### **1.7.1 Personnel Qualifications & Training**

Standard hydrographic training and qualification requirements are not currently established for NOAA’s hydrographic personnel. Therefore, it is incumbent on each field unit to establish internal standards to ensure that hydrographic personnel are adequately qualified to safely and efficiently accomplish the unit’s mission. Such a program of training and qualification can be crafted from any of several available components including, but not limited to, the following:

#### **1.7.1.1 Internal Training and Qualification Standards**

These are standards of training and qualification developed by the field unit to meet the particular needs of its configuration and mission. Examples include:

- Launch Hydrographer-in-Charge (HIC) workbook and qualification
- Launch Person-in-Charge (PIC) workbook and qualification
- Launch Coxswain workbook and qualification
- Officer Of the Deck (OOD) workbook and qualification

#### **1.7.1.2 NOAA Hydrographic Training**

The Office of Coast Survey organizes an annual basic hydrographic training program (“Hydrotraining”). One session per year is offered at a location on each coast, typically Norfolk, VA and Seattle, WA, and all new survey personnel are encouraged to attend. Subject to demand and available funding, sessions on advanced topics suitable for hydrographers with more than one year of experience may also be offered in conjunction with the basic course.

CO-OPS is available to provide training on basic tidal theory, tide gauge installation, discrete tide zoning and TCARI methodology. Elements of these topics are covered in basic Hydrotraining, but field units may choose to schedule additional training with CO-OPS to meet their specific needs.

### **1.7.1.3 External Training**

Hydrographers may be eligible to pursue hydrographic qualifications from an outside agency or organization such as the American Congress on Surveying and Mapping (ACSM).

### **1.7.2 Reporting Requirements**

Although the Hydrographic Systems Inventory includes only a basic roster of hydrographic personnel, deficiencies in either numbers or qualification of personnel should be noted in the Hydrographic Systems Readiness Memo described in section 1.1.1

Additionally, OCS recommends that each field unit maintain a record of personnel training and qualifications. Formally documenting personnel training and qualifications will assist Chiefs-of-Party in assessing the readiness of their personnel. This record can also help identify hydrographic training needs, enabling units to request and allocate resources accordingly. Copies of curriculum and/or requirements for any internally crafted qualification or training should be maintained by the field unit for reference purposes.

## **1.8 Data Storage Availability**

An inventory of all available data storage shall be completed and documented as part of the HSRR.

## Chapter 2

### Pre-Survey Planning

Pre-survey planning is essential for any field unit to effectively and efficiently conduct hydrographic survey operations. When planning operations, the hydrographer must keep in mind the assigned survey specifications and approved methods for meeting those criteria. This Chapter describes information that will be provided to a field unit when a hydrographic survey is assigned and provides project preparation and survey planning guidance.

#### 2.1 Crew & Vessel Safety

Above all, every member of the field party should understand that safety of the crew and vessel is the number one priority. Safety shall be the foremost consideration in all aspects of Office of Coast Survey (OCS) hydrographic surveys, from the planning stages through data submission. It is the responsibility of the Chief-of-Party, as well as vessel crew, to be aware of safety hazards and take steps necessary to ensure undue risks are avoided, even if it means ceasing operations.

Good planning and information can minimize risks associated with hydrographic surveying. Recommended practices to increase safety include, but are not limited to the following:

- Use historical weather information to prepare for seasonal patterns.
- Review the survey region for exposed areas, constricted areas, shallow areas, surf, etc. Plan on surveying challenging areas when weather, tides, and currents are optimal.
- Review prior survey Descriptive Reports (DR) and smooth sheets for uncharted hazards. Often, the DR will describe deficiencies, hazards, and challenges from prior surveys and field experience.
- Work progressively from safe water towards unknown, shallow, or potentially hazardous areas.
- Use daily survey information progressively in the field to minimize hazards. Communicate survey and safety information to all personnel involved in operations. ‘

Read the Automated Wreck and Obstruction Information System (AWOIS) features included with the project files descriptions to understand hazards and survey the feature project area safely.

Understand the limitations of charted and source information and approach features conservatively during initial operations.

## 2.2 The Project CD/DVD

When a hydrographic survey is assigned, the HSD Operations Branch (OPS), or the NSD Navigation Response Branch (NRB) if the unit is an NRT, will generate and compile relevant project information onto a Project CD/DVD. This information will include project instructions, as well as supporting information and data files to be used during field operations and subsequent survey processing. Copies of the Project CD/DVD will be disseminated to the appropriate field unit six weeks prior to the start of the project. The file structure illustrated in Figure 2.1 represents that of a typical Project CD/DVD. If a folder is intentionally left empty, the project planner will place in a readme.txt file indicating as such.

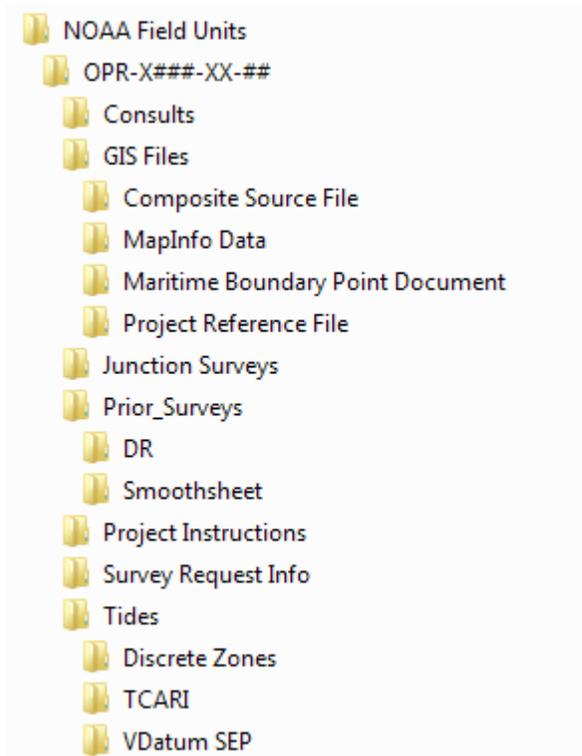


Figure 2.1: Project DVD Structure

## **2.2.1 Hydrographic Survey Project Instructions**

The Hydrographic Survey Project Instructions will identify specific requirements for a survey project. Project Instructions will be included on the Project CD/DVD and can be equated to a Requirements Document or Statement of Work. Field units shall acknowledge receipt of Project Instructions via email to the assigned OPS Project Manager or the NRB Technical Assistant.

## **2.2.2 Supporting Project Information**

Extensive supporting project information will be provided on the Project CD/DVD. The following items are included: Consults folder containing relevant project correspondence, project GIS Files, Junction Surveys, Prior Surveys, and preliminary tidal zoning files. The naming conventions for project information files generated at OPS or NRB will reference the applicable project number or survey sheet number.

### **2.2.2.1 Consults**

OCS, as a unit of a federal agency, has responsibilities under section 106 of the National Historic Preservation Act (NHPA, 16 U.S.C. 470 et seq.) to take into account the effects of its undertakings on historic properties. The process for federal agencies in complying with the NHPA is laid out in 36 C.F.R. Part 800, which prescribes consultation with the State Historic Preservation Officer (SHPO). In addition, OCS may consult with other NOAA offices or governmental agencies, depending on jurisdiction. The Hydrographic Surveys Division is responsible for conducting the entire consultation process. Correspondence and documentation relating to consultations with these Historic Preservation Points of Contact (HPPOCs) will be included in the Consults folder as background information for the field units.

Any additional relevant project correspondence will be included in this folder.

### **2.2.2.2 GIS Files**

This folder will include the Composite Source File, MapInfo Sheet Limits, Maritime Boundary Point(s) Document, the Project Reference File, and Aids to Navigation Records.

The OPS Project Manager or NRB Technical Assistant will compile all available shoreline source files into one “composite source” file (CSF) in S-57 .000 format. Shoreline source files include: ENC, RNC, Geographic Cells (GCs – also labeled as DCFF ), and Lidar files. Compilation will include reviewing the CSF to determine which shoreline features shall be verified by the field unit. Features requiring verification shall have the attribute Assignment (asgmt) populated with “Assigned”.

The MapInfo sheets .tab will be provided to identify the planned area of hydrography for each project.

Layouts for Field Examinations (FEs) will vary according to the item, feature, or area to be surveyed. Any MapInfo tables created by the OPS Project Manager or NRB Technical Assistant will be projected in Universal Transverse Mercator (UTM) using the North American Datum of 1983 (NAD83).

A Project Reference File (PRF) will also be delivered with the CSF. The PRF is an S-57 attributed dataset containing reference layers such as survey limits, junctions, recommended bottom sample locations and features which are specifically targeted for investigation such as AWOIS points or Maritime Boundary points.

The project wide AWOIS items are assigned to the field unit for investigation by the OPS Project Manager or the NRB Technical Assistant. This subset of the master AWOIS database will contain all items falling within the limits of the particular project, as well as any critical items in close proximity to the survey area.

AWOIS items are represented as placeholders by the S-57 Feature Object CRANES. The AWOIS radii are represented by the S-57 Feature Object ACHBRT. The AWOIS search radii are assigned based upon extensive research of historical documents and factors such as the original source of the feature and the quality of that feature's positioning.

Prescribed investigation requirements for each AWOIS item will be specified in the NOAA Extended Attributes (see section 8.2 of HSSD for details).

All AWOIS items included in the project area are "assigned" for verification (asgmt = "Assigned"). In addition, the project planner may "assign" AWOIS items outside of the project area.

There are two types of AWOIS verification:

1. AWOIS items which have not been verified in the past (Item Status = "Assigned", Search Type = "Full" or "Limited") – investigation includes verifying or disproving the item by covering the entire search radius regardless of location with respect to survey limits.
2. AWOIS items which have been verified in prior surveys (Item Status = "Completed", Search Type = "Information") – no search radius is required. Investigation includes verifying or disproving the feature just as any other feature within the project area is verified or disproved. A search outside of the survey limits is not required (i.e. items inshore of the NALL).

See section 7.3 of the HSSD for further information on AWOIS items.

If shoreline verification is not required, there will be no CSF however all projects will contain a PRF containing a minimum of the survey limits.

NOAA's Update Service Branch (USB) within the Marine Chart Division will review NOAA's Critical Corrections Database (CRIT) and/or USCG Integrated Aids to Navigation Information System (IATONIS) database to identify ATONs within the survey area that require positioning. Records for each assigned ATON will be provided by USB for inclusion on the Project CD/DVD. ATON records will include the current database position for each assigned ATON, position accuracies or positioning methods that were used (if available), and any special positioning requirements.

### **2.2.2.3 Junction Surveys**

Assigned surveys may include a junction with contemporary data from a recent field season and all field units are required to ensure continuity in survey coverage and depth by evaluating junctioning or overlapping surveys. The Project Instructions will indicate if a junctioning survey is in a projection and datum other than UTM NAD83 and requires a datum conversion or reprojection.

### 2.2.2.3.1 Junctioning with Light Detection and Ranging (Lidar) Surveys

Lidar junction data will be provided in S-57 (.000 or .HOB) format on the Project CD/DVD. Features found by the Lidar survey will be added to the Composite Source File (CSF) as an existing feature. Lidar investigations will be added to the Project Reference File (PRF). Field units should obtain the required coverage type to the Lidar extent line or the Navigation Area Limit Line (NALL), whichever is further offshore. The standard practice for coverage overlap between Lidar and MB surveys is to overlap one swath width inshore of the LGL. Verify or disprove all Lidar investigation items seaward of the NALL.

The following files will be included on the Project CD/DVD for junctioning with Lidar data.

File Name	Description
Hxxxxx_LI_BASE_3m	3 meter resolution surface.

Table 2.2: CARIS file included on the Project CD/DVD for junctioning with Lidar data.

File Name	Description
Hxxxxx_DR.pdf	Descriptive report and Appendices.

Table 2.3: Other files included on Project CD/DVD for junctioning with Lidar

The following common attributes are used to define feature objects in the deliverables.

Attribute	Description
NINFOM	Remarks and description of the feature.

Table 2.5: Object attributes used in HOB files for junctioning with Lidar data.

For more information about the inclusion and treatment of Lidar items in the Composite Source, refer to section 2.2.1 and 3.5.5.1 .

### 2.2.2.4 Prior Surveys

The Project CD/DVD will include the Descriptive Report raster images of the smooth sheet, features and soundings (in .000 format) for all available prior surveys in the assigned area.

### 2.2.2.5 Survey Request Information

The OPS Project Manager or the NRB Technical Assistant will include, if available, copies of documents from the maritime community, research groups, or other entity requesting the survey on the Project CD/DVD.

### 2.2.2.6 Tides

The Project CD/DVD will identify vertical control requirements for a project. Vertical Requirements which are further explained in sections 2.4.4 & 3.5.2 , could consist of traditional tidal zoning, TCARI, VDatum, constant separation value, or ellipsoidally referenced zoned tides (ERZT). The Project Instructions will explicitly list any required subordinate tide gauges. A VDatum or constant separation file to correct soundings from the ellipsoid to chart datum will be provided on the project CD/DVD. For ERS vertical datum QC procedures, refer to chapter 9 of the HSSD.

The NOAA Center for Operational Oceanographic Products and Services (CO-OPS) provides three basic types of water level data, “predicted tides,” “preliminary water levels” and “verified water levels” referenced to MLLW or other appropriate chart datum. All of this data can be downloaded from the CO-OPS website. Typically, CO-OPS posts preliminary water level data within a few hours of data acquisition. Stations included on the Hydro Hotlist (see section 3.5.2.3.1) are processed weekly and verified water level data is typically available at the start of the following work week. Verified tides can be downloaded from the CO-OPS Data Retrieval website:  
<http://opendap.co-ops.nos.noaa.gov/axis/text.html>

The CO-OPS Hydro Planning Team (HPT) also supplies discrete zoning or TCARI to estimate water levels across the entire survey area where the water level characteristics may vary from those where tide gauges are located. Historical water level station information, including the location of each station site, benchmark description and elevations, and historical datum references will also be provided if historical tide stations need to be reoccupied.

Predicted tides using 6-min format will be supplied on the Project CD/DVD.

#### **2.2.2.7 Orthoimagery**

The hydrographer may request orthoimagery for a project if considered necessary to support pre-survey planning and post processing. Examples may (but are not limited to) include areas where there are drastic differences from the shoreline features in the CSF to the real world features. In these cases the hydrographer should contact the project planner from HSD or NRB which is listed in the project instructions to request approved orthoimagery. The project planner will work with the HSD OPS Team Lead and RSD to acquire the approved orthoimagery if available. Note: Orthoimagery is for reference only and shall not be used as source for surveying (i.e. digitizing features from orthoimagery is not allowed).

### **2.3 Additional Resources**

Although the majority of information required to conduct an OCS hydrographic survey will be provided on the Project CD/DVD, additional resources such as training or reference materials may be necessary throughout a field unit’s operating season.

#### **2.3.1 Hydrosoft Website**

The Hydrosoft website, <https://inside.nos.noaa.gov/hydrosoft/welcome.html>, is maintained by OCS’s Hydrographic Systems and Technology Program (HSTP) and provides an extensive amount of reference materials to the field. A Site Download option will be made available at the beginning of each field season to download the entire Hydrosoft website via a zip file. Additionally, the Recent Updates page lists all the changes that have been made in reverse chronological order.

The following types of materials can be found on the Hydrossoft Website:

- Common survey software packages and applications, both commercial and in-house.
- Software and hardware manuals and guides.
- NOAA hydrographic training presentations and resources.
- Nautical and navigation reference materials (e.g., Bowditch, Coast Pilot, Chart 1).
- NOAA Hydrographic survey references (e.g., HSSD, FPM, IHO documents).

## **2.4 Project Preparation**

Once a field unit has received the Project CD/DVD, survey personnel should begin preparatory tasks such as reviewing project information, establishing a data management plan, contacting constituents, and planning horizontal and vertical control if necessary. These tasks are typically performed on a project-wide basis, prior to individual survey planning.

### **2.4.1 Project Information and Instructions**

As soon as practicable, the field unit should inventory files provided on the Project CD/DVD to verify that all necessary information has been included. Once it has been confirmed that all files are present, project information should be copied to the field unit's computer systems in accordance with the unit's standard data management practices. The OPS Project Manager or the NRB Technical Assistant will deliver draft Project Instructions approximately two months prior to the start of a project. The Field Operations Officer and Chief Hydrographic Surveyor should review the draft Project Instructions to raise questions and concerns with HSD OPS or NRB at this time. Once the final Project Instructions are delivered (approximately one month prior to the start of a project) all appropriate hydrographers should review the Project Instructions and Project CD/DVD files to become familiar with the project.

### **2.4.2 Data Management**

Guidelines for effective field unit data management are described in the following sections.

#### **2.4.2.1 Digital Data Directory Structure**

Data directory structures used during acquisition and processing may vary among field units. However, a standard should be in place within each field unit. It is important to adhere to any field unit directory standards, as some software configurations must reference specific directories. Refer to Appendix II for an example of a field unit directory structure.

### **2.4.2.2 Digital File Naming Conventions**

It is important to follow file naming standards within the field unit. Maintaining these conventions greatly assists AHB and PHB in identifying data records. Do not create data files with non-standard names that are unrelated to the file content and will confuse others who must access that data. Additionally, any preliminary, temporary, or extraneous files created by the field unit should not be included with data submitted to AHB or PHB.

### **2.4.3 Horizontal Control**

Horizontal Control (HorCon) refers to the terrestrial network of geodetic marks that support two-dimensional hydrographic positioning. Typically, NOAA field parties use USCG differential beacons to correct GPS for hydrographic positioning. USCG differential correctors are subjected to an internal quality control process, ensuring a stable meter-level service. Additionally, USCG differential beacons are precisely positioned; thus, it is generally unnecessary for NOAA field units to establish horizontal control points when using this positioning method.

In remote survey locations or confined areas such as a fjord, USCG differential correctors may be unavailable or severely limited. For these areas, the field unit shall establish at least one horizontal control point where a portable DGPS control station can be installed. A review of the survey area should be combined with local knowledge to determine a feasible location. Keep in mind that public properties are usually preferred over private properties because special permissions will typically not be necessary for future access. However, equipment security must also be considered in populated areas which are easily accessible. Security measures may include locking instruments, affixing owner identification to equipment, and choosing a discrete station location. After a suitable location has been chosen, the field unit should obtain permission to access the property and install HorCon equipment. If it is necessary to drill into rock during the installation, permits should be obtained for this purpose.

The Federal Aviation Administration's Wide Area Augmentation System (WAAS) may be used provided a QC procedure is followed as per Section 3.2.2 of the HSSDM.

HorCon techniques may also be used to determine high accuracy DGPS positions for ATONs. If OCS's Update Service Branch requires that an ATON be positioned using high accuracy HorCon methods, specifications will be noted in the ATON information provided on the Project CD/DVD. Typically, higher order ATON positions will be required for range lights.

### **2.4.4 Vertical Control**

Vertical control refers to a network of geodetic marks that supports three-dimensional hydrographic positioning. Vertical control activities are typically conducted to support water level gauge installations, water level measurements, and ERS. Personnel from CO-OPS are responsible for all planning of tide and water level requirements for OCS hydrographic surveys. CO-OPS will analyze historical data and tidal characteristics for each project area, specify operational NOS control stations, specify general locations for subordinate water level stations to be installed, and provide the tidal zoning (both preliminary and final) to be used during survey operations.

Installation, operation, and maintenance of controlling water level stations is typically the responsibility of the CO-OPS Field Operations Division (FOD). However, the hydrographic field unit may be required to install, monitor, repair, and/or uninstall a control water level station under the instructions of the CO-OPS FOD. The Project Instructions will state if installation, operation, and/or removal of subordinate water level stations is

required for a project. In such cases, FOD will work in collaboration with the field unit to complete these tasks. The field unit will be responsible for ellipsoidal positioning of benchmarks near subordinate water level stations, in accordance with section 4.2.5 of the HSSD.

To prepare for vertical control operations, the field unit should verify that all necessary equipment and tools have been obtained from CO-OPS. The following manuals should accompany the equipment received from CO-OPS FOD:

- Portable Tide Gauge Setup, Configuration, and Data Export Procedure
- 9210B Xlite Data Logger Operations and Maintenance Manual
- Paros User's Manual
- Satlink2 Operations and Maintenance Manual
- H-355 Pump User's Manual

A sample equipment checklist for water level station installations is included in Appendix 2 (Wtr\_Lvl\_Statn\_Equip\_Checklist.pdf). Several reference guides are available to assist the field unit with water level station procedures. For reference, the following manuals can be found on the Hydrosoft website and can also be downloaded from the CO-OPS website [tidesandcurrents.noaa.gov/pub.html](http://tidesandcurrents.noaa.gov/pub.html)

- NOS User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations.
- Specifications and Deliverables for Installation, Operation, and Removal of Water Level Station
- CO-OPS User's Guide for Electronic Levels
- CO-OPS User's Guide for Writing Bench Mark Descriptions
- CO-OPS User's Guide for GPS Observations

Additionally, the field unit should review any subordinate water level station locations specified in the Project Instructions and, if necessary based on local knowledge, recommend alternate sites to CO-OPS. Keep in mind that public properties are usually preferred over private properties because special permissions will typically not be necessary for future access. However, equipment security must also be considered in populated areas which are easily accessible. Security measures may include locking instruments, affixing owner identification to equipment, and choosing a discrete station location. Once locations have been agreed upon, survey personnel should obtain permission to access the property and install the staff, benchmarks, and gauge at the selected site.

#### **2.4.5 Constituent Contact**

The Project Instructions will list constituents who must be contacted at or near the beginning and end of field operations to discuss survey objectives and accomplishments. It is mandatory that the field unit contact the appropriate regional NOAA Navigation Manager as identified in the Project Instructions.

The Project Instructions will also list various local contacts for reference. These resources should not be overlooked and can often provide local knowledge regarding AWOIS items, shoaling, marine activities, traffic patterns,

and other areas of concern. Local information sources include Port Authorities, Pilot Associations, local ferry companies, fishermen, towing companies, U.S. Coast Guard, U.S. Army Corps of Engineers, and local and state government agencies. Information regarding local survey requests or charting concerns that will not be addressed during the current project should be conveyed to either the Chief of Operations or the Chief of NRB.

#### **2.4.5.1 Local Notice to Mariners Announcement**

Prior to commencing survey operations for a project, the field unit shall submit an announcement to be included in the USCG Local Notice to Mariners (LNM). At a minimum, this announcement should be submitted 2-weeks prior to commencing operations and include information about the project work area, the type of work being conducted, the field unit characteristics (e.g. size, color, markings of ship and launches), means of contacting the field unit, and the start and end dates of the survey. These announcements can be submitted via e-mail to the appropriate USCG District e-mail, which are listed in the LNM for each district (<http://www.navcen.uscg.gov/?pageName=lnmMain>). See Appendix 2 for an example of a LNM announcement.

#### **2.4.5.2 Cultural or Historic Submerged Features**

HSD Operations Branch will contact the State Historic Preservation Officer (SHPO), historical/archaeological contact at NOAA's Office of National Marine Sanctuaries (ONMS), or other relevant governmental agency during preparation of Project Instructions to request information on any historically significant man-made features on the seabed within the survey area. Information provided by these Historic Preservation Points of Contact (HPPOCs) will be included in the Project Instructions. While the Project Instructions will also include contact information, field units are generally not required to consult with the HPPOCs. Instead, the Hydrographic Processing Branches are responsible for contacting the HPPOCs in the event of discovery of a potentially historically significant man-made feature, in accordance with section 4.4.3 .

#### **2.4.5.3 Potential for Lost or Damaged Fishing Gear**

In many areas, particularly the Northeast United States, field units may encounter significant densities of fixed or floating fishing gear; such as lobster pots, crab pots, fishing pots, long lines, gill nets, etc. NOAA field units should always attempt to minimize the impact of hydrographic survey operations on the commercial fishing industry. There is an expectation that Coast Survey and all field units will make every effort to prevent damage or interaction with fishing gear. However, if damage does occur, State agencies may not detain or prosecute a Federal employee for violation of State law. For example, it is a violation of Massachusetts law if someone destroys any lobster or other fishing gear and can be punished through a fine or imprisonment; however, if they are engaging in an activity authorized by the Federal law (e.g. conducting survey operations), then they cannot be detained. See Appendix 2 for a legal opinion from NOAA's Office of General Counsel.

When operating in areas with high densities of fishing gear, field units should consider modifying survey operations to reduce the possibility of damaging fishing gear and survey equipment. Some steps that may be taken in areas of dense fishing gear include:

- Limiting survey operation to daylight hours.
- Utilizing survey launches instead of the ship to conduct operations.
- Utilizing hull-mounted sonar systems instead of towed survey gear.
- Limiting use of towed sensors such as Moving Vessel Profilers

In an effort to be pro-active and incorporate better coordination, the Operations Branch will contact fishing and lobster associations and organizations to inform them, prior to the field season, where a NOAA survey vessel will be working and the approximate time frame. This notification will be completed via an official letter to the association president or other point of contact. The Navigation Manager for the region and field unit should be carbon copied on this letter. See Appendix 2 for an example of a notification letter.

A mandatory point of contact will be listed in the Project Instructions for projects which have the potential to significantly interfere with the work of local fishermen/lobstermen. In those cases, the field unit must use that point of contact to solicit input and coordinate with the local fishermen/lobstermen in an effort to reduce possibility of fishing gear interaction and better plan survey operations.

Additionally, the Navigation Manager or field unit will submit an announcement of the survey project for inclusion in the USCG (LNM) as early as is practicable (usually as soon as Project Instructions are received). See section 2.4.5.1 for information on submitting announcements. These announcements should also be provided directly to the fishing or lobstermen association for distribution to their members and inclusion in their newsletters. Notices should not only be sent to associations operating in the region the survey operations are being conducted, but also adjacent associations, as they will likely have some overlap.

While field units will make every effort not to cause damage or otherwise interfere with fishing gear, some entanglements and other damage may occur. In instances where fishing gear has been damaged local fisherman or lobstermen may make a claim regarding lost or damaged fishing gear and request compensation. The claims process for damaged fishing gear that may have been damaged by a NOAA hydrographic survey field unit is listed below:

1. Initial claims of gear interaction may be received from the fishermen by the field unit, the USCG, or the State Marine Patrol. Claimants will typically be referred to the State Marine Patrol as the best point of entry into the process. Note that NOAA hydrographic survey field units are not authorized to collect sworn statements, so whenever possible claimants should be referred to a law enforcement agency.
2. State Marine Patrol and NMFS Office of Law Enforcement special agents will collaborate to collect sworn statements from affected fishermen, depending on whether alleged loss occurred in state or federal waters. At a minimum, claims need to give the location of gear lost, estimate of when it was lost, what was lost, and the fair market value.
3. All completed claims will be routed from NMFS OLE special agents to the regional NOAA Navigation Manager.
4. The Navigation Manager will request route data from the field unit, and compare the positions and times of the alleged loss with the unit's activities. The Navigation Manager may request assistance from the local NOAA Fisheries lab to determine if fair market value claimed for lost gear is reasonable.
5. The Navigation Manager will forward substantiated claims to NOAA Office of General Counsel for final certification and payment. See Appendix 2 for an example letter for reimbursement. Unsubstantiated claims will be referred back to the State Marine Patrol and NMFS OLE with supporting documentation.
6. OCS and OMAO leadership will determine how costs of any claims will be shared.

## **2.5 Survey Planning**

OCS recommends that systematic data acquisition plans be prepared prior to vessel operations. These plans may consist of lines used directly for vessel navigation, polygons used to designate survey areas if the acquisition software provides a real time coverage map, or target files used to mark pre-determined data acquisition points.

When creating data acquisition plans, many factors must be considered, including the scope of the survey, object detection criteria, sheet layout with respect to surrounding features, available data acquisition systems, number of features to be addressed, traffic patterns, local currents, tide stages, and prevailing weather and sea conditions. Input from other survey personnel, particularly those who have previously operated in the area, can be invaluable when creating data acquisition plans. Proposed plans should be reviewed by the FOO and/or Chief-of-Party prior to vessel operations.

### **2.5.1 Survey Scope**

The scope of an OCS hydrographic survey will be categorized as basic hydrographic, navigable area, field examination, or special project. Survey requirements will vary according to this classification. The type of survey to be conducted and any special requirements will be identified in the Project Instructions.

The type of specific hydrographic survey projects are created via an evaluation of known requirements and priorities. Survey limits are based on these requirements and priorities as well as quantitative and qualitative measures of shipping and boating in an area, the adequacy of existing survey information in the area, the rate of change of the bathymetry, safety precautions and an assessment/weighting of benefit versus efficiency.

#### **2.5.1.1 Basic Hydrographic Surveys**

A basic hydrographic survey must be able to stand alone, without supplementation by any other survey. The basic survey must be adequate to supersede all prior surveys for charting purposes and meet all applicable survey requirements specified in HSSD.

#### **2.5.1.2 Navigable Area Surveys**

Navigable area surveys must meet the requirements of basic hydrographic surveys, but will have special survey limits defined in the Project Instructions. Typically for this type of survey, the limits have been restricted to omit areas that are not considered navigationally significant. Another scenario would be restricting the survey to primary shipping traffic areas. Assigned survey limits may require adjustment based on safety and field unit observations of local traffic patterns. Any significant survey limit adjustments shall be coordinated through the Chief of OPS.

#### **2.5.1.3 Field Examinations**

Field Examinations (FE) are item investigations or surveys that cover small areas of specific interest. These surveys may be assigned to prove/disprove the existence of reported dangers or obstructions, to provide data for harbor development, or to supplement prior surveys for construction of large-scale charts.

#### **2.5.1.4 Special Projects**

Special Projects are surveys typically performed for purposes other than creating nautical charts, such as habitat mapping, ocean exploration, or homeland security. The Project Instructions will define requirements for Special Projects.

Note: Depending upon the type of project, data acquired for Special Projects may be subject to additional security measures. Any required security practices will be defined in the Project Instructions. The field unit should use discretion when handling Special Project data and contact the Chief of OPS or Chief of NRB if data security requirements are in question.

#### **2.5.1.5 Homeland Security Surveys**

Homeland security surveys may be assigned in response to requests by the US Naval Oceanographic Office (NAVOCEANO) for hydrography to support Homeland Security in the nation's coastal waterways. These projects are typically 200% side scan sonar surveys conducted in accordance with NOS requirements for SSS data acquisition and processing with minor modifications. Any additional project specific requirements will be provided in the Project Instructions. In the event that it is not possible to adhere to the HLS specifications, Chief, HSD Operations Branch should be contacted for further guidance.

Special attention should be given to setting up survey plans and file structures when a survey area contains a region to be submitted for Homeland Security purposes. Careful advance planning will ensure that the relevant Homeland Security survey data and associated ancillary files will be easily extractable for submission to NAVOCEANO.

#### **2.5.2 Object Detection Criteria**

Unless otherwise specified by the Project Instructions, all data acquisition shall be conducted to meet object detection criteria as set forth in the HSSD; this may be accomplished with SSS, MBES, or a combination of the two. Object detection capabilities are dependent upon the acoustical characteristics of the sonar system. Vessel speed versus sonar pulse repetition rate (ping rate) must also be considered in order to meet coverage requirements in the along track direction. Standards set by OCS for object detection vary depending on sonar technology and requirements for each sonar type are discussed individually below.

##### **2.5.2.1 Side Scan Sonar (SSS)**

The HSSD states that side scan sonar systems shall be operated such that a 1m x 1m x 1m object on the sea floor can be detected from acoustic shadow measurements. OCS has determined that this object detection criteria can be met by acquiring a minimum of 3 independent ensonifications (pings) per meter traveled in the along-track direction. This criterion can be met by regulating vessel speed based on sonar range scale. Longer operating ranges have slower pulse repetition rates, thus requiring that the vessel speed be slower to meet object detection requirements. Refer to sections 6.1.2 and 6.1.3 of the HSSD for further guidance on side scan object detection standards. Sonar ping rates should be defined in the operator's manual or the manufacturer's technical documentation.

### **2.5.2.2 Multibeam Echosounder (MBES)**

Multibeam echosounder object detection criteria vary according to water depth. Adequate detection has been defined by OCS as 3.2 beam footprints, center-to-center, per 3 meters (in depths of 40 meters or less) or a distance equal to 10 percent of the depth (in depths greater than 40 meters). In the along track direction, this criterion can be met by regulating vessel speed based on sonar range scale, which directly affects ping rate. Since the size of MBES beam footprints will be greater as the angle from nadir increases, object detection capabilities should be calculated based on outer beams. Field personnel should refer to section 5.2.2 of the HSSD for further guidance on multibeam object detection standards. Sonar ping rates should be defined in the operator's manual or the manufacturer's technical documentation.

### **2.5.3 Survey Line Planning**

Before creating a line plan, the Project Instructions should be reviewed for any required methodology, line spacing, or coverage requirements. Besides Project Instruction requirements, factors such as general bathymetry, traffic patterns, shoreline features, currents, prevailing weather and sea states, and distance from GPS base stations should also be considered during line plan creation. New features discovered during operations may warrant additional adjustments to line plans as the survey progresses. It should be noted that survey limits are subject to revision based upon command decision and/or requirements for safe vessel operation. Any significant survey limit adjustments shall be coordinated through the Chief of HSD Operations Branch.

Safety should never be compromised for the sole purpose of following a line plan. Line plans used for data acquisition can be classified into the following categories:

- Mainscheme (MBES, SSS, or VBES)
- Holidays (MBES, SSS or VBES)
- Crosslines (MBES or VBES)
- Developments (MBES or VBES)
- Target Files
- Special Circumstances

Acquisition requirements vary depending upon data category and the type of equipment used. OCS recommends that field units standardize survey line numbering such that data classification can be determined based upon line number. For example, use the 100 number series for the first 100% of side scan sonar lines; the 200 number series for 200% side scan numbers; the 300 number series for side scan holidays lines; the 400 - 500 number series for mainscheme multibeam lines; the 600 - 800 number series for development data; and the 900 number series for crosslines. Specific line numbering standards have not been implemented by OCS; however, standardization within each field unit is strongly recommended.

Line plan requirements and guidelines for each data category are discussed in the following sections. Keep in mind that these guidelines are provided to help the field unit maximize survey efficiency, but they should not be followed at the expense of personnel and vessel safety.

### **2.5.3.1 Mainscheme**

Mainscheme refers to the primary survey data that are systematically acquired to meet basic survey requirements. Mainscheme data are typically comprised of complete or object detection MBES data or 200% SSS imagery data acquired simultaneously with VBES bathymetry. However, in some circumstances variances such as a combination of complete multibeam and 100% side scan data may be preferred.

When planning mainscheme lines, special consideration should be given to junction areas. For surveys that are part of the same current project and from the same year, data overlap in junction areas shall be sufficient to ensure continuous coverage. To adjoin with a non-contemporary survey from a different year and possibly conducted by a different vessel, a 100-200 meter overlap of mainscheme data is required, unless the Project Instructions and provided project limits indicate otherwise.

#### **2.5.3.1.1 Multibeam Echosounder (MBES)**

When planning mainscheme MBES lines, the hydrographer must consider object detection requirements, echosounder system, and water depth. If complete coverage is desired, line spacing will vary according to the effective swath width. The available swath width will vary between systems, but object detection requirements may require data filtering by swath angle or could even limit the types of sonars which may be used. Generally, lines should be oriented parallel to depth contours for consistent swath widths and line spacing. The following formula can be used as a general rule of thumb for determining swath width:

Available Swath Width = 2 x Water Depth x (tangent 1/2 swath angle)

The hydrographer should keep in mind that allowing for adequate data overlap when planning mainscheme lines can significantly reduce the number of holidays created during acquisition. Based on the above formula and collective OCS experience, mainscheme line spacing is commonly set at 3 x Water Depth to obtain complete coverage.

In special cases, partial MBES coverage may be used for mainscheme survey data. This type of coverage might be assigned if time is limited and existing survey data are fairly modern. In such cases, required line spacing will be noted in the Project Instructions. For further information on MBES requirements for OCS surveys, see section 5.2.2 of the HSSD.

#### **2.5.3.1.2 Side Scan Sonar (SSS)**

Typically, two-hundred percent coverage is required when using SSS as a mainscheme survey technique. One hundred percent coverage is completed by acquiring data that meet the assigned object detection requirements over the entire survey area one time. This process is performed a second time to obtain two-hundred percent coverage. Side scan sonar data quality will, inherently, degrade both at nadir and at outer ranges. Because of this characteristic, line plans for the second hundred percent should be either offset or oriented differently than the first hundred percent. OCS recommends offsetting 200% lines by ½ of the line spacing for the first 100% coverage. If possible, SSS data should be acquired by running lines perpendicular to depth contours to avoid imagery distortion caused by slopes in the athwartships direction.

Note: Multibeam backscatter imagery is not considered equivalent to, or a replacement for, side scan sonar imagery. Side scan sonar provides low grazing-angle imagery that enables identification of features not visible in lower resolution, higher grazing angle MBES backscatter imagery.

The line spacing necessary to obtain 100% SSS coverage is dependent upon the effective range scale, achievable positional accuracy, and any positioning errors inherent to a towed system. A good rule of thumb to obtain complete coverage is to plan survey line spacing at 1.6 x Range Scale, allowing for an overlap of 40% of range scale (20% of the total swath) between adjacent swaths. Note: Range Scale refers to the athwartships distance ensonified on each side of the towfish. Thus, Range Scale equals one half of the total swath ensonified.

Generally, SSS range scale is chosen for maximum survey efficiency. The sonar should be maintained at an altitude of 8 - 20% of range scale during acquisition; thus, water depth will determine an upper range scale limit or a particular survey area. However, the hydrographer should also consider the system configuration and if a minimum sonar depth will be necessary to avoid water column disturbances such as propeller wash. Based on the chosen range scale's corresponding ping rate, vessel speed should be adjusted to ensure that object detection criteria are met (see section 2.5.2.1 ). If a specific range scale is required for a survey, it will be indicated in the Project Instructions.

### **2.5.3.1.3 Vertical Beam Echosounder (VBES)**

Since complete coverage can not be efficiently completed using VBES alone, this will rarely be assigned as the sole method for acquiring mainscheme survey data. Typically, VBES systems will be used to provide correlating sounding data for SSS operations, define an inshore contour, or develop very shoal or foul areas where there is a high probability of damaging either a MBES or SSS system.

If VBES has been assigned as a stand-alone mainscheme data acquisition method, the required line spacing will be noted in the Project Instructions. If possible, VBES mainscheme data should be acquired by running lines perpendicular to depth contours. This practice assists the hydrographer in accurately identifying contour intervals. If extensive discrepancies are found between VBES sounding data and charted depths, the Chief of OPS or Chief of NRB should be contacted to determine if a more extensive survey is warranted.

### **2.5.3.2 Holidays**

Holidays are defined as gaps in mainscheme data or areas where accuracy requirements have not been met. Holidays may be caused by various events, such as vessel maneuvering, survey equipment problems, unexpected shoals, or rejection of poor quality data during post-processing. Holiday line plans are typically developed to address these data gaps as mainscheme acquisition progresses, rather than at the end of mainscheme operations. This practice will minimize transit time required to revisit each area of the survey with a holiday and the time required to acquire, process, and manage additional sound speed profiles. If the field unit uses a real-time coverage map during mainscheme data acquisition, most holidays can be identified and addressed prior to ceasing operations that day, thus increasing survey efficiency.

### **2.5.3.3 Crosslines**

Crossline data are used to identify any systematic data problems by comparing it to mainscheme data acquired at different times, water levels, and line azimuths. Separate vessels may also be used for crossline data acquisition to help identify any vessel to vessel system biases.

Ideally, crosslines should be acquired prior to mainscheme data, in areas of gently sloping bottom, and when water levels are as close to survey datum (MLLW) as practicable. Crossline data may not agree well with mainscheme soundings if acquired in areas of irregular submarine relief and/or if VBES systems are used. In rocky areas, large

depth differences may occur over small horizontal distances, making a small positioning error appear to be a large depth error. This effect is often noted when using VBES systems due to the large beam footprint.

#### **2.5.3.4 Developments**

A development is performed to either obtain a least depth over a known point feature or further define an area based feature such as a shoal. Typically, dense MBES data are acquired for developments, although multiple VBES lines may be more appropriate for defining very shoal area features due to the significant decrease of MBES efficiency in such depths. If a VBES system is used to determine the least depth on a point feature, several parallel lines should be run over the feature until the hydrographer is confident that the least depth is recorded. A third method for determining a feature's least depth is by diver investigation. The process of using a diver least depth gauge is discussed in section 3.2.5 For additional information on feature investigation, refer to section 4.4. Note: Conducting developments during high stages of tide will improve MBES efficiency and may also provide increased vessel safety by maximizing underkeel clearance. If development lines are created to be run during a specific tide range, the hydrographer must be certain to convey this information to the vessel crew that will be acquiring the data.

When developing point features, least depths should be acquired using the center region of the MBES swath, typically 45° or less off nadir. This section of the MBES swath will have less error due to refraction than the outer beams. It is recommended that, during development acquisition, a confidence swath be run in an orthogonal direction to the primary development lines. A common MBES development line plan may appear to be an assortment of “H” or “+” patterns over numerous features.

#### **2.5.4 Survey Polygon Planning**

Most field units will be equipped with data acquisition software that allows the sonar operator and the coxswain to view a real-time coverage DTM of the data being acquired. As an alternative to line planning, which is most often redundant with this software capability, polygons that define areas to be covered are created by the sheet manager. While the entire area could just be covered with a continuous line, polygons provide the hydrographer with discreet sections to be covered assisting in better plans for survey timing and vessel efficiency. Most of the guidance that applies to line plans also applies to polygon planning. The data should still be acquired with the boat traveling parallel to the contours.

- Polygons should be planned such that the boat will be running offshore to nearshore. This is a safety tip! Creating separate offshore and onshore polygons (those that can be run at any time vs. those that need a specific tide window) is also helpful.
- Make polygons longer in the dimension the boat should run, providing a clear indication to the coxswain and surveyor of the polygon's directionality. (If running N to S will be most efficient with the contours, make your polygon longer in the N to S dimension).
- If there is a MHW Buffer, a limit line that defines the shoal edge of the survey (survey to the 4 meter curve) or a NALL established during shoreline verification, do not plan polygons inshore of these limits unless there is a specific reason to do so.
- In a channel that could be filled in with one polygon (shore to shore), consider breaking it down into two polygons such that there is a straight edge in the middle of the channel. This provides the vessel with a straight baseline, and encourages running from offshore to nearshore.

- Set polygons up in such a way that turns are minimized and lines are of a manageable length for processing.
- Be aware of any possible sources of fresh water, or other factors that will affect the water column and make smaller polygons in these areas.

#### **2.5.4.1 AWOIS Items**

For all assigned AWOIS investigations, the entire search radius shall be investigated if possible, regardless of its position relative to the survey limits. Specific investigation methods considered adequate for an item's disproof will be noted in the attributes of the placeholder AWOIS feature, CRANES. Often, AWOIS items can be investigated in conjunction with mainscheme data acquisition.

Note: If the entire search radius is not investigated, it is nearly impossible to disprove an AWOIS item.

#### **2.5.4.2 Target Files**

Target files refer to a collection of geographic positions designated for point data acquisition. These files are typically created to designate specific positions for acquiring other types of data. For example, the hydrographer may create a target file to show the specific position where a sound velocity profile is desired or specific locations of items to be developed.

##### **2.5.4.2.1 Bottom Samples**

Samples of bottom sediment throughout the survey area shall be obtained and analyzed in accordance with the HSSD, if required by the Project Instructions. A bottom sample plan is compiled by the HSD Project Manager and delivered to the field unit in the Project Reference File (PRF) using the S- 57 Object Class, 'SPRING'. The field unit should review the bottom sample plan to the survey data acquired (bathymetry and backscatter) to determine if the bottom sample locations are appropriate. The survey data will often better differentiate varying bottom characteristics within the survey compared to the bottom sample plan. The field unit should contact HSD Operations Branch to discuss modifying the plan if needed.

#### **2.5.4.3 Special Circumstances**

##### **2.5.4.3.1 Search Patterns**

In emergency or accident situations, NOAA field units may be involved with wreck, obstruction, or debris searches. When planning this type of operation, the direction of the search pattern should be oriented within 20° of the set of any significant current present in the survey area. This arrangement will minimize towfish offset from the planned tracks, increase position accuracy, and increase towfish stability by minimizing forces that are not aligned with the longitudinal axis of the towfish. However, tracks run in the same direction as a very strong current may result in an increased speed over ground, which could decrease object detection capabilities; thus, this parameter should be monitored if searching for small objects. If strong currents exist in the area and running search tracks in a pattern oriented normal to the current is unavoidable, the operations should be timed to coincide with periods of slack or minimum current, if possible.

#### **2.5.4.3.2 Special Wreck Investigations**

If a hydrographic field unit discovers a potentially significant historic wreck site, or conducts a special wreck investigation through a contract from another NOAA program or a request from a NOAA Navigation Manager, the field unit should make an effort to ensonify the wreck site and associated debris field with each type of sonar system that is readily available. When conducting side scan sonar operations, run parallel tracks on either side of the wreck, so that both sides are imaged, as well as two additional tracks orthogonal to the site. The imagery and bathymetry data will provide clues to the wreck's status and identity, identify any obstructions, and provide researchers with an adequate baseline assessment with which to compare future surveys.

#### **2.5.5 Survey Plan Finalization**

Proposed survey acquisition plans should be reviewed by the FOO and/or Chief-of-Party and any necessary adjustments made. Once approved by the Chief-of-Party, the plan should be converted from the format generated by the GIS software used to design the plan to a format that can be read by the field unit's survey navigation software. Typically, acquisition plans will be designed using CARIS Notebook or Bathy DataBASE software for polygon planning or MapInfo software for line planning. The MapInfo files are converted into a HYPACK line file (\*.lnw) or HYPACK target file (\*.tgt) for vessel navigation. This specific conversion process can be accomplished using the Hydro\_MI.mbx MapBasic tool, which will also report the number and the total mileage of the planned lines. Number and mileage statistics should be recorded and used to estimate the amount of time required to complete the survey. These estimations are critical to overall project planning.

#### **2.5.6 Preparing the Survey Crew**

The Survey Manager will provide a boat sheet to the survey crew(s) with a plot depicting line plans, polygons, and/or shoreline files overlaid on the largest scale chart with any uncharted hazards, lines planned for acquisition during high tide or slack current, AWOIS items, contacts, and/or developments prior to each survey day.

# Chapter 3

## Data Acquisition

### 3.1 Sensor Risk Management

NOAA field units deploy valuable oceanographic sensors in the water when conducting hydrographic surveys. The sensors are typically deployed in a variety of ways including: mounted directly on the hull of the survey vessel, suspended in the water by mounting them to a rigid retractable pole, towed via a cable, and temporarily installed on shore.

#### 3.1.1 Best practices for preventing loss of equipment

The utmost care should be taken to prevent the loss of a hydrographic sensor prior to its deployment. This is accomplished through regular inspection of all key components of survey systems, proper preventative maintenance, safe operation procedures, and adequate precautionary measures to aid in recovery if a loss does occur.

All mounting hardware should be inspected regularly (weekly inspections are recommended) for defects or potential loosening. It is useful to mark mounting hardware, such as screws and bolts, with a reference mark to indicate whether the fasteners are backing out and becoming loose. Components that are susceptible to degradation in marine environments such as rubber isolation mounts or metal fasteners prone to oxidation should be checked regularly for material condition. Routine inspection of mounting hardware and components for any sensor system should have an established inspection schedule that is determined by the likelihood of system loss. A period of no more than 1 week between inspections is recommended.

If available, safety devices designed to prevent the loss of a sensor (i.e. a safety cable attachment) or aid in the recovery of a sensor (i.e. a pinging locator beacon) should be used at all times. These devices and associated components should be checked regularly (weekly inspections are recommended) for material defect, damage, or disengagement of fastening components. In the case of a system that is deployed over the side and is not statically mounted, the safety system should be checked before every deployment of the sensor. Fixed mounted sensor's safety systems should be checked on a regular basis in the same manner as the mounting hardware.

If possible, the sensors should be stowed for transit (i.e. SSS tow-fish secured on deck, swing arm multibeam in the retracted position, etc.) when not in use.

Whenever the launch is operating with sensors in the water (which may be at all times in the case of a fixed mount sensor array) the sensors should be operating and the vessel's navigation system should be recording data. If the sensor is not operational and not being actively monitored, the loss could occur without being noticed. Additionally, an accurate position for the vessel at the time of loss is extremely important in locating the sensor if a loss should occur.

Dual frequency GPS base stations may be installed for up to 30 days in a variety of locations. Once installed it is important to ensure that the antennae are not disturbed or moved for the duration of deployment. Antennae should be secured in such a way that wind and rain or snow events will not move the antennae. GPS receivers as well as batteries and radio electronics should be enclosed in a weather proof, locking case. Care should be taken to stage this equipment in secured areas (whenever possible) to prevent vandalism or theft. If the base station is installed in a remote location, the user should be aware of natural conditions (such as wildlife) that may disturb the installation and take action to prevent damage or loss.

### **3.1.2 Best practices for recovery of lost equipment**

While the guidance outlined in section above are intended to prevent sensor loss, a loss may still occur. In the event of a sensor loss, the probability of recovery can be maximized by (1) rapidly informing the ship of the potential loss, (2) determining if the sensor might still be connected to the launch, (3) determining an accurate and precise location where the loss occurred, and (4) utilizing all available search and recovery means to locate the sensor as soon as possible. Details for each item are below.

Once a loss is suspected, the entire survey crew should be informed so that appropriate action can be taken. The ship should be notified immediately as they can provide additional guidance on the proper course of action and dispatch assistance. The loss of a sensor with mountings that go through the hull could represent a catastrophic failure in hull integrity. It is important that other vessels be made aware of the situation so that response can begin immediately.

The vessel should immediately come to a gentle stop as the sensor may still be attached by a safety tether or electrical cabling. The vessel should avoid transiting at speed until it is confirmed that the sensor is not still attached. If possible, divers should enter the water and examine the sensor mounting to determine if the sensor is still attached by any means. If the sensor is held in place by cabling or a safety tether, it should obviously be retrieved. However, if retrieval is not feasible (i.e. dangerous conditions, insufficient equipment, etc.) or is determined to be too risky (i.e. launch is in water too deep for dive recovery if the sensor should become disconnected) then the dive team should secure it as best as possible and the launch should make its way at slow speed to a more appropriate recovery location (i.e. the ship or shallow water). If it is not possible to use divers to investigate, the launch should transit at slow speed back to the ship or other area of safety, where an inspection of the sensor mounting can be performed.

As soon as a loss is suspected, the position of the survey launch should be marked in the acquisition system if possible or noted via GPS coordinates or, at the very least, roughly plotted on a chart. A successful recovery of the sensor is dependent on having an accurate location to begin the search. Marking this location, even if approximate, at the time of the loss will greatly increase the chances of locating the sensor subsequent to its loss.

Alternately, if the navigation data was logged, the position for loss can likely be determined through analysis of the data. For instance, logging POS data throughout the day will allow post processing in the POSpac software suite to generate a smooth best estimate of trajectory (SBET) for the launch, which will provide an extremely accurate track-line. If the sensor package was recording at the time of loss, the exact time of disconnection should be easily determined and coupling this time with the accurate track-line data for the launch will result in an exact position for sensor loss. If the sensor was not recording when lost, it is still possible to determine the approximate time of loss by examining the HYPACK log file, which will generate an error message when the data string from the sensor is lost. There is approximately an 8 second time lag between disconnection of a sensor from HYPACK and the data timeout error being entered in the log (note that this timing latency may vary with different sensors). If you are unsure of the timing latency and a similar instrument set-up is available, it may be useful to experiment with error log time to determine the latency.

Once a position for the loss is determined, the search and recovery operation for the sensor should begin. It is imperative to begin the search operation as soon as possible after the loss to increase the probability of locating the sensor. All available means should be used to conduct the search. If located, the likelihood of recovery is good. Search mechanism should be determined based on depth of search area and bottom type. Multibeam is of limited use in locating objects smaller than a meter, unless in relatively shallow water. A side scan tow fish may provide the best chance of detecting the sensor. If other survey vessels are operating in the area it could be possible to immediately survey the area with multibeam or side scan sonar for any indication of the lost sensor. A diver search and recovery is the best way to locate and recover the sensor. In water where diving is not possible or practical, an ROV can be very useful for locating small objects, such as a sensor.

## **3.2 Bathymetry Acquisition**

NOAA hydrographic field units primarily use two types of echosounders to acquire bathymetry data: multibeam echosounders (MBES) and vertical beam echosounders (VBES). This section is dedicated to operating echosounder systems and recording sonar data using common software packages.

### **3.2.1 Lead Line Data**

A lead line can be used to measure depths in areas too shallow for echosounders, to verify least depths over dangers to navigation or shoals, and to calibrate echosounders. Lead line soundings should be acquired at slack current, if possible, to ensure that readings are true vertical measurements of depth. All lead line soundings should be clearly identified as such in the survey records. The hydrographer shall also, at a minimum, record the lead line number, geographic position, and time of measurement for each sounding. Water level correctors must be applied to lead line data during post-processing.

### **3.2.2 Sounding Pole Data**

Sounding poles can be used to acquire data in near shore areas where depths are less than 4 meters. Sounding poles should be carefully deployed so that a significant amount of sediment penetration does not occur and a true vertical measurement of depth is obtained. Each pole sounding should be clearly identified as such in the survey records. The hydrographer shall also, at a minimum, record the sounding pole number or identifier, geographic position, and time of measurement for each sounding. Water level corrections must be applied to sounding pole data during post-processing.

### **3.2.3 Vertical Beam Echosounder (VBES) Data**

Vertical beam echosounder systems may vary among NOAA hydrographic field units. Most OCS systems are dual frequency, using both a high and a low frequency, with beamwidths between three and eight degrees for high frequency, larger for low frequency (20-30 degrees). Provided the magnitude of vessel roll and pitch is less than the sonar beamwidth, these attitude characteristics will have little effect on sounding accuracy and their application to VBES data is not required by OCS. However, to maintain data quality in sea states where vessel roll and pitch angles exceed sonar beam width, OCS recommends that an external sensor be used to record heave data for application during post-processing. If a heave sensor is not employed, the VBES system should be used only when conditions are favorable for minimizing heave bias and data must be scanned for heave artifacts during post-processing. Data acquisition should be suspended if the heave signature exceeds 0.5 meters and a heave sensor is not being used.

Many VBES systems output calculated depth values rather than the two-way travel time of each sonar ping. To facilitate internal depth calculations, these types of VBES systems must be configured with an estimated value for the speed of sound through the water column. When necessary, hydrographic field units shall configure VBES systems using 1500 m/s, the standard estimate for the speed of sound in sea water. VBES data shall then be corrected using a full sound speed profile during post-processing.

Note: Sonar manufacturers often suggest applying real-time attitude, sound speed, and other corrections during data acquisition. It is OCS's standard policy to apply such data corrections during post-processing if possible.

The HYPACK software package is commonly used by NOAA hydrographic field units to acquire VBES data. OCS guidelines for using HYPACK with VBES systems are described below. Users should also refer to the HYPACK systems incompatible with HYPACK should consult the appropriate user's manuals and/or contact the regional HSTP Field Support Liaison for guidance.

### **3.2.3.1 HYPACK**

HYPACK is produced by HYPACK, Inc. This software is compatible with most types of VBES systems and can also be used for MBES data acquisition, as discussed in section 3.2.4.1 In addition to recording bathymetry data, HYPACK includes capabilities for completing the following tasks:

- Survey preparation and line planning.
- Precise survey line navigation.
- Recording of supporting sensor data such as position, heading, and attitude.
- GPS coordinated time-tagging of sonar and supporting data.
- Display of geo-referenced images as background files during acquisition.

#### **3.2.3.1.1 System Setup**

To record, or "log," data using HYPACK, a Project must first be created. Separate HYPACK Projects are typically created either for each survey or for each data type to be acquired. Be certain to save each newly created Project with a unique name, or all changes will be lost when another Project is loaded. Critical steps for Project creation are described below. Once saved, Projects can be loaded and changed as necessary.

##### **3.2.3.1.1.1 Device Setup**

For each Project, the hydrographer should assign a default Device Setup that includes drivers and recording settings for each sensor. Since data formats can vary drastically and HYPACK manages data for numerous sensors, it is critical that the correct Device Setup be loaded for each type of sensor being used. If a Project's default Device Setup is incorrect for the systems being used, a different Device Setup can be loaded after the Project has been opened. Although creating a Project for each survey seems well organized, having a Project for each data type may better ensure that the correct Device Setup is used for data acquisition if multiple configurations will be needed for a single survey. OCS recommends that master Device Setups for each system configuration be backed-up to a removable disk and maintained by the FOO or equivalent.

As a general rule, no offsets should be entered in the HYPACK Device Setup. It is OCS's policy to record survey data in the most "raw" form possible, then apply corrections and offsets during post-processing. One exception to this rule is transducer offsets. Transducer offsets entered in HYPACK will not be applied to recorded data. However, they will affect the displayed data and may be desirable for precise line-steering, particularly if offsets are large as with a side-mounted system.

### **3.2.3.1.1.2 Geodesy**

Default geodesy parameters should be set for each Project. All OCS hydrographic survey data shall be acquired in the North American Datum of 1983 (NAD83). This is accomplished in HYPACK by selecting the GRS80 ellipsoid and appropriate UTM zone.

### **3.2.3.1.1.3 Line and Background Files**

Planned survey line files and any associated background files, such as charts and limits, should be loaded for each Project. HYPACK is capable of reading these files from any local computer directory as well as across a network. However, it is recommended that all Project files be stored within the local HYPACK Project directory. This file management strategy is easily implemented by using the File > Add File and Copy option when initially loading Project files, which will automatically copy each file to the current HYPACK Project directory.

### **3.2.3.1.2 Recording Data**

Prior to recording survey data in HYPACK, certain critical system settings and operations should be verified. These quick system checks are highly recommended by OCS, as they can prevent errors that require extensive editing or complete reacquisition of data.

#### **3.2.3.1.2.1 Time Synchronization**

Through the Kinematic.dll device driver, HYPACK uses an internal timing algorithm called "Veritime" to time stamp data during acquisition. Veritime synchronizes the time recorded in the raw data to UTC time from the GPS system, and will also automatically reset the acquisition computer clock to UTC time. By default, Veritime will determine UTC time from the GPS receiver's NMEA0183 ZDA message. Thus, the hydrographer must ensure that this ZDA message is being output by the GPS unit. Note: HYPACK provides an option to "Sync clock on other sentences than ZDA." This option is not recommended by OCS and should not be used for OCS survey data without first contacting the regional HSTP Field Support Liaison. Time is a critical component of survey data, and it is recommended that the hydrographer periodically verify that time stamps are being applied correctly to logged data.

#### **3.2.3.1.2.2 Devices Test**

Once all survey sensors are operating, the user should test that sensor data are being properly received by HYPACK. By navigating through the HYPACK Hardware program, the user can "Test All" devices. This function opens a new window for each sensor in the current Device Setup. Data strings being received by HYPACK will be displayed for each device. Although data strings can be complex, the expected data from each sensor should be easily identifiable somewhere in the datagram. Two common problem indicators during this test are either no data

or a string of gibberish being displayed. No data being displayed is often indicative of sensor or cable failure, while gibberish frequently means that the sensor output baud rate does not agree with the receiving baud rate setting in HYPACK.

### **3.2.3.1.2.3 Logged Data Paths**

By default, HYPACK will log survey line data under the active HYPACK Project directory in a folder named “Raw”, and target files will be recorded to a file in the format mmddyyyy.tgt created in the Project directory. However, each field unit will have a standard directory structure to which data and targets should be logged. It is important for the user to check “Override Project Path” (in SURVEY mode under Options > Project Information) and select the appropriate folder for both survey line data and target file data prior to beginning daily data acquisition. Using this option, survey and target data may be logged anywhere on the local system or across a network.

Additional point data can be appended to a target file by pre-loading an existing target file. Pre-loading is accomplished in the primary HYPACK window by copying files into the “Target Files” folder, a process similar to loading planned survey line files. Target files can also be loaded as Chart Files (background data) in SURVEY mode, but these targets will be simply displayed on the screen, i.e., it will not be possible to select a target and see a range and bearing to it for use in navigation.

### **3.2.3.1.2.4 File Extensions**

Unless otherwise specified, VBES data will be automatically recorded with the file extension \*.raw. However, it is OCS standard policy to log HYPACK VBES data with a Day of Year (DOY) file extension. Note: HYPACK erroneously terms the DOY format as “Julian Day”. In SURVEY mode, the “Julian Day as Extension” option should be chosen under the Options > Project Information menu to create files with DOY extensions.

## **3.2.4 Multibeam Echosounder Data**

NOAA hydrographic field units typically use swath systems which produce multiple acoustic beams from a single transducer and measure both the angle and two-way travel time of the acoustic signals. The frequency of the signal varies from system to system and typically ranges between 12 and 455 kHz. During each sonar ping, a projector transmits a swath of acoustic energy into the water and reflected energy returns to the transducer where it is detected by a hydrophone.

Swath MBES systems may be capable of two different scanning modes: (1) Equidistant and (2) Equiangular.

The equidistant mode electronically forms the center of each footprint at a uniform distance from each other across the swath width. This even sampling across the swath width reduces the amount of overlapping coverage and intensity of returns in the inner half of the swath in effort to improve resolution in the outer beams. This is not recommended for hazard investigation surveys because of weak, lower resolution inner beams. Another disadvantage of this mode is that it reduces the received signal aperture of the outer beams thus reducing the possibility of detecting distant returns.

The equiangular mode electronically forms the receiving beams in equal angles. This means in the outer beams the beam footprint increases in length across-track providing bottom coverage across the entire swath width. The advantage of this mode is the overlapping coverage of the inner half of the swath, excellent for hazard investigation surveys where precise measurements of small targets are necessary. The primary disadvantage is the lower resolution in the outer beams. To maintain equal resolution across an entire survey area, survey lines must be planned for at 100% overlap (outer beam matching the nadir of the adjacent lines).

NOAA hydrographic field units have mounted MBES systems using a variety of methods, but these configurations can be classified into one of two basic types: hull-mounts and pole-mounts. Each type of sonar mount has inherent benefits and potential problems that should be considered during data acquisition.

A hull-mounted system is generally very stable, producing data with minimal noise due to vibration. A hullmounted configuration can be accomplished by notching the vessel keel and installing the sonar head along the keel line, attaching a mounting plate for the sonar head to the vessel hull, or cutting a box into the hull and creating a retractable mount for the sonar head. The flow of water along a vessel hull can create air bubbles, which may cause noise in a hull-mounted system. This problem should be considered when designing a hull-mount system. Note: The aforementioned retractable mounting system is essentially a hybrid of a hull-mount and a polemount. Benefits and drawbacks associated with each type of configuration should be considered when designing and installing such a system.

A pole-mounted system is often the quickest and least intrusive mounting configuration. In its simplest form, the sonar head is mounted to a large pole that can be pivoted into the water during data acquisition, then pivoted back out and secured to minimize drag during transits. When using a pole-mounted system, it is critical that the sonar can be both reliably deployed to a repeatable position (with respect to the vessel reference frame) and adequately stabilized during data acquisition. Pins or guy-wires are often used to help with system stabilization. Noise due to vibration of the mounting pole at certain vessel speeds is a common problem with pole-mounted systems.

Many MBES systems are capable of recording acoustic back-scatter data. Multibeam backscatter is intensity data that can be processed to create low resolution imagery. Backscatter is co-registered with the bathymetry data and is often used to assist with bathymetric data interpretation and post-processing. To optimize a system for backscatter data quality, refer to the manufacturer's documentation. However, the hydrographer should be cognizant that adjusting a MBES system to enhance backscatter data may detrimentally affect bathymetry data quality.

Auxiliary sensors are normally used for acquiring data to correct MBES soundings for vessel attitude, position, and sound speed. Time synchronization of all sensor inputs is critical when acquiring MBES data, and there are several methods which can be used to accomplish this. If using a flat-faced MBES transducer array, it is also critical that sound speed be measured at the face of the transducer for beam forming and beam steering. For this type of system, a surface sound speed measuring instrument should be mounted at the sonar head, and its data input directly to the sonar processing unit.

The HYPACK/ HYSWEEP software package is commonly used by NOAA hydrographic field units to acquire MBES data. OCS guidelines for using HYPACK/HYSWEEP with MBES systems are described below. Users should also refer to the HYPACK User's Manual which can be found on the Hydrosoft website. Field units equipped with alternate software or systems incompatible with this software package should consult the appropriate user's manuals and/or contact the regional HSTP Field Support Liaison for guidance.

### **3.2.4.1 HYPACK / HYSWEEP**

HYSWEEP is an additional module available for the HYPACK software package discussed in section 3.2.3.1 of this manual. HYSWEEP enables the hydrographer to record both MBES and SSS data, and runs simultaneously with HYPACK. The HYPACK base program enables precise survey line navigation for MBES operations. Many of the procedures required for VBES data acquisition in HYPACK also apply to MBES and SSS data acquisition using HYSWEEP.

Basic information for using the HYSWEEP software module is provided in this manual. For more detailed information about the HYSWEEP program, refer to the HYSWEEP User's Manual, which can be found on the Hydrosoft website.

#### **3.2.4.1.1 System Setup**

System setup for HYSWEEP consists of adding MBES system devices in the HYSWEEP Hardware configuration to enable communication with the sonar system and the HYPACK parent program. Note: HYSWEEP software can not be used to manipulate the sonar system settings. Any sonar setting changes must be performed using the sonar manufacturer's software interface. The HYSWEEP Hardware menu is accessible through the HYPACK Hardware menu. No vessel or hardware offsets should be entered in HYSWEEP, as it is OCS's policy to apply corrections and offsets to data during post-processing. Additional devices may also be added to the HYPACK hardware configuration for displaying multibeam data (nadir depth and matrix data) in the HYPACK survey window. Refer to Appendix 3 for detailed instructions for the standard setup of HYPACK and HYSWEEP devices (HYSWEEP Device Setup SOP.pdf).

To record data using HYSWEEP, a Project must exist in HYPACK. HYPACK Project creation is discussed in section 3.2.3.1.1 . Be certain to save each newly created Project with a unique name, or all changes will be lost when another Project is loaded. HYSWEEP files will be recorded to the same directory selected in HYPACK.

#### **3.2.4.1.2 Recording Data**

Recording data using the HYSWEEP module of HYPACK is nearly identical to logging data directly in HYPACK, as described in section 3.2.3.1.2 . Typically both programs are run simultaneously. Data logging can be controlled in either the HYPACK or the HYSWEEP program using the same commands and keyboard shortcuts. The two survey programs will begin/end logging simultaneously when a record or stop recording command is given in either one.

For OCS hydrographic surveys, HYSWEEP data shall be logged in ASCII HSX (HYSWEEP Survey Extension) format. While logging data, the HYSWEEP main survey window should be used to monitor logging and device alarms. MBES or SSS data can be displayed and monitored in real-time using windows selected under the View menu. Range scales for depth and beam width are accessed under the View > Options menu, and must be set to the appropriate values according to expected water depth or data will not be displayed in the survey windows (though it will still be logged). Multibeam display options, quality control tests, coverage map settings, and heave, pitch, and roll correction options are also accessed under View > Options menu. Note: the option to "Apply Heave, Pitch, and Roll Corrections" is used for display purposes only, and will not affect the raw recorded data.

### **3.2.5 Diver Least Depth Gauge (DLDG) Data**

A Diver Least Depth Gauge can be used by NOAA hydrographic field units to determine or verify the least depth of a feature. Depth is determined by comparing a pressure value at a feature's least depth to a surface pressure and correlating this difference to water depth based on the local water density. For more detailed DLDG information, refer to the document DLDG.pdf in Appendix 3.

At each dive site, a surface DLDG pressure must be recorded. OCS recommends taking a surface reading both before and after the dive, then averaging the two surface values for post-processing. Divers should survey the entire feature to identify the point of least depth. Once the least depth point is located, the DLDG should be placed level with this point and a pressure reading determined. Pressure values will vary with surface sea action, so a value eye averaged over a period of a few seconds should be recorded. A buoy marker should then be moved to the point of least depth so that a DGPS position can be obtained from the surface. If time permits and the item is complex, it is beneficial to record dimensions and make a quick sketch, noting the point of least depth. At the conclusion of the dive, a sound speed profile must be conducted in the vicinity using a Sea-Bird SEACAT profiler to determine local water density. Using a SEACAT system enables the DLDG pressures to be processed with Velocipy software.

## **3.3 Acoustic Backscatter Acquisition**

NOAA hydrographic field units use a variety of sonar systems to acquire acoustic backscatter data. Side scan sonars (SSS) collect backscatter imagery and are preferred for their object detection capabilities. MBES systems can record seafloor acoustic backscatter data that are collocated with their range and angle measurements. Although acquisition of seafloor acoustic backscatter may be required in the project instructions and processed MBES backscatter may assist with determination of seabed characteristics when planning bottom sample operations, it does not meet OCS object detection criteria for hydrographic surveys. While it is also possible to collect water column backscatter with MBES, collection of this data is not expected or discussed further.

### **3.3.1 Side Scan Sonar (SSS) Data**

Side scan sonar systems and configurations vary among NOAA hydrographic field units. Traditional SSS operations consist of a sonar body, or "towfish," which is towed behind a vessel via a cable and winch system. During operations, transducers located on each side of the towfish emit an acoustic signal that ensonifies a wide swath of seabed. The frequency of the signal varies from system to system, typically ranging between 100 and 500 kHz. Lower frequencies will increase the maximum range scale of a SSS, but imagery quality and resolution increases with higher frequencies. The amplitude of returning echoes from the seafloor are recorded and geo-referenced based on the return time series. The intensity of the SSS return signal will also be affected by the acoustic reflectivity of the sea floor. For example, rock and metal objects are better reflectors than sand or mud. If the seafloor is flat, the return signal will include amplitude values at regular intervals along the entire range scale.

However, if a scour is present or an object is elevated from the sea floor, a portion of the return signal will be irregularly spaced in time. This interruption causes an acoustic shadow, or a lack of return signal, along a portion of the range scale. This basic side scan sonar theory of operation is illustrated in Figure 3.1.

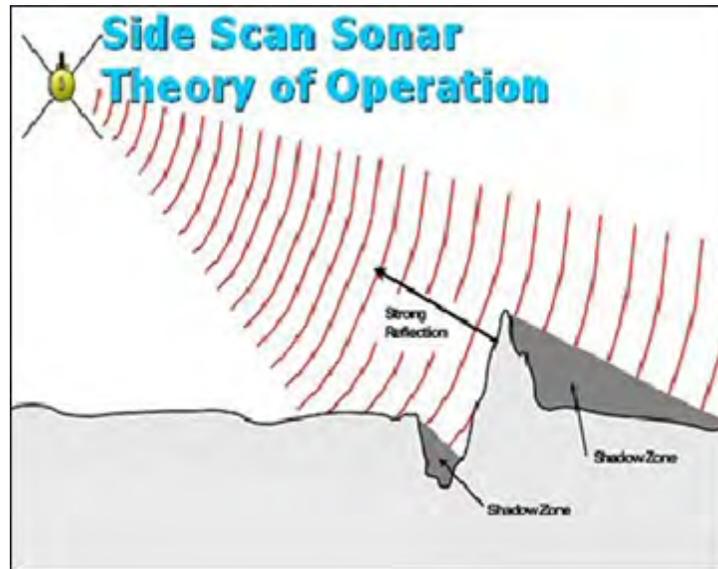


Figure 3.1: Basic side scan sonar theory of operation

Side scan systems are typically towed at depth to increase sonar grazing angles and object detection capability. For optimum object detection, OCS requires maintaining a towfish height of 8-20% of the operating range scale. NOAA's hydrographic field units effectively use both towed and hull-mounted SSS configurations. Each type of configuration has inherent benefits and potential problems that should be considered during data acquisition.

In towed configurations, towfish height is controlled by a combination of vessel speed and cable out. Although a towed configuration will maximize object detection abilities in various water depths, a certain amount of positioning error is inherent in any towed system. Because of this additional error source, SSS data are rarely used for final positioning of a feature. For hull-mounted configurations, position data are more accurate and operations can be conducted safely and effectively in shallow waters. However, since a hard-mounted system can not be lowered into the water column, sonar grazing angles will be directly affected by the water depth. As depth increases, object detection capabilities will decrease. It may not be possible to meet object detection criteria in deeper waters with a hull-mounted configuration.

Note: When operating a towed SSS system, towfish height should be carefully monitored. If a sonar grounding is imminent, increasing vessel speed will typically raise the towfish.

SonarPro software is commonly used by NOAA hydrographic field units to acquire SSS data. OCS guidelines for using SonarPro is described below. Users should also refer to the SonarPro Operation Manual, which can be found on the Hydrosoft website. Field units equipped with alternate software/systems incompatible with this software package should consult the appropriate user's manuals and/or contact the regional HSTP Field Support Liaison for guidance.

### 3.3.1.1 SonarPro

SonarPro, is a comprehensive software package compatible with the Klein 5000 Multibeam & Klein 3000 Dual Frequency SSS systems. In addition to display and recording of SSS data, SonarPro includes a capability for managing sonar targets which is useful when performing emergency response surveys. Detailed information about SonarPro can be found in the SonarPro Operation Manual.

### 3.3.1.1.1 System Setup

Since SonarPro is specifically designed to operate with Klein System 5000 and 3000 side scan sonars, system setup requirements are minimal. Klein System 5000 and 3000 sonars must be booted using a program called vxWorks. (OCS recommends that the boot process be monitored using a HyperTerminal connection between the acquisition computer and Klein TPU.) The vxWorks program will differ depending on which sonar system is being used (5000 or 3000), allowing SonarPro to automatically detect and configure for the type of system to which it is connecting.

Note: If using both 5000 and 3000 systems on the same acquisition system, be certain that the vxWorks file corresponding to the current system configuration is loaded in the “klein” directory before booting the sonar.

### 3.3.1.1.2 Recording Data

Once the SSS has been booted, SonarPro software should be started (or if already running, select the towfish button from the main SonarPro display window to connect to the sonar). The user will be prompted to enter the Klein TPU Internet Protocol (IP) address to establish a connection between the acquisition computer and the sonar system. After creating a connection to the TPU, a Survey Wizard window will open that can be used to set up a data logging directory and target parameters. (The wizard may also be bypassed and accessed later from the main tool bar.) SonarPro will automatically display a Sonar Viewer window with SSS waterfall and towfish controls allowing the operator to start and stop the sonar from pinging. Once the operator is satisfied with the primary system setting choices, he/she should save the session by executing the Save State-Registry option under the Sessions menu. Saving State-Registry will cause SonarPro to open in this configuration the next time the software is opened.

#### 3.3.1.1.2.1 Towfish Setup

Towfish setup is accessed through the Towfish button in the Sonar Viewer window. OCS recommended setup values are listed in Table 3.1. When conducting standard OCS hydrographic surveys, the most efficient SSS range scale should be used, as described in section 2.5.3.1.2 . SonarPro will automatically select an optimal pulse length for the user defined range scale.

Sonar Setting	High Frequency	Low Frequency
Sonar Range	Set for maximum efficiency according to depth	Set for Maximum efficiency according to depth
Pulse Length	Default	Default
Despeckle Sonar Image	Off	Off
Sonar Resolution	Normal	Normal
Side Scan System State	Default	Default
TPU Responder Control	Off	Off
Responder Frequency	28.5	28.5
Towfish Speed	Determine by GPS	Determine by GPS
Speed of Sound	150000 cm/s	150000 cm/s

Table 3.1: Recommended Towfish Setup

### **3.3.1.1.2.2 Cable Out and Layback**

The Cable Out window is accessed either using the Cable Out button or from inside the Layback window by selecting the External Cable Out Source button. Cable out values can be entered manually or automatically through external cable out sources.

Note: When entering manual cable out, new values will not take effect until the user clicks the “Apply” button.

The cable out source and settings will vary depending on the system configuration. The operator should verify that Sonar Pro is reading the correct cable out values before logging data.

The hydrographer may want to enter vessel layback parameters (i.e., offsets from the navigation source to the sheave) so that SonarPro can generate accurate real-time positions for targets. Entering these offset values is important when investigating targets on the fly, such as during emergency response surveys. Vessel layback parameters are accessed through the Layback button in the SonarPro window. Save and apply the layback parameters by selecting the “Store Layback Parameters” button.

Note: Entering layback offset values will only affect the calculated positions of targets selected during acquisition. Logged vessel navigation will not be affected, and towfish position should be calculated during post-processing in CARIS.

### **3.3.1.1.2.3 Data Display**

Individual data display windows can be selected from the Window tab of the main SonarPro screen. If using a Klein 3000, separate SSS Sonar Viewer windows should be opened to display both low frequency (100 kHz) and high frequency (500 kHz) data. Since high frequencies provide higher resolution data, this data should be viewed in the primary display window. However, low frequency data should also be monitored as it may pick up features missed by the high frequency.

The user may want to display charts in SonarPro for navigation purposes. For the navigation window to work properly, the user must first copy the desired \*.BSB and \*.KAP raster chart files to the sub-folder designated for charts (commonly labeled Maptech) during SonarPro installation. It is recommended that only the charts needed for a given work area be maintained in the chart folder to minimize software loading time. Note: If attempting to display multiple charts, the charts must all have the same projection. Skewed raster charts will not display in SonarPro.

SonarPro provides two types of informational alarms, towfish altitude and towfish roll. It is strongly recommended that the towfish altitude alarm be set to visually and (if possible) audibly alert the user when this value falls below 5 meters. Towfish roll is a less critical value, and this alarm can be used at the hydrographer’s discretion.

### **3.3.1.1.2.4 Data Logging**

SonarPro provides the option of logging SSS data in either \*.XTF format or Klein’s proprietary Sensor Data Format (\*.SDF). OCS’s standard policy is to log SonarPro data using the \*.SDF format. The \*.SDF format logs vessel position and cable out values, but not towfish position. A towfish position will be calculated during post-processing in CARIS. To begin logging \*.SDF data, select the Record SDF button in the Sonar Data Recorder window. Maximum file size is set by specifying the maximum number of minutes per disk file in the data logging window. A maximum file size between 30 and 45 minutes is recommended based on field unit experience.

Note: If using HYPACK software for vessel navigation and logging bathymetry data, HYPACK and SonarPro must be started and stopped independently.

### 3.3.2 Multibeam Echosounder Seafloor Backscatter

The acquisition of multibeam echosounder seafloor backscatter may be required in the project instructions. MBES backscatter may be used to supplement hydrographic data for non-charting purposes. See section 6.2 of the HSSD for further instructions on MBES backscatter requirements in Appendices 4 for standard operating procedures on processing MBES backscatter data.

### 3.4 Position and Attitude Data

NOAA field units often measure position and attitude data using a single piece of equipment, the POS/MV (Position and Orientation System for Marine Vessels), manufactured by Applanix. Alternately, a combination of systems may be used to measure position, heading, and heave/pitch/roll individually.

#### 3.4.1 Applanix POS/MV

The Applanix POS/MV is a GNSS-aided Inertial Navigation System. It consists of two dual-frequency GNSS receivers, an Inertial Measurement Unit (IMU), and a POS Computer System (PCS). The IMU and GNSS receivers are complementary sensors; data from one are used to filter and constrain errors from the other, resulting in high accuracy position and heading data. AGNSS Azimuth Measurement Subsystem (GAMS) is used to aid the POS/MV in determining heading. GAMS heading aiding increases the system's achievable heading measurement accuracy, independent of latitude or vessel maneuvers. Additionally, the IMU senses linear acceleration and angular motion along the three major axes of the vessel to determine heave, pitch, and roll.

POS/MV Controller software allows the user to interact with the PCS for purposes such as performing calibrations and monitoring data accuracy. When acquiring data for OCS hydrographic surveys, POS/MV User Accuracy parameters shall be set such that the error values identified in Table 3.2 are not exceeded. If these User Accuracy parameters can not be met, the field unit shall contact the regional HSTP Field Support Liaison for guidance.

Data Parameter	Maximum Allowable Error
Attitude (Roll/Pitch)	0.05 degrees
Heading	0.05 degrees
Position	2.5 meters at 1 sigma
Velocity	1.0 m/s

Table 3.2: Maximum Allowable POS/MV Error for OCS Surveys

The POS/MV Controller Program should be monitored continuously during survey data acquisition to ensure that the system is functioning properly and accuracy parameters are not exceeded. Occasionally, GAMS will experience difficulty determining heading parameters. Three common GAMS problems and corresponding solutions recommended by Applanix are described in Table 3.3.

POS/MV Symptom	Cause of Problem	Recommended Solution
POS/MV heading is correct within the User Accuracy parameters, but the “Invalid Installation Parameters” fault is red.	POS/MV has resolved the wrong set of ambiguities for its GAMS heading aiding	<ol style="list-style-type: none"> <li>1. Select View &gt; GAMS Solution and ensure PDOP is less than 3 and number of satellites is greater than 5.</li> <li>2. Select Settings &gt; Installation &gt; GAMS Installation Parameters and click “Apply.”</li> </ol>
Heading Accuracy on the main Controller screen reads 55° for more than five minutes after powering on system.	POS/MV was not able to obtain an initial heading, a.k.a. “resolving its quadrant.” This will most likely occur if POS/MV is powered on while the vessel is stationary.	<ol style="list-style-type: none"> <li>1. Cycle POS/MV power.</li> <li>2. Temporarily turn off DGPS corrections.</li> <li>3. Power on POS/MV only while underway.</li> </ol>
Heading does not match known vessel heading once quadrant is resolved. The “Invalid Installation Parameters” fault is red	POS/MV has resolved the wrong quadrant.	Cycle system to “Standby” and back to “Navigate”.

Table 3.3: Common GAMS Problems and Recommended Fixes.

Refer to the appropriate Applanix POS/MV User’s Manual, found on the Hydrossoft website, for additional information on the POS/MV system.

### 3.4.1.1 Differential Correction

GPS accuracy is improved by applying correctors from land-based differential radio beacons. The POS/MV system uses these differential corrections (RTCM SC-104 messages) when determining vessel position. However, the POS/MV system does not include a differential receiver. A separate receiver must be serially integrated into the POS/MV configuration to obtain these messages.

NOAA hydrographic field units should use differential corrections from the United States Coast Guard (USCG) radio beacon closest in distance to the survey area, if possible. If a beacon receiver is capable of monitoring more than one radio beacon frequency, the unit should be set such that only one beacon station will be used. Allowing only one beacon frequency will prevent the receiver from switching to another beacon station without the operator’s knowledge, which could cause erratic positioning and make determining the source of correctors difficult. It may be necessary to use an alternate radio beacon station if the preferred beacon is not functioning properly. In such cases, the use of this secondary differential beacon should be noted in the data acquisition log.

#### 3.4.1.1.1 Portable DGPS Reference Stations

If differential correctors are not available from a USCG radio beacon, a portable DGPS reference station can be set up by a field unit. A DGPS Reference station (Figure 3.2) consists of an L1/L2 GPS receiver, a radio transmitter, a radio receiver, a VHF antenna, tripods or light brackets, marine batteries, solar panels, a timer, and a laptop computer.

When choosing a site for DGPS reference station installation, the hydrographer should set it in a convenient place with good VHF line of sight to survey area and clear view of GPS satellites overhead (substantially clear sky all around from 10 degrees above horizon – see Appendix 3 (User’s Guide for GPS Observations.pdf for more information). Effective ranges of Portable DGPS Reference Stations will be a factor of obstructions within the line of sight and antennae height, nominally 15 km can be used as a rule of thumb. Consider in particular the following locations:

- setup over tidal bench mark: provides connection between tidal and GPS correctors
- setup over other existing control mark: provides check with prior survey work
- least favorite: establish a new control mark (monumentation instructions available from NGS)

Find existing control marks using the “datasheets” link from National Geodetic Survey <http://geodesy.noaa.gov/> If no accurate coordinates exist for your control mark, submit a survey data file to OPUS <http://www.ngs.noaa.gov/OPUS/>. For maximum accuracy, submit two 6-hour files (see section 3.5.3 and average the resultant coordinates (if OPUS results do not agree within 2cm, consult with NGS). Occasional repetition of this OPUS solution is recommended to provide confidence checks. Note: OPUS will soon allow archiving of geodetic control directly from the website. To allow this, record photos of the mark and a description of the mark location (see draft requirements here: <http://beta.ngs.noaa.gov/OPUS/> ).

Instructions for setting up the beacon are provided with the kit and will not be provided here.

Check the entire beacon system by placing a roving receiver in a stable spot and tracking the position for 24 hours (see section 3.2.2. of the HSSD). If the resulting scatter plot (from the Trimble Pathfinder ProXRS or other receiver software) shows that more than 5% of positions exceed 5 meters from the average, this is an indication that there is a problem. Otherwise, save a screen shot of the scatter plot for your files. Both a one-time DGPS site confirmation and a weekly position uncertainty check are required per section 3.2.2 and 3.4 (resp.) of the HSSD. The weekly QC procedure is detailed in section 3.4.1.1.3 below.



Figure 3.2: DGPS Reference Station

### **3.4.1.1.2 WAAS-corrected GPS data**

NOAA prefers all in-house and contract hydrographers to use USCG Differential GPS (DGPS) as the primary means of positioning. However, there are some project areas for which reliable DGPS coverage is unavailable or inadequate. In some case, coverage may be provided by the Federal Aviation Administration's Wide Area Augmentation System (WAAS). When working in inshore areas that are relatively close to WAAS reference stations, WAAS may be able to replace DGPS as the primary means of positioning if prior permission is obtained from the Chief of the Hydrographic Systems and Technology Program in NOAA's Coast Survey Development Laboratory. WAAS can be an option if it can be shown that WAAS meets the positioning accuracy requirements listed in the HSSD. The procedures for discovering if WAAS may serve as the primary positioning method are listed below.

- Identify a point ashore with position known to ~0.5m accuracy (either a point surveyed yourselves with precision GPS methods, or retrieved from the NGS database at <http://www.ngs.noaa.gov/OPUS/>). This site should be in close proximity to the survey area, and have a relatively unobstructed sky view to maximize the available GPS constellation.
- Occupy the point with your WAAS-enabled receiver for at least 24 hours, logging position data at no less than 1 minute intervals.
- Assess WAAS position accuracy and precision by constructing a scatter plot of the 24-hour time series, and computing the average WAAS position. 95% of the WAAS positions must fall within 5m of both the high accuracy mark position and the average WAAS position.
- Before acquiring WAAS-corrected hydrographic data, a brief report describing methods, data, test results, and your plans for quality control shall be submitted to the Chief of the Hydrographic Systems and Technology Program in NOAA's Coast Survey Development Laborator

### **3.4.1.1.3 PPK/RTK Base Station Position Uncertainty Checks**

If a PPK/RTK GNSS base station is maintained and used by the field unit to improve horizontal positioning and/or survey to the ellipsoid, a weekly base station uncertainty check shall be performed (see section 3.4 of the HSSD).

NOAA hydrographic units shall use the known location of the base station used during post processing/RTK corrector generation as the "Known" location for the check. NGS OPUS shall be used to determine the Known location position. A position uncertainty check shall be performed each week of occupation by submitting a 6 hour session file to OPUS and verifying the "Check" position against the Known position.

NOAA hydrographic units shall use the NGS program INVERS3D to perform the weekly position uncertainty check of the base station. INVERS3D is available as either a free download or web based program from NGS [http://www.ngs.noaa.gov/PC\\_PROD/Inv\\_Fwd/](http://www.ngs.noaa.gov/PC_PROD/Inv_Fwd/). The procedure for performing the weekly check is listed below:

- Submit both the Known position and Check position GNSS session files to NGS OPUS
- Run INVERS3D from the downloadable executable or web based form
- Enter the First Station (Known position) coordinates as Geodetic coordinates

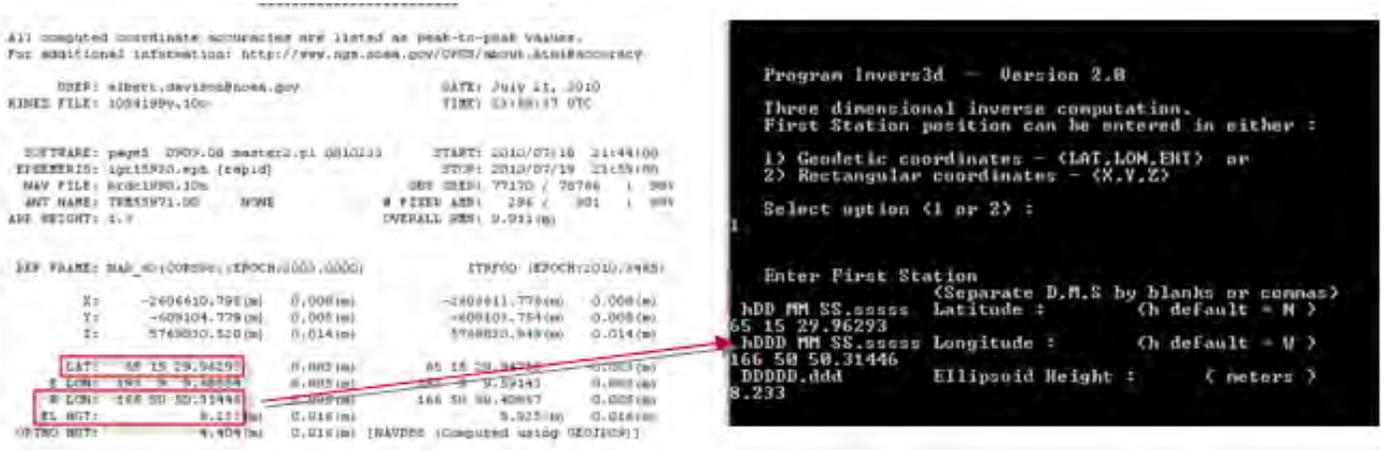


Figure 3.3: Base Station Known Coordinates

- Enter the Second Station (Check position) coordinates as Geodetic coordinates

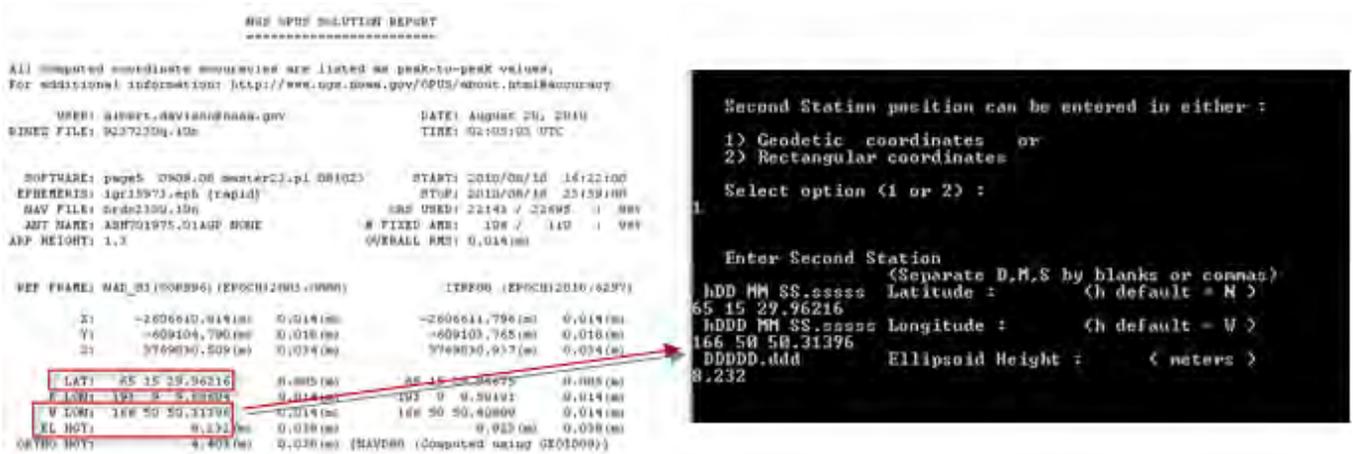


Figure 3.4: Second Station Coordinates

- Save the output into a file using the naming convention Station ID\_QC\_Week Number of check.txt (ex. 9237\_QC\_33.txt)
- Give First Station name using the naming convention Station ID\_Known (ex. 9237\_Known)
- Give Second Station name using the naming convention Station ID\_Check (ex. 9237\_Check)

```

Do you want to save this output into a file (y/n)?
y
Enter the output filename :
9237_QC_33.txt
Enter the First Station name :
9237_Known
Enter the Second Station name :
9237_Check

```

Figure 3.5: Base Station Naming

- Examine the results of the text file. The Mark-to-mark distance (D) shall be:

$$\leq 2 * \sqrt{OPUS\ Known\ Position\ RMS^2 + OPUS\ Check\ Position\ RMS^2}$$

**SOLUTION REPORT**  
=====

listed as peak-to-peak values.  
<https://www.noaa.gov/OPUS/about.html#accuracy>

DATE: July 21, 2010  
TIME: 23:59:27 UTC

310233 START: 2010/07/18 21:44:00  
STOP: 2010/07/19 23:59:00  
OBS USED: 77170 / 78766 : 98%  
# FIXED ANB: 306 / 301 : 98%  
**OVERALL RMS: 0.011(m)**

3 START: 2010/08/18 16:22:00  
STOP: 2010/08/18 23:59:00  
OBS USED: 22143 / 22695 : 98%  
# FIXED ANB: 106 / 110 : 96%  
**OVERALL RMS: 0.014(m)**

First Station : 9237\_Known  
-----  
X = -2606610.7948 m LAT = 65 15 29.96293 North  
Y = -609104.7789 m LON = 166 50 30.31446 West  
Z = 5769830.5197 m EHT = 8.2330 Meters

Second Station : 9237\_Check  
-----  
X = -2606610.8140 m LAT = 65 15 29.96216 North  
Y = -609104.7901 m LON = 166 50 30.31366 West  
Z = 5769830.5068 m EHT = 8.2320 Meters

Forward azimuth FAZ = 164 46 43.5417 From North  
Back azimuth BAZ = 349 46 43.5421 From North  
Ellipsoidal distance S = 0.0247 m  
Delta height dh = 0.0010 m  
**Mark-to-mark distance D = 0.0247 m**

DX = -0.0192 m DY = -0.0112 m  
DZ = -0.0109 m

Zenith Apparent  
 $2 * \sqrt{0.011^2 + 0.014^2} = 0.036$   
**0.0247 < 0.036 = Good QC Check**

Figure 3.6: Base Station Uncertainty Check Results

### 3.4.1.2 True Heave

Heave data is calculated using a double integration of acceleration over a period of time. When recording heave in real-time, the calculation is performed using only past measurements of acceleration. An improved estimate of vessel low-frequency heave can be calculated by performing the integration over a time period centered on the time of interest, resulting in a “true heave” value (also referred to as “delayed heave”). POS/MV TrueHeave is effective across long-period wave conditions (16- to 30-second period swell), whereas a real-time heave filter tends to exhibit its most notable artifacts in such conditions (>16 seconds).

Note: TrueHeave does not replace the need for dynamic draft corrections or water level corrections.

TrueHeave is logged using the POS/MV Controller software, via the Ethernet connection to the POS/MV PCS. TrueHeave data logging must be controlled separately from the primary data acquisition software, but it can be continuously recorded throughout the day. The TrueHeave filter requires a period of up to five (5) minutes after it has been enabled to initialize. The filter uses vertical acceleration data three (3) minutes past real time; hence, logging must continue for at least three (3) minutes past the ending time of survey line data acquisition. The time

base used for TrueHeave data, “Heave Time 1”, is user selectable in the POS/MV Controller software. For OCS hydrographic surveys, UTC (default) should be selected, not GPS time. Refer to the POS MV with TrueHeave document, found on the Hydrosoft website, for more information regarding the theory, operation, and setup of TrueHeave.

TrueHeave files are applied to survey data during CARIS HIPS post-processing via the Load True Heave tool, as discussed in section 4.2.3.5 .

### **3.4.1.3 POSpac Files**

The POS Controller (POS VIEW) program is used to log POS PCS files that contain all the files necessary for IAPPK processing of SBET in POSpac. See Appendix 4 for (Ellipsoidally Referenced Survey SOP.pdf). Also, refer to the appropriate Applanix POS/MV User’s Manual, found on the HydroSoft website, <https://inside.nos.noaa.gov/hydrosoft/welcome.html> , for additional information on the POS/MV system.

## **3.4.2 Alternate Positioning Equipment**

### **3.4.2.1 Vessel-mounted DGPS Receivers**

Numerous types of differential positioning systems are available on the open market, including terrestrial based DGPS receivers as well as satellite based DGPS receivers. NOAA hydrographic field units planning to acquire hydrographic survey data with a positioning system not identified in this manual should contact the regional HSTP Field Support Liaison for guidance and review the system’s accuracies to confirm that survey specifications can be met. DGPS receivers that can automatically switch DGPS stations based on signal strength or distance from station should have these options disabled so that the receiver does not switch beacons while acquiring data. This can lead to horizontal shifts in data.

#### **3.4.2.1.1 Global Satellite-Based Augmentation System (GSBAS) correction**

In situations where USCG DGPS correctors are not available and it is not feasible to set up a portable DGPS station, a field unit may choose to subscribe to a service such as NavCom Technologies StarFire network or C & C Technologies C-Nav network. These services utilize NASA’s Jet Propulsion Laboratory’s Real-Time GIPSY (RTG) Precise Point Positioning (PPP) technology to generate corrections and then broadcast them over L-Band communication satellites.

#### **3.4.2.2 Portable GPS Units**

In some situations, such as shoreline verification, it is more efficient for the field unit to position features using a portable GPS unit. Various models of portable GPS units are available on the open market. Portable GPS units shall meet the horizontal accuracy requirements as stated in section 3 of the HSSD.

These systems and survey techniques are discussed in section 3.5.3 – Position Uncertainty and Precision.

### **3.4.3 Alternate Heading Sensors**

#### **3.4.3.1 Gyroscopic Compass**

A gyroscopic (gyro) compass may be used to determine vessel heading. Gyro compasses use the effects of gravity and the Earth's rotation to produce a true north reference and may be mechanical by design or use fiber optic or laser technology. Ideally, a gyro compass should be installed on the centerline of the ship. When a gyro compass is used, the manufacturer's information should be reviewed carefully to determine if the system requires any user input such as vessel latitude and/or speed to achieve the specified heading accuracy and to identify approximately how much time is required for the system to slew when first powered up.

#### **3.4.3.2 Course Over Ground (COG)**

Vessel course over ground (COG) can be used to calculate a smoothed vessel heading. This technique will not be appropriate when acquiring all types of hydrographic data. Generally, any system hard mounted to the vessel will require an instantaneous heading. Since towed systems will not be affected by every slight motion of the vessel, they can typically use a calculated COG heading without detrimentally affecting the survey data. It may be possible to adjust the smoothing factor associated with COG heading data. Manipulating the smoothing factor would allow the user to adjust the frequency with which heading is calculated or how many position points are used to estimate the vessel course.

### **3.5 Ancillary Data**

Two basic types of ancillary data are acquired in conjunction with OCS hydrographic surveys. The first type is used to correct sonar data and includes such measurements as sound speed and water levels, as well as horizontal and vertical control data. The second type consists of information that supports survey analyses beyond basic water depth measurements and object detection. Positions for aids to navigation (ATONs), bottom samples, shoreline determination, and Coast Pilot reviews are included in this second category.

#### **3.5.1 Sound Speed Data**

Sound speed data are used by NOAA hydrographic field units for multiple purposes. Primarily, sound speed profiles of the entire water column are used to correct sounding data for the effects of refraction and varying speed of sound through water. Water column profiles are also used when processing absolute pressure data obtained by a DLDG so that a water depth can be calculated. Additionally, flat arrays and to a lesser extent, the far off nadir beams in curved arrays (of MBES systems) require a continual real time input of sound speed data at the sonar head for proper beam forming and beam steering. It should be noted that using incorrect sound speed at the transducer face in beam steering can seriously impact the proper computation of launch/receive angle of all off-nadir beams on curved arrays.

When acquiring sound speed profiles to correct bathymetry, OCS recommends taking casts in the deepest portion of the project area that best represents the surveyed area for which the profile will be applied. If data will be processed using Velocipy software, the sound velocity speed profile can be extended up to 30% of the cast's overall depth (in water depths less than 300 meters), providing more flexibility for cast locations. In water depths greater than 300 meters, the cast data will be extended to the maximum depth of historical data files loaded in the Velocipy program. The required frequency of casts will be dependent on the survey area, but OCS strongly recommends that a cast be performed at least every four hours during MBES data acquisition and once per week for VBES data.

The Sea-Bird SEACAT conductivity, temperature, and depth profiler (CTD), Odom DigibarPro, and Rolls- Royce Moving Vessel Profiler (MVP) are commonly used by NOAA hydrographic field units to acquire sound speed data. Position information will be required by Velocipy software for data processing and the user must be certain to record the most accurate GPS position possible. Data acquisition is briefly discussed for each of these systems below.

### **3.5.1.1 Sea-Bird SEACAT**

The SEACAT is a portable, user-deployed, battery-operated instrument, typically housed in a protective cage. The SEACAT records water salinity, temperature, and pressure (i.e., depth) during deployment and retrieval. Sampling rate depends upon the CTD model being used, and is typically between 2-4 samples per second. These data are processed using NOAA's Velocipy software to calculate a sound speed profile for the water column. Prior to performing a cast, OCS recommends that the SEACAT memory be cleared by performing a Pre-Cast Setup and the instrument status be reviewed using Velocipy (see Velocipy Operation Manual, included on the Hydrossoft website). If the SEACAT voltage is less than the following values listed below, the instrument batteries should be changed:

- SBE 19plus: 9.5 volts
- SBE 19: 7 volts

In both cases, the user is told to inspect the battery cut-off value in the status message. The battery should, at the very least, be one volt greater than the cut-off value.

When conducting SEACAT casts, using the SBE 19plus, the instrument should be lowered and held just below the water's surface for about 1 minute to flush air out of the salinity cell. After soaking the instrument beneath the surface, the user should slowly lower the instrument through the water column.

When conducting SEACAT casts, using the SBE 19, the 3-2-1 rule of thumb must still be followed. The instrument should be turned on and allowed to sit on deck for 3 minutes while the sensors settle and form baseline measurements. Next, lower and hold the instrument just below the water's surface for 2 minutes. Finally, deploy it at a rate of approximately 1 meter of depth per second.

With either the SBE 19 or the SBE19plus, lowering the instrument too quickly may not provide enough data points for an accurate water column profile. In areas with lenses of fresh water or other complex sound speed variation near the surface, the instrument should be lowered slowly (in some cases, much less than 1 meter/second) by hand through the first 5-10 meters of water in order to accurately sample the sound speed. After the instrument has descended through the initial 5-10 meters, the user should proceed to drop it at a rate of about 1 meter/second.

Refer to the Sea-Bird SBE User's Manuals, found on the Hydrossoft website, for additional operating instructions.

### **3.5.1.2 Odom DigibarPro**

The DigibarPro Profiling Sound Velocimeter is a portable, user-deployed instrument. The DigibarPro system includes a high frequency "sing-around" transducer and a reflector precisely spaced to facilitate measuring the speed of sound in water by continuously transmitting and receiving a signal across a known separation distance. The sing-around frequency and associated depth information are recorded at a rate of 10 samples per second. In

many OCS applications, DigibarPro systems have been mounted to or near a MBES transducer to directly measure sound speed at the sonar face; however, some units deploy this instrument to obtain full water column profiles. Recorded DigibarPro sound speed profiles can be uploaded to a PC and processed using NOAA's Velocipy software. Refer to the DIGIBAR-PRO Profiling Sound Velocimeter Operation Manual, found on the Hydrossoft website, for additional operating instructions.

### **3.5.1.3 Rolls-Royce Moving Vessel Profiler (MVP)**

The Moving Vessel Profiler (MVP) is an automated winch system that deploys various payloads such as a free fall fish (FFF) that can be fitted with a sound speed sensor. The FFF is configured to "fly" at a specified depth until deployed by use of a "messenger" on the cable. Once at the depth limit, the winch is stopped manually and the drag forces on the FFF cause it to rise toward the surface due to the ship's forward motion while the slack cable is pulled in by the winch. For OCS operations, the messenger is set on the tow cable so that the FFF flies at survey transducer depth while the vessel is moving at survey speed. The FFF can either be user-deployed or deployed automatically by the computer at a defined time interval to a user-defined depth or a preset depth off bottom (typically 10 meters). The FFF is automatically recovered to transducer depth, ready to be deployed again. Because of the large number of casts that can be recorded by the MVP in a short time frame, it is convenient to batch process the sound velocity profiles using Velocipy.

Note: Sound velocity profiles created by the MVP must be processed using Velocipy.

Refer to the MVP Operation and Maintenance Manual and the MVP Controller Software Manual, found on the Hydrossoft website, for additional information on this system and to section 1.5.2.3 . .

### **3.5.1.4 Reson SVP 70**

The Reson SVP 70 is a portable sound velocity probe consisting of a 6.5 inch, 2.2 pound probe which connects to a topside computer. The SVP 70 measures the sound speed up to 20 times per second in a direct measurement by transmitting a sound pulse and detecting its time to travel a well-defined path length. The transmitted signal is generated using waveform techniques that yield optimal conditions for timing the arrival of the returning signal, which is digitized at high frequency and high resolution. The timing is established using a high-stability clock oscillator.

The SVP 70 should be mounted at or near the head of a flat face MBES transducer to ensure that valid sound speed data is being utilized during the beam forming process.

## **3.5.2 Vertical Datum Transformation Data**

Tide and water level data are used by NOAA hydrographic field units to reduce bathymetric data to local "chart datum", most often mean lower low water (MLLW). The hydrographer should be aware of the difference between tide data and water level data. Tides refer to the changes in water levels due to astronomical forces only. Tides are the only water level changes that can be scientifically predicted. Water level data refer to the actual (i.e., observed) changes in water level due to the combined effects of astronomical forces, wind, rain, freshwater runoff, and other meteorological events. It should be noted that predicted tides may differ significantly from actual water levels. Typically, inland water level stations are more susceptible to meteorological effects; thus, tide predictions for coastal water level stations can be expected to more accurately represent actual water levels than those for inland stations. Stations in relatively shallow water or with a small tidal range are also highly susceptible to meteorological effects, making water levels difficult to accurately predict.

For projects involving ERS, the hydrographer shall utilize approved vertical datum transformation methods (e.g. VDatum, ERZT, and Constant Value) in lieu of traditional water levels to reduce the bathymetric data to chart datum. The accuracy of the vertical transformation process is highly dependent on Global Positioning Systems. Therefore, it is important for the hydrographer to recognize potential satellite ephemeris and clock errors related to variables such as orbital decay. These variables comprise and explain the components of orbital perturbations. As a result, orbital perturbations can alter satellite trajectories from its predicted path. This “ephemeris error” is the difference between the expected and actual orbital path. These deviations are corrected in post processing using rapid or precise ephemerides.

### **3.5.2.1 Water Level Station Installation**

Although CO-OPS will install, operate, and maintain control water level stations, hydrographic field units may be required to install subordinate stations. If an installation will be necessary for a project, it will be stated in the Project Instructions. In such cases, CO-OPS will provide a recommended general area for the gauge. The field unit is responsible for performing reconnaissance to determine if the recommended location is feasible. If the initial location is determined to be unsuitable, the field unit shall recommend an alternate location for CO-OPS approval. Gauge installation, operation, and removal shall be performed and documented in accordance with section 4 of the HSSD and section 5.2.2.2.4 of this manual. A copy of CO-OPS’ (Standing Project Instructions and Requirements For the Coastal and Great Lakes Water Level Stations) is included in Appendix 3.

### **3.5.2.2 Bench Mark Recovery and Leveling**

A bench mark is a fixed physical object or marker (monumentation) set for stability and used as a reference to the vertical and/or horizontal datums. Bench marks in the vicinity of a water level station are used as the reference for the local tidal datums derived from the water level data. The vertical relationship between the bench marks and the water level sensor or tide staff is established by differential leveling. NOAA Hydrographic field units will often be required to install and/or recover benchmarks and perform leveling operations for applicable water level stations at the start and end of data acquisition for a project. Existing bench mark descriptions and locations can be found under the Products menu of the CO-OPS website <http://www.tidesandcurrents.noaa.gov>.

Each water level station will have one bench mark, designated as the primary bench mark, that shall be leveled to on every run. Levels must be run between the water level sensor or tide staff and the required number of bench marks when the water level measurement station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. Levels are required at least every six months during the station’s operation, and are recommended after severe storms, hurricanes, or earthquakes to document stability. Levels run at subordinate stations operated for less than one-year shall be at least third-order. Any requirements for higher order levels will be specified in the Project Instructions for the project. Bench mark installation and gauge leveling shall be performed and documented in accordance with section 4 of the HSSD.

Bracketing levels to an appropriate number of marks (five for subordinate stations) are required (a) if a gauge is in operations for more than 30 days but less than 12 months (b) if final tides are required, or (c) every 6 months for stations collecting data for long term hydrographic projects.

### **3.5.2.3 Water Level Data Retrieval**

Typically, predicted tides or preliminary water level data are applied to soundings during initial post-processing. As verified or final water level data become available, the best quality data should be applied to bathymetry. Field units can download six-minute preliminary water level data directly from the Products > Tides section of the CO-OPS website <http://www.tidesandcurrents.noaa.gov> within hours of data acquisition. Verified water level data should be available from the CO-OPS website within seven days if the station has been placed on the Hydro Hot List. If a station is not on the Hydro Hot List, verified data may take up to a month to be posted. Final water levels should be requested from CO-OPS, via a Request for Tides package that can be automatically generated using Pydro software. Guidance for submitting a Request for Tides is included in section 5.2.2.3.3 .

#### **3.5.2.3.1 Hydro Hot List**

CO-OPS maintains a list of water level stations that are currently providing data for OCS hydrographic surveys. This list is referred to as the “Hydro Hot List.” If a water level station is on the Hydro Hot List, it is monitored by CO-OPS’ Continuously Operating Real-Time Monitoring System (CORMS) and its data are given priority over other gauge data for office processing. Field units shall notify CO-OPS by e-mailing: [nos.coops.hpt@noaa.gov](mailto:nos.coops.hpt@noaa.gov) and [nos.coops.oetteam@noaa.gov](mailto:nos.coops.oetteam@noaa.gov) when data acquisition begins for a new survey so that the associated water level stations can be put on the Hydro Hot List. Include the following information in the email: project name and number, start and end date, and the names of the required gauges. CO-OPS should also be advised when hydrographic survey data acquisition has been completed in an area so that stations can be removed from this list. The Hydro Hot List can be found at <http://tidesandcurrents.noaa.gov/hydro.shtml>.

#### **3.5.2.3.2 Fetchtides**

Fetchtides is a procedural program which allows a user to retrieve tides data from a variety of sources including data e-mailed from tidebot, data in local files, and live data available through CO-OPS’s Web Services. fetchtides then provides a mechanism to store the imported data locally and then combine multiple days worth of data into one CARIS readable tide file.

### 3.5.3 GPS Horizontal and Vertical Positioning

NOAA hydrography frequently requires GPS positioning of features in the survey area independent of depth sounding operations. Field units have a range of equipment and techniques at their disposal to perform these measurements. While each survey will have slightly different requirements, typical operations are summarized in Table 3.4. The rationale for recommended or required durations of GPS observations is given in Table 3.5. Exact requirements can be found in the NOS Hydrographic Surveys Specifications and Deliverables or the relevant Project Instructions.

Accuracy Regime	Typical System	Typical Technique	Typical Applications
Sub-Meter horizontal and/or vertical.	Dual-frequency receiver; constant height tripod	Two 6 hour occupations  OPUS post-processing with precise ephemeris	Water level station geodetic benchmarks with vertical accuracy of 2 cm @ 95% confidence*  portable DGPS Reference Station Control Points Horizontal Accuracy: 3rd Order or better (~1m @ 95% confidence)  Range Markers Horizontal: 0.1m @ 95% confidence
0.5 - Meter Horizontal	Single Frequency Portable GPS Receiver (Trimble ProXRS or similar)	5 minutes of static L1 GPS data and differential correction	Ground Control Point Positioning by Navigation Response Teams for the National Geodetic Survey's Remote Sensing Division.
1m @ 95% Confidence Interval	Single Frequency Portable GPS Receiver (Trimble ProXRS or similar)	10 to 15 minutes of static occupation  Post-processed differential correction (Pathfinder Office utility or similar)	Fixed ATONs (beacons or lights)  Mooring Facility features used for zero visibility docking
5m @ 95% Confidence Interval	Survey Vessel DGPS or Single Frequency Portable GPS Receiver (Trimble ProXRS or similar)	DP with offset, short static occupation, or roving as appropriate	Floating ATONs  General Shoreline Features

Table 3.4: Typical GPS Positioning Scenarios

\*Per requirements of the CO-OPS Users Guide for GPS Observations and NGS-58.

Recommended or Required Duration of Observation	Explanation	For Horizontal or Vertical Positioning
5 Minutes	Due to advances in GPS technology, sub-meter horizontal positioning is now possible with an observation period of 5 minutes using the parameters found in Table 3.6	Horizontal Only
15 Minutes	Minimum recommended for OPUS-RS which may be a preferred alternative for much of your work. Unfortunately, it doesn't work in most remote locations or far offshore.	Horizontal and Vertical
2 Hours	Minimum recommended for normal OPUS and is fine for your accuracy needs.	Horizontal and Vertical
4 Hours	Minimum required for OPUS database (at least for now).	Horizontal and Vertical
6 Hours	May be considered overkill, but preferred whenever practicable; e.g., if the system is set up to automatically record unattended and would be left set-up anyway	Horizontal and Vertical
2nd Observation	This is basic geodetic practice, but probably won't tell you much unless you really try for an independent observation with a new observer, independent antenna setup and measurement, etc.	Horizontal and Vertical

Table 3.5: Rationale for recommended or required durations of GPS observations.

It should be noted that independent observations are the key to survey confidence. If the hydrographer is using the same equipment, then it isn't true independence but it will give at least different satellites, different atmosphere, different ephemeris which could be an issue, at least theoretically. Whenever there is a convenient opportunity to collect more observations, it is recommended to do so and prove from repeated consistent OPUS results that you know where you are.

### **3.5.3.1 Sub-Meter GPS Positioning**

#### **3.5.3.1.1 Equipment for Static Positioning**

Operations which require sub-meter accuracy measurements of horizontal and/or vertical position are generally accomplished with the following equipment:

- Dual Frequency (L1/L2) GPS receiver with internal logging, and appropriate batteries.
- L1/L2 ground plane GPS antenna.
- Antenna cable less than 10m in length. Shorter is better, but if you have or need longer (to protect receiver or observer), then use it. Cables should be treated gently to avoid lost or noisy signal which will decrease accuracy.
- Tripod or light bracket for antenna mounting (Fixed-height Tripod for high accuracy vertical measurements).

The following additional equipment is typically needed to install the GPS equipment:

- Magnetic Compass (for antenna orientation).
- Observation Log (see HorCon\_VerCon\_Obs\_Log.pdf in Appendix 3).
- Eyebolts, rock drill, rope/cable, etc. as required to secure antenna for long duration observation sessions.
- Digital Camera for site documentation.

#### **3.5.3.1.2 Observations for Static Positioning**

Sub-meter GPS positioning requires concurrent observations at one or more Continually Operating Reference Station (CORS) sites and/or other pre-existing control stations with accuracies of at least a 1st order triangulation (for sub-meter horizontal measurements) as well as vertical control for accurate vertical measurements. For best results, the control station should be within 75km of the measurement site. Longer distances may be unavoidable in remote areas but may necessitate longer observation sessions to achieve the same order of accuracy. Both CORS sites and supplemental reference station information is provided on the National Geodetic Survey CORS website: <http://www.ngs.noaa.gov/CORS/>.

To perform GPS observations, first assemble the tripod or light bracket (for fixed lighted ATONs) over the point for which a new position will be determined. Be certain that the antenna is plumb to the mark, oriented north, and level to the earth. Accurately measure the height of the antenna reference point.

Once the antenna has been properly set up, connect the GPS receiver and check that it has the expected number of satellites in view and is computing a position. If performing a vertical position measurement on the geodetic benchmark of a water level station, ensure that the Vertical Dilution of Precision (VDOP) is less than 6.0 (as required by the CO-OPS Users Guide for GPS Observations and NGS-58, included in Appendix 3). At sites with poor satellite visibility, it may be necessary to use a GPS constellation prediction tool such as the Trimble Planning software to schedule sessions for best available satellite geometry.

Configure the GPS receiver to record GPS pseudo ranges for the appropriate amount of time to meet both accuracy specifications and post-processing requirements. There are several methods that can be used to postprocess GPS data; however, NOAA hydrographic field units typically use NGS's Online Positioning User's Service (OPUS), which utilizes data from three nearby CORS sites and is available at <http://www.ngs.noaa.gov/OPUS>. To ensure that the data can be processed using OPUS, the following guidelines should be followed during data acquisition:

- Recording intervals on the GPS receiver(s) should be set to 15s or some multiple that coincides with the three nearest CORS site sampling rates. Sampling rates for each CORS site may differ and can be reviewed on the NGS CORS website.
- If using more than one receiver for an observation session, all of the receivers should be set to the same recording interval, since there must be common data between all stations.
- Observation times should be a minimum of two hours. For a strong OPUS solution, at least two hours of good data are needed. NGS recommends four hours of good data to achieve horizontal accuracy of 0.035 m. For further information on positioning, refer to the following Users\_Guide\_for\_GPS\_Observations At Tide and Water Level Station Bench Marks: <http://tidesandcurrents.noaa.gov/pub.html>
- OPUS can convert them to RINEX for most receivers. If not, before uploading GPS files to OPUS, convert them to RINEX2 format using the RINEX Conversion module included with the receiver manufacturer's software.
- Monitor the position and positional dilution of precision (PDOP) information displayed on the GPS receiver. PDOP is a unitless value that indicates the degree of position error in a measurement. Do not start logging data until PDOP is below six. Maintaining a PDOP less than six will help ensure that the observation file contains clean data that will not be rejected by quality control checks performed by OPUS. Note: Some systems will automatically begin logging data when powered on. In such cases, the user may need to manually stop a session once PDOP is below six, create a new session in the receiver, and start a new session so that data begin logging under a new file name. The first file can be easily deleted after downloading data.
- An observation log for every setup shall be completed by the observer(s) on site. A blank HorCon/Vercon Observation Log is included in Appendix 3 (HorCon\_VerCon\_Obs\_Log.pdf).

Additional detail on processing GPS Observations with OPUS can be found in section 4.4.1 .

### **3.5.3.1.3 Ellipsoidally Referenced Surveys**

ERS vertical control is discussed in Appendix 4 of the FPM and in Chapter 9 of the HSSD.

### **3.5.3.2 Meter-level GPS Positioning**

While horizontal position to 1m accuracy can be accomplished with the same equipment described above for higher accuracy measurements, it is often more efficient and convenient to utilize portable single frequency logging GPS receivers for this purpose. The Trimble ProXRS receiver with TSCe data collector or notebook PC is an example of this equipment commonly found in NOAA field unit inventories.

The Trimble Pathfinder ProXRS is a backpack GPS system which combines a GPS receiver and a beacon differential receiver. Although a single frequency (L1) GPS receiver, the ProXRS is capable of logging carrier phase data, which can be post processed to recover significantly improved positional accuracy. With the addition of the TSCe data collector, this system can be used to acquire static point or roving line data, and immediately assign object types and attributes based on the S-57 catalog. Static position accuracies of 1m or better can be attained when the system is used to occupy a point for a minimum of approximately 10 minutes, and the resulting data is post-processed with Trimble Pathfinder Office software.

### **3.5.3.2.1 System Software**

Two types of software are used to conduct operations with the Trimble Pathfinder unit. GPS Pathfinder Office software is used to create an initial configuration file for the ProXRS receiver and allows field personnel to post-process logged GPS data, including converting data into Shapefiles, which can be exported to Pydro. Trimble TerraSync software runs on the TSCe data collector or notebook computer, and is used to control the ProXRS receiver and log and attribute data. Refer to the TerraSync Operation Guide found on the Hydrosft website for specific information on this software.

### **3.5.3.2.2 System Configuration**

Prior to acquiring data with the Trimble Pathfinder system, a project and configuration file must be created. Both of these tasks should be completed using GPS Pathfinder Office software, although field adjustments can be made to the configuration file using TerraSync. Refer to the GPS Pathfinder Office Getting Started Guide, found on the Hydrosft website, for specific details on how to create a project and configuration file. Numerous parameters must be entered in the configuration file. Those which have been recommended for use by OCS are listed in the table below.

<b>Configure Parameters</b>	<b>OCS Recommended Value</b>
Log SuperCorrect Data	Yes
DOP Type	HDOP
HDOP Mask	2.5
PDOP Mask	6.0
SNR Mask	4
Elevation Mask	10 degrees
RTK Static Precision- Horizontal	5.0 cm
RTK Static Precision - Vertical	5.0 cm
TK Roving Precision- Horizontal	10.0 cm
RTK Roving Precision- Vertical	15.0 cm
RTCM Age Limit	20 s
Integrated Beacon Mode	Manual
Integrated Beacon Frequency	varies by area
Coordinate System	Latitude/Longitude
Datum Name	NAD83
Distance Units	Meters
Altitude Reference	HAE (height above ellipsoid)
Area Units	Square Meters

Table 3.6: Recommended Trimble Pathfinder Pro XRS Configuration Parameters

\*Per NOAA Technical Memorandum NOS NGS 58, for observation sessions less than 30 minutes, data collected below the 15° elevation mask angle should only be used if required to derive a successful GPS solution. OCS recommends acquiring data at an elevation mask of 10°, and increasing the elevation angle to 15° during postprocessing. If data will not be post-processed, a mask of 15° should be used during acquisition. A copy of NOS NGS 58 is included in Appendix 3 (NGS-58.pdf).

### 3.5.3.2.3 Data Dictionary

The Trimble Pathfinder Pro XRS uses a digital Data Dictionary to attribute data acquired with the unit. NOAA hydrographic field units shall use the Data Dictionary as a base for acquiring S57 attributed data. The Data Dictionary should be loaded into TerraSync on the GPS datalogger or PC being used to record data. Consult the GPS Pathfinder Office Getting Started Guide, found on the Hydrosoft website for further information on editing the Data Dictionary.

### 3.5.3.2.4 Recording Data

The Trimble Pathfinder Pro XRS can record position data as points, lines, and areas. Recording procedures will vary depending upon the position accuracy required. In general, a single geographic position with real-time differential correctors applied should be accurate within 2-5 meters and adequate for positioning features such as large shoreline features and bottom samples. The TerraSync acquisition software also includes options for applying offsets to a position which can not be directly accessed. Position offsets can be defined by a distance and bearing from a recorded point (distance/bearing), distances from two recorded points (distance/distance), bearings from

two recorded points (bearing/bearing), distances from three recorded points (triple distance), or bearings from three recorded points (triple bearing). Distances and bearings can be either visually estimated or measured using a laser range finder and compass. Of these options, triple distance offsets measured with a laser range finder will provide the most accurate position, but this method may not always be feasible or necessary. The hydrographer should use the most efficient method of positioning that will meet data specifications.

When recording line data, the operator can configure the Trimble Pathfinder Pro XRS to record positions at specified time intervals. For positioning linear shoreline features such as piers, hydrographic field unit experience has shown a 1 second recording interval to be sufficient in most cases. A shorter interval may be necessary for more complex features, or multiple single points may more accurately portray a feature that requires indirect routes between corner points such as a cluttered pier. Refer to the GPS Pathfinder Systems User Guide, found on the Hydrosoft website, for detailed information on Trimble Pathfinder Pro XRS operating procedures.

Higher accuracy positioning can be obtained by static occupation of a site for multiple position measurements, and/or post-processing ProXRS data with the Trimble Pathfinder Office software's Differential Correction Utility.

### **3.5.3.3 Special Instructions for Positioning Aids to Navigation (ATONs)**

Positions and characteristics for all ATONs within a survey area shall be visually observed and compared to both the largest scale chart and current USCG Light List information during survey operations.

Note: Any ATON that is not serving its intended purpose, off-station, damaged, otherwise compromised, or uncharted and is determined by the field unit to present a hazard to navigation shall be immediately reported to the local USCG district.

NOAA's Update Service Branch (USB) will assign specific ATONs (fixed type only) which require positioning based on NOAA's Critical Corrections Database (CRIT) and/or USCG Integrated Aids to Navigation Information System (IATONIS) database records. Information for assigned ATONs will be provided on the Project CD/DVD. Additional ATONs may be positioned at the field unit's discretion if determined to be navigationally significant. Unless specific positioning methods or accuracies are assigned in the Project Instructions, ATONs throughout the survey area shall be investigated, and positioned if necessary, in accordance with the following guidance:

- Assigned Charted Fixed ATONs – If possible, the field unit shall position each fixed ATON assigned by MCD. Assigned ATONs shall be positioned to an accuracy of less than one meter, at a 95% confidence level, unless otherwise specified - such as range markers, which shall be positioned to within 4 cm precision and reported to one-thousandth of a second of latitude (0.001'). Many NOAA hydrographic field units meet this accuracy criteria by performing static GPS observations for minimum a period of 10 to 15 minutes and post-processing position data using correctors from the nearest CORS station (e.g., using the Differential Correction utility in GPS Pathfinder Office software as described in 3.5.3.2.1 ). If obtaining this level of accuracy is unfeasible, but the field unit is able to acquire a higher quality position than that in the current database record, an upgraded position should be determined and included in the ATON Report (see section 5.2.2.3.4 . Acquisition methods and limitations should be described in the comments section for that ATON.
- Unassigned Charted Fixed ATONs – Charted fixed ATONs will not be assigned if a position accurate to less than one meter, at a 95% confidence level, has already been determined. If an unassigned fixed aid is observed to be significantly off station based on the largest scale chart, the hydrographer should review the USCG Local Notice to Mariners (LNM) for a discrepancy report on the aid. (Discrepancy reports are issued by the USCG when an ATON is known to be off station, but the agency has not yet been able to repair the aid. These reports are contained in section 2 of each LNM.) If no discrepancy report has been published, the local USCG district

should be contacted to determine whether the aid was compromised or intentionally relocated to serve its intended purpose. Following USCG confirmation that the aid is correctly positioned or has been properly relocated, the field unit should re-examine the aid. If it remains off station, this ATON should be positioned and reported as if it was an assigned aid.

- Uncharted Fixed ATONs – This category of ATON is typically comprised of privately maintained aids, and the field unit must determine if such an ATON is navigationally significant. If navigationally significant, a position should be acquired and the ATON reported as if it was assigned. For private aids reported, the field unit should specify both the apparent purpose and by whom the aid is maintained in the report.
- Charted Floating ATONs – The field unit shall visually verify positions and characteristics of charted floating ATONs during survey operations. If a floating aid is significantly off station with both the scale of the chart and scope of chain considered, the hydrographer should review the LNM for a discrepancy report on the aid. Note: Temporary positions of aids relocated to facilitate dredging, construction, or similar activities are typically not charted. If no discrepancy report has been published, the local USCG district should be contacted to determine if the aid was compromised or intentionally relocated to serve its intended purpose. Following USCG confirmation that the aid is correctly positioned or has been properly relocated, the field unit should re-examine the aid. If it remains off station, acquire a detached position (DP) for the ATON and report this item as if it was an assigned aid. Static GPS observations are not required when positioning floating aids.
- Uncharted Floating ATONs – The field unit shall determine if each uncharted floating ATON is navigationally significant (e.g., a mooring buoy or full-size private buoy, typically not a small private float). If navigationally significant, the field unit should acquire a DP for the ATON and report this item as if it was an assigned aid. Static GPS observations are not required when positioning floating aids.

For each survey, the field unit shall digitally submit an ATON Report to MCD as described in section 5.2.2.3.4 .

### **3.5.4 Bottom Samples**

Bottom samples are typically obtained and analyzed in accordance with section 2.5.4.2.1 of this manual and section 7.1 of the HSSD, and then discarded. Several sizes of bottom samplers are used in the NOAA hydrographic fleet, and the field unit shall use the most appropriately sized bottom sampler for the vessel and conditions. If the bottom sampler is successfully deployed and tripped three times, yet no sediment sample is acquired, the station shall be labeled "unknown" unless additional knowledge is available to the hydrographer. If sediment samples are to be retained for future analysis, guidelines will be provided in the Project Instructions.

### **3.5.5 Nearshore Hydrography and Shoreline**

All modern NOAA hydrographic surveys are Navigable Area Surveys, unless explicitly stated otherwise in the Project Instructions. The navigable area concept is defined in section 1.1.2 of the HSSD. Working near shore is inherently dangerous, and all field units are reminded that safety shall always be the primary consideration when conducting operations. Shoreline verification should not be attempted unless conditions are favorable. Even though an initial assessment is made by the Chief-of-Party, conditions at the actual survey area may be different or degrade as the day progresses. In such cases, the launch or skiff personnel shall not perform shoreline operations until conditions are favorable.

### 3.5.5.1 Source Shoreline Data

Unless otherwise specified in the project instructions, HSD Operations Branch/Navigation Response Branch shall compile and provide a Composite Source File (CSF) and a Project Reference File (PRF) for all projects.

The composite source is an S-57 attributed dataset in .000 file format, compiled from one or a combination of the following sources: largest scale ENC's, preliminary ENC's, GC's and/or Lidar junction surveys. During planning the project planner reviews the sources listed above to ensure the shoreline files reflect the most recent data coverage for the project area. The following list is a description of how each source is applied to the CSF:

- ENC's – the largest scale ENC's of an area are applied to the CSF. If ENC's of different scales overlap, the larger scale ENC is used to “clip” (remove) the smaller scale ENC so there is only one instance of all features at the largest scale for the area.
- Preliminary ENC's – Preliminary ENC's are ENC's which have had source applied (e.g. GC) but the ENC has not been reviewed by MCD and released to the public. Preliminary ENC's are applied to the CSF in the same manner as different scale ENC's. A preliminary ENC may be used to clip the ENC ensuring only one instance of all features.
- GC's - GC's that have not been applied to the ENC will be applied to the CSF by clipping the existing ENC shoreline (COALNE) and replacing it with the GC shoreline. All remaining GC features are added to the CSF. There is no further clipping of other features. This may result in duplicate features such as rocks or piles in the CSF which will need to be reconciled by the field unit during verification.
- Lidar Surveys – Lidar junction data is applied to the CSF by adding the approved Lidar features to the CSF. No clipping occurs with the addition of Lidar features which may result in duplicate features which will need to be reconciled by the field unit. (Note, HSD is currently not using shoreline (COALNE) from Lidar surveys)

The source of each feature is indicated in the SORDAT and SORIND attribute fields.

The project reference file is an S-57 attributed dataset containing reference layers (i.e. sheets, junctions, recommended bottom sample positions) and features which are specifically targeted for further investigation, such as items from the Automated Wreck and Obstruction Information Service (AWOIS) database, Maritime Boundary, or those surveyed by Lidar but not fully resolved.

Reference Features	S-57 Object	Description
Investigation Items	CRAINES	AWOIS, Lidar, Maritime Boundary investigation items
AWOIS Radii	ACHBRT	AWOIS Search Radius
Survey Sheets	TESARE	Outline of the survey sheet*
Junction Surveys	TWRTPT	Outline if junction survey
Bottom Samples	SPRING	Recommended bottom samples locations

Table 3.7: Features contained in the Project Reference File from Operations Branch

\*Note: The inshore limit has been clipped at the 0.8 mm bufer. The buffer will no longer be supplied as a seperate S-57 object.

For reference, prior survey features may be provided in S57 format on the project CD/DVD in the prior survey folder.

### 3.5.5.2 Types of Shoreline Verification

Hydrographic Survey Project Instructions will specify which shoreline source documents are to be verified as well as the type of verification required, either “traditional” or “limited.” Shoreline source(s), chart scale(s), and local vessel traffic patterns are among the factors used in determining which method is appropriate for the survey area.

#### 3.5.5.2.1 Traditional Verification

Traditional shoreline verification is the most thorough and complete method, requiring full examination of all shoreline detail and features seaward of MHW. This technique is very rarely required, and is only necessary if the Project Instructions explicitly call for it. The hydrographer should examine all near shore detail and features seaward of the shoreline (MHW line) originating from composite source documents, NGS-verified remote sensing shoreline data, prior hydrographic surveys, and nautical charts. All features shall be verified, changed, or disproved, provided the operations can be conducted safely. Features located near the shoreline or some accurately plotted reference point may be verified by visual inspection.

#### 3.5.5.2.2 Limited Verification

Typically, a limited verification will be assigned for OCS hydrographic surveys. When conducting limited shoreline verification, the hydrographer shall examine all features seaward of the Navigable Area Limit Line (NALL) as defined in section 1.1.2 of the HSSD. If there is no MHW adjacent to features and the area is not safe to survey, then the area is determined to be foul. Features shall be examined in accordance with the following direction:

- All ENC, RNC, Preliminary ENC’s, Geographic Cells, and contemporary LIDAR features in the composite source file that are seaward of the NALL should be verified or disproved. If a feature is found within 2 millimeters at the survey scale of the composite source position, a revised field position is not required (This 2mm tolerance does not apply to fixed ATONs specifically assigned for updated positions. See section 3.5.3.3 for additional guidance on these features.). Heights/depths of all features seaward of the NALL should be determined by the best means available given the sea conditions at the time of the survey

Chart Interval (millimeters)	Survey Scale	Ground Distance (meters)
2mm	1:5,000	10m
2mm	1:10,000	20m
2mm	1:20,000	40m
2mm	1:40,000	80m
2mm	1:80,000	160m
2mm	1:100,000	200m

Table 3.8: Common survey scale examples of the chart interval 2mm converted to ground distance.

- New features seaward of the NALL should be properly positioned.
- New point features and new area features where the high point may be used for a navigational landmark also require a corresponding height/depth. Composite source features that are correctly charted do not require corresponding height/depth verification.

- Features with any horizontal dimension greater than 1.0mm at survey scale should be treated as area features and delineated appropriately. Features with lesser horizontal dimensions should be positioned and attributed as point features.
- The hydrographer shall address blatant and obvious shoreline discrepancies between hydrography and deconflicted features in the Composite Source File.
- Prior survey features are for reference only. There is no requirement for the hydrographer to address prior survey features in the Descriptive Report.

It may be necessary to position, verify, or disprove some features inshore of the NALL, if they are both navigationally significant and safe to approach. Examples of features which might meet this standard include:

- Aids to Navigation
- Natural or man-made features sufficiently conspicuous to be an obvious navigational landmark (e.g., piers, pilings, or very large and isolated boulders or outcroppings)

Note: “Navigationally significant” is not easily and absolutely defined. As such, it makes up part of the “art” of hydrography versus the more easily quantifiable “science” aspect of the profession. Navigational significance depends on location, proximity to shore and/or other features and the marine traffic patterns/usage in the area. Ideally the person making the determination of navigational significance will be one who has extensive experience utilizing NOAA/NOS charts for navigation and can convey that perspective to the persons conducting the field survey work. This is typically the NOAA vessel Commanding Officer (Chief-of-Party) or Field Operations Officer, Hydrographer-in-Charge, or the contractor’s Lead Hydrographer.

### **3.5.5.3 Conducting Shoreline Verification**

Shoreline verification operations should be scheduled for daylight periods when the tide is less than 0.5m above Mean Lower-low Water (chart datum). To maximize the shoreline “window”, it is usually advantageous to plan for shoreline operations during spring tides when the extreme range allows for longer low water periods each day. In some cases, ideal water level conditions may not be available while the field unit is in the project area. In these cases, the Chief-of-Party should request further instructions from the Chief, HSD Operations Branch. Shoreline verification should be performed prior to main scheme bathymetric data acquisition in nearshore areas to ensure that submerged hazards have been identified to the fullest extent possible before launches with protruding transducers operate in the area.

Shoreline verification is typically conducted from a small, maneuverable survey vessel such as a skiff or jet-drive survey launch. The vessel should be equipped with survey-grade GPS and vertical beam or tilted multibeam echosounder interfaced to an appropriate data acquisition computer and software. Multibeam echosounders which are mounted perpendicular to the seafloor (i.e. not tilted) are not ideal for shoreline verification because of the increased risk of damage to hull-mounted transducers when operating in unsurveyed nearshore areas.

The vessel’s data acquisition software should be loaded with the composite source and other applicable files (ENC, RNC, and Project Reference File). In addition, it is often helpful to print a large “boat sheet” of the composite source on a large format printer. This is useful for orientation and quickly recording field observations.

A common and effective method for conducting shoreline verification is to run a VBES survey line parallel to shore, observing exposed features. In the case of Limited Shoreline Verification, this survey line should approximate the NALL, allowing the hydrographers to focus most of their attention offshore of the vessel. This approximate NALL can be used later to assist in planning the inshore extent of bathymetry. As features meeting the criteria given in section 3.5.5.2 are encountered, the survey vessel should break off from following the NALL, investigate the features as required, and return to following the NALL.

Note that not all features require or even warrant investigation at low water. To maximize efficient use of low water windows, it may be best to skip these features on the initial pass, and return at a higher stage of tide. In extreme cases, it may be possible and advantageous to acquire complete MBES coverage of features which are exposed at low water.

### **3.5.5.4 Recording Shoreline Data**

Point features are generally positioned using Detached Positions with a range and bearing from the survey launch, or by direct occupation with a portable GPS system. Line features or the extents of areas can be bounded by recording data as the launch passes as close as possible to the feature, taking DPs at the extents of the feature, or using a roving portable GPS to walk the extents ashore. In all cases, it may be prudent to take written notes on log sheets and/or the boat sheet in addition to recording data digitally.

Accuracy requirements for point positions depend on the type of feature being located. If the feature is a wharf or pier potentially to be used for zero-visibility docking, the horizontal position error should be 1.0 meter or less. For features not critical to zero-visibility navigation or docking, accuracy for all points should meet the minimum horizontal position accuracy requirement set forth in the HSSD. The method of positioning a feature to the required accuracy is typically left to the discretion of the hydrographer, subject to the guidance in section 3.5.3 .

When recording line data, positions are logged at regular intervals small enough to facilitate a “connect the dots” drawing of the area. Line data is a valuable tool for accurately delineating curved or irregular features. OCS recommends that line data used to define such features be acquired with a data collection interval of one second.

All data should be acquired with S-57 and NOAA attribution collected at the times of acquisition. While many S-57 object types and attributes are self-explanatory, the hydrographer should consult the S-57 catalog for further guidance.

## **3.5.6 Maritime Boundary Delineation**

### **3.5.6.1 Background**

OCS is responsible for depicting the Three Nautical Mile Line (old territorial sea), Territorial Sea at 12 nautical miles, Contiguous Zone at 24 nautical miles, and Exclusive Economic Zone (EEZ) at 200 nautical miles on NOAA nautical charts. These maritime zones, whose limits are measured using principles set forth in the United Nations Convention on the Law of the Sea (UNCLOS), define areas of U.S. jurisdiction for a variety of regulations. Noteworthy examples that highlight the importance of near-shore surveys include provisions of the Clean Water Act and Oil Pollution Act, which are tied to the inner and outer extents of the old territorial sea at 3 nautical miles. In addition, the Three Nautical Mile Line is often used by state and federal enforcement officials to police fisheries and other laws.

Figure 3.7 highlights the breadth of offshore maritime and marine boundaries. Among a host of marine boundaries, the U.S. maritime zones (in red) include the territorial sea (0-12nm), contiguous zone (12-24nm), and EEZ (12-200nm). The U.S. also retains and charts a territorial sea at 3nm, which supports enforcement of the Clean Water and Oil Pollution Acts. All of these zones are measured from the U.S. baseline, which is largely composed of the charted low water line (at MLLW) as well as closing lines across legally-defined bays and rivers. Various federal, state, and local governments reference the limits on NOAA nautical charts as well as best practices for defining those limits to enforce their own regulations.

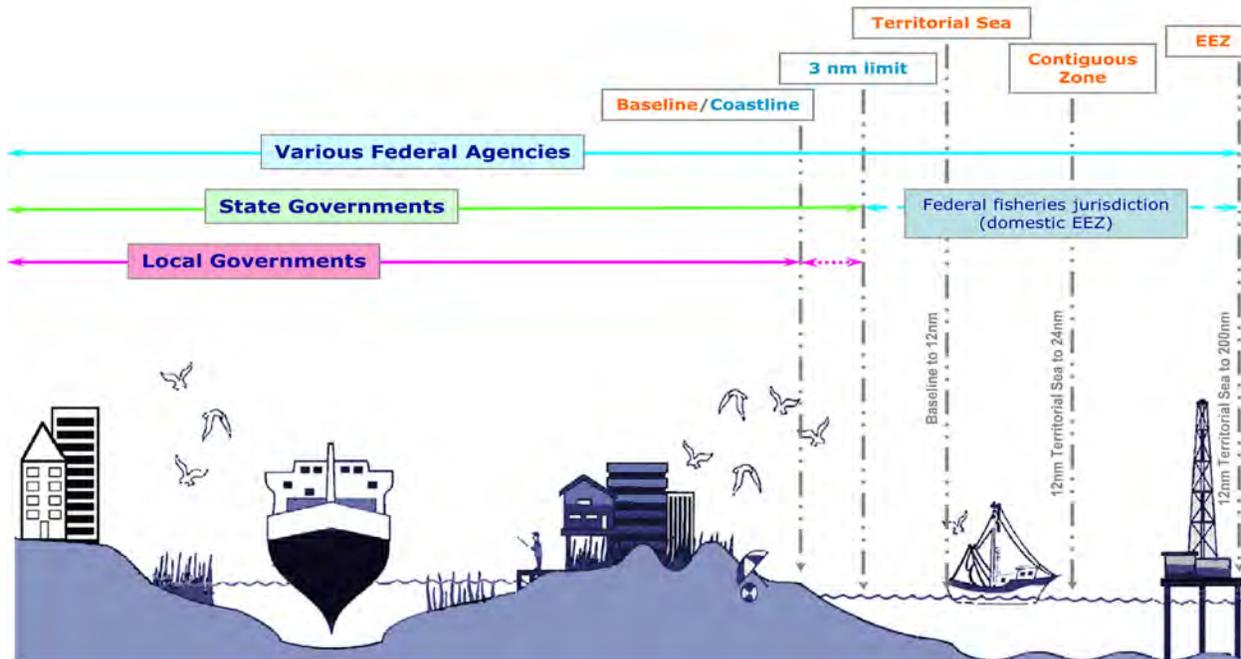


Figure 3.7: Breadth of Offshore Maritime and Marine Boundaries

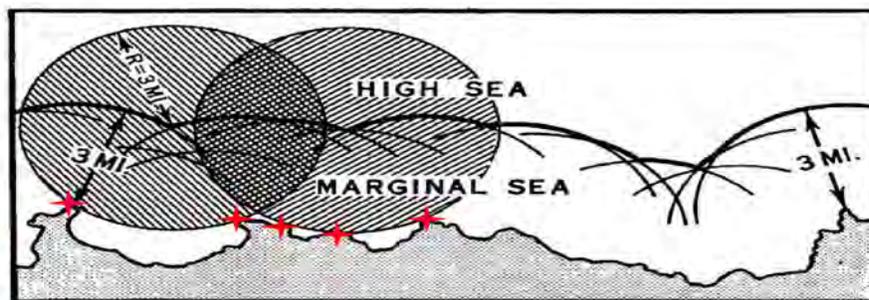


FIGURE 27.—The envelope line is the locus of the center of a circle rolled along the coastline with circumference always in contact with it.

★ Contributing Baseline Points

Figure 3.8: Normal baseline with projected envelope of arcs  
(from “Shore and Sea Boundaries by Shalowitz)

In accordance with customary international law and UNCLOS, the U.S. maritime zones are measured from what is referred to as the “normal baseline.” Simply stated the normal baseline is composed of features that are dry at mean lower low water (MLLW). This includes naturally-formed offshore rocks awash and harbor structures, such as groins, jetties, and breakwaters (not recreational fishing piers). The maritime zones are measured from the baseline using a method called “envelope of arcs” (see Figure 3.8). Using this method, only the most seaward features influence the outer limits of the U.S. maritime zones.

Arcs generated from these salient baseline points are blended together to form continuous limit lines at 3, 12, 24, or 200 nautical miles. Finally, the U.S. baseline as well as the maritime zones are reviewed and approved by an inter-agency federal group called the U.S. Baseline Committee, which was established in 1970 and is chaired by the Department of State.

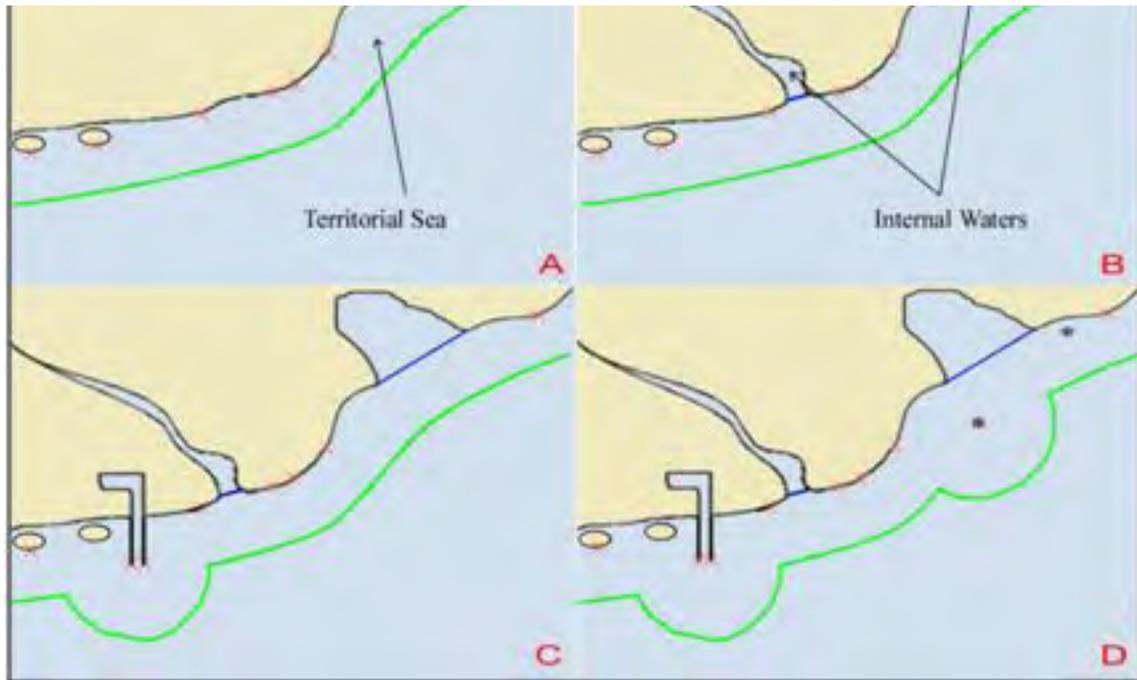


Figure 3.9: Near-shore Feature Impacts to Offshore Limits

Figure 3.9 highlights how near-shore features can impact the offshore limits. Occasionally and depending upon segment length and orientation, closing lines across legally-defined bays and rivers (another component of the U.S. baseline) will influence the outer limits of the U.S. maritime zones. The territorial sea is measured from a normal baseline, which generally consists of the mainland low-water line and offshore islands (A), plus any closing lines across the mouths of rivers or legal bays (B), the outermost points of permanent harbor works (C), and low-tide elevations wholly situated at a distance not exceeding the breadth of the territorial sea from the mainland (D). Contributing baseline points, which are used to generate the maritime limits, are denoted as red Xs.

Determining the exact nature of charted low-water features is not always straightforward, and to aid enforcement of the U.S. maritime zones, U.S. policy is to refrain from using uncertain features in the baseline. The most controversial feature is the charted rock awash because many times compilation of older surveys to the nautical chart did not include height information. In addition, the rock awash symbol is compiled through different standards with east coast (includes Gulf of Mexico), west coast and Great Lakes surveys. The standards for compiling rocks and islets to the nautical chart can be found in the HSSD Appendix 8: Rock Attribution and in excerpts from MCD's Nautical Chart Manual sections 4.9.1 and 4.9.2.

### 3.5.6.2 Procedures

The maritime boundary verification requests are compiled by HSD OPS and delivered to the field units in the Project Instructions. The point features are included in the Project Reference File (PRF) as the S-57 Object CRANES and are distinguished by the NOAA Extended Attribute "Special Feature Type" (sftype) populated with MARITIME BOUNDARY. The hydrographer is responsible for verifying the existence of the furthest offshore feature that is dry at MLLW recognizing that the furthest offshore feature may not be the feature within close proximity to the Maritime Boundary investigation point.

See sections 7.3 Investigation Items and 8.2 S-57 Soundings and Feature Deliverables of the HSSD for further information on Maritime Boundary point requirements and attribution.

Note, if MBES was used for verification the hydrographer should not delineate the linear MLLW on the field deliverable as this is performed by cartographers at the branches.

#### **3.5.6.2.1 Processing & Deliverables**

Maritime boundary features are flagged in the processing software as Maritime Boundary features. The field notes are updated in the Remarks attribute and digital photographs are labeled and correlated to the Maritime Boundary item. If MBES was used for verification the hydrographer should not delineate the linear MLLW on the field deliverable as this is performed by cartographers at the branches. Point features covered by MBES should follow the standard procedures as described above.

#### **3.5.7 Coast Pilot Data**

A Coast Pilot Review shall be conducted for each assigned survey area. The review consists of downloading the appropriate Coast Pilot section for verification and updates. In addition, reviewing the information relating to general operations in the area such as frequent transited areas and facilities utilized. See section 7.4 of the HSSD for further information on requirements and the sections below for procedures.

### **3.5.7.1 Performing a Coast Pilot Review**

When determining what information is pertinent for the Coast Pilot, the size, type, and number of vessels using each waterway must be taken into account. The requirements of the deep-draft navigator, yachtsman, and fisherman must all be kept in mind. Allowance must also be made for the thoroughness with which the region has been surveyed and charted. If the surveys of the area are incomplete, if the harbor charts are on too small a scale, or if the harbor has grown in importance, more detail will be required in the Coast Pilot. If possible, digital photographs should be submitted for significant Coast Pilot features in accordance with section 3.5.7.2.

If additional information is necessary to address a Coast Pilot item, a wide variety of locally knowledgeable people can be used. However, information from outside sources should be verified by the reviewer. The source of the report should be given so that the report's value may be weighed against conflicting information that may be received by NOAA's Marine Chart Division. The following is a list of the principal organizations and officials who can be interviewed for the purpose of obtaining local information: Coast Guard stations and other aids to navigation units, buoy tenders and other cutters, patrol craft, and Marine Safety Offices

- Corps of Engineers district offices or other Federal field offices such as Customs Service
- Pilot associations, port authorities, harbor masters, and harbor police
- Other NOAA field parties operating in the area
- Operators of repair yards and marine service stations
- Captains of towboats, ferries, and coastwise vessels operating in the area
- Individuals very familiar with the area such as fishermen and longtime residents
- Yacht clubs

The following sections describe categories of information that should be addressed during a Coast Pilot Review. The majority of this information is best obtained during field operations and is thus considered a part of data acquisition.

#### **3.5.7.1.1 Aids to Navigation**

Every effort should be made to ensure that aids to navigation referenced in the Coast Pilot are correctly identified and in agreement with both the chart and the Light List. Information regarding significant new aids to navigation (e.g., buoys/lights marking specific dangers to navigation) should be added.

#### **3.5.7.1.2 Anchorages**

Attempt to obtain information on both charted and uncharted anchorage areas. The adequacy and accuracy of anchorage information in the Coast Pilot should be checked, and new reliable information should be added when possible. Anchorage information is one of the most difficult types of information to obtain and check, since it must come from actual anchoring experience. Good judgment must be exercised by field personnel in obtaining such information. A particular location is not a good anchorage simply because someone has anchored there.

### **3.5.7.1.3 Bridges**

Note bridges that are in the process of renovation (to the extent that type of bridge, vertical clearance, horizontal clearance, or other description normally mentioned in the Coast Pilot is affected), bridges that have been newly constructed, and/or bridges that have been removed in whole or in part. Confirm proper names of bridges as included in the Coast Pilot or shown on the charts. Obtain new names as appropriate. Confirm or obtain VHF radio frequencies/channels monitored, hailing protocols used by local traffic and telephone contacts related to bridge operations, if applicable.

### **3.5.7.1.4 Channels**

Text referring to privately maintained channels and basins, natural channels, and federally maintained channels within the assigned survey area should be reviewed and updated as necessary.

### **3.5.7.1.5 Dangers to Navigation**

Review and update as necessary any Coast Pilot text addressing charted rocks, shoals, reefs, wrecks, piles, snags, and other objects dangerous to navigation within the survey area.

### **3.5.7.1.6 Depths and Sounding Data**

Once present survey soundings have been processed and compared to charted depths, any Coast Pilot text referencing specific depths within the survey area should be reviewed and updated as necessary. Note: The hydrographer should be certain that final water level correctors have been applied to sounding data prior to reporting specific depths in the Coast Pilot Review.

If new depth information is received for an area outside of the assigned survey, but can not be verified by approved NOAA hydrographic survey methods, this information can be included in the Coast Pilot as “reported.” Reported information should be avoided unless deemed critical for safe navigation. If reported information is used, it must be qualified as such, giving the date and the source of information. Reported depths are published in the Coast Pilot as shown in the following example: “In June 2004, the channel had a reported controlling depth of 3 feet.”

### **3.5.7.1.7 Ferries, Cable Ferries, and Pontoon Bridges**

Report the locations of new ferry terminals and routes and/or the abandonment of old ones. If applicable, include information about VHF radio frequencies monitored, hailing protocol, and telephone contacts. Cable ferries and pontoon bridges pose a potential hazard to mariners. Obtain detailed information on their operations. Information regarding operational peculiarities of any other movable bridges encountered should be included.

### **3.5.7.1.8 Landmarks**

Landmarks shall be inspected from seaward insofar as practicable. New landmarks considered to be significant for vessel navigation should be positioned with DGPS, if possible. Describe each landmark, including position, height, color and any other distinctive features that will aid in identification. Give the shape of objects that may not be generally recognized by the name alone, such as “the large white dish of the charted radiotelescope.”

### **3.5.7.1.9 Locks, Canals, and Hurricane Gates**

Operational peculiarities of locks, canals, hurricane gates, and other navigation projects should be noted. Include information about traffic signals, VHF radio frequencies/ channels monitored, hailing protocol, and telephone contacts, if applicable.

### **3.5.7.1.10 Overhead Cables**

Make note of overhead cables that are not charted and/or not mentioned in the Coast Pilot. Attempt to ascertain the following about the owner of the new cable: name of the company, address, telephone number, and name of a cognizant individual in the company. This information is necessary in order to obtain copies of the cable permits from the local District Engineer staff of the Corps of Engineers.

### **3.5.7.1.11 Major Deep Draft Ports**

Coast Pilot information pertaining to major ports, shipping terminals, and wharves within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Particular attention should be paid to depth information stated in the text.

If at all possible, the local pilot association should be contacted. Pilotage information is one of the most important items in the Coast Pilot. Pilots should be requested to read the pilotage section in the Coast Pilot and point out any errors and/or new information that should be added. Be sure to address where vessels are boarded or anchored for quarantine, and whether inspections are made by any U.S. Government agency.

Additional information, such as low altitude oblique photographs, may be obtained from a variety of sources such as the local port authority, harbor master, harbor police, and customs, immigration, public health, and agriculture officials at the port. Information on repair facilities can be obtained from shipyards and boatyards. Local towboat companies are often a good source of information, not only regarding the size and type of tugs available, but also for other information such as local peculiarities of winds and currents, the routes followed by tugs and barges, etc.

### **3.5.7.1.12 Small Deep Draft Ports**

Coast Pilot information pertaining to smaller deep-draft ports, shipping terminals, and wharves within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Particular attention should be paid to depth information stated in the text. Although small deep-draft ports do not typically have large port authority staffs, additional information may be available from the port's general manager.

### **3.5.7.1.13 Small Craft Harbors**

Coast Pilot information pertaining to small craft harbors within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Additional information may be available by contacting either the harbor master or harbor patrol personnel, as well as operators of towboats, boatyards, marinas, and state and federal agencies. Local yachtsmen and fishermen can be consulted when appropriate.

### **3.5.7.1.14 Radar and Radio Information**

If possible, obtain information on the best radar targets and the approximate maximum range at which they can be positively identified and used. The VHF radio frequencies/ channels used in port areas for different types of communications between various private and public concerns should be ascertained. Where a radio watch is maintained by pilots, harbor masters, bridge tenders, lockmasters, and other parties significant to the mariner, confirm guarding schedules, VHF radio frequencies, hailing protocol, and telephone contacts, if applicable.

### **3.5.7.1.15 Shoreline Changes**

Coast Pilot information pertaining to shoreline within the survey area should be reviewed and confirmed to whatever extent practicable via sounding data and reconnaissance during survey operations. Note condition, additions, and deletions of wharves, piers, and other waterfront structures. If a pier or other shoreline structure has been removed, note whether piles or ruins remain as a navigational hazard. Assume the existence of submerged ruins unless there is contrary evidence. Also report significant shoreline changes, whether caused by dredging and/or filling or by natural events.

If Coast Pilot information pertaining to shoreline outside of the survey area (e.g., areas frequently transited or facilities utilized during imports) can be verified or updated during survey operations, this information should be addressed in the Coast Pilot Review.

### **3.5.7.1.16 Wrecks**

If numerous wrecks are found to exist in a specific location, an attempt should be made to ascertain the causes from survey data and/or local sources. If a specific hazard is determined, suitable highlighting of the situation should be verified or added in the Coast Pilot.

In addition to the above categories of information, any anomalous conditions that may affect safe navigation should be addressed.

## **3.5.7.2 Digital Photographs**

When possible, digital photographs portraying significant Coast Pilot features should be acquired. Sea level photos should be taken from seaward, from as high a vantage point as possible and close enough so that principal landmarks can be identified. Photos taken successively from 2 miles out or less, typically upon entering or departing a harbor, may be useful in identifying the harbor approach or specific landmarks. If a single photo will not adequately cover the view of a harbor with sufficient detail, a panoramic series of photos can be submitted.

Digital photos submitted to the Coast Pilot Branch may be included in subsequent editions of the publication. To ensure photographs are of sufficient quality for publication, the following criteria should be met:

- The camera should have a resolution capability of 4 megapixels or better.
- A digital zoom feature should not be used. A camera with minimum optical zoom capability from wide angle (35mm) to a mild zoom (out to 105mm) is recommended. (Ideally, the camera would accept lenses of different focal lengths, such as wide angle, normal, and zoom.)
- Photographs should be taken using an ISO setting of 100 (preferred) or less, but in no case higher than 200.

- Shutter speed should be set to at least 1/100th of a second.
- The photograph should be taken using a pixel setting of approximately 2300 x 1700 or better.
- JPEG (\*.jpg) format is required for submission. Use of any other format should be cleared by the Coast Pilot Branch. Select “JPEG (EXIF)” if that choice is given. EXIF is a standard metadata format that embeds information about the camera and its settings such as focal length, shutter speed, lighting condition, and other valuable information about the photograph into the file.

### **3.5.8 Electronic Navigational Chart (ENC) Verification**

Verifications of ENC data are primarily performed by the NRTs. If ENC verification is required in conjunction with a standard NOAA hydrographic survey, it will be stated in the Project Instructions. Information regarding ENC shoreline and offshore features is given below.

#### **3.5.8.1 ENC Shoreline Features**

##### **3.5.8.1.1 Aids to Navigation**

Unless specifically assigned, aids to navigation to be located are left to the discretion of the hydrographer. Range lights, channel lights, and major pier lights are priorities and should be positioned using static GPS whenever possible, unless an acceptable (Third-order, Class I or higher) published position is available. Other federally maintained aids such as day beacons and buoys, as well as privately maintained aids may be located using hydrographic positioning methods. Refer to section 7.2 of the HSSD for further guidance.

##### **3.5.8.1.2 Structures**

On features directly affecting vessel docking, obtain one-meter accuracy DGPS positions on all critical points. Other points on the same feature may be surveyed to five-meter accuracy and/or derived from the imagery/shoreline files, provided they are accurate to five meters or less. All other structures may be surveyed to five-meter accuracy. Enter all relevant information; i.e., name, status, condition, etc., in the “Remarks” column.

##### **3.5.8.1.3 Works in Progress**

Determine the status of construction for the identified marine facility or other chartable shoreline construction. Obtain as-built plan drawings if possible. When as-built drawings are obtained, ensure that they have a coordinate system on them. If they don't, the NRT should obtain reference positions for the drawings using a GIS data collection and data maintenance system. Use the “Remarks” column to report the name, status, condition, or other relevant information.

### **3.5.8.1.4 ENC Offshore Features**

#### **3.5.8.1.4.1 Bridges**

The appropriate NSD Navigation Manager will attempt to get as-built drawings for project area bridges before the NRT arrives. If as-built drawings have been supplied, then the NRT will position the ends or other identifiable points of the bridge to provide geo-reference points for the drawing.

When no drawings are supplied and no DGPS interference is experienced, one-meter accuracy DGPS positions are required, to delineate clearances between bridge pier fenders facing commercial vessel traffic. Bridge pier fender points not facing commercial vessel traffic may be surveyed to five-meter accuracy depending on the relative importance to be determined by the hydrographer. When acquiring data points around obstructions such as bridges, differential correctors from the USCG beacons should be used. The Trimble Pathfinder Pro XRS has multi-path rejection technology that works best when using USCG correctors. Use the “Remarks” column in MapInfo Final Field Sheet table to report the name, status, condition, or other relevant information.

When a drawing is not available and DGPS interference is experienced, then the NRT will attempt to obtain positions over the supports that separate the commercial channel. NRB will not acquire positions on bridge fenders where the bridge structure causes DGPS interference.

#### **3.5.8.1.4.2 Channel Depths**

Where applicable, inquire with facility owners/managers about the status of privately maintained channels to update charted notations. Provide documentation in the Descriptive Report or Chart Letter and submit diagrams or survey copies when possible. In some cases (at the discretion of the Team Leader) a survey of the channel will be required to obtain the current operating depths.

# Chapter 4

## Data Processing and Analysis

The purpose of this chapter is to provide the information necessary to clean, finalize, and analyze data for OCS hydrographic surveys. The following types of data are addressed separately in this chapter.

- Bathymetry (VBES and MBES data)
- Imagery (SSS data)
- Features (bathymetry and imagery contacts, detached positions, AWOIS items, geographic positions)

Relevant steps regarding the post-processing of inertially-aided GPS data are mentioned in this section but full details are discussed in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4. For additional guidelines consult the HSSD Chapter 9 Ellipsoidally-Referenced Surveys.

### 4.1 Preparation for Data Processing

Data processing for OCS hydrographic survey data is typically performed using CARIS HIPS and SIPS software. HIPS tools are used to process bathymetry data, and SIPS tools are used with imagery data. To begin processing data in CARIS HIPS and SIPS, a “Project” must be created. A CARIS Project consists of a data filing system, structured according to a tree of project/vessel/day/line (PVDL) folders, where “vessel” refers to a particular vessel configuration file, known as a HIPS Vessel File (HVF).

The HVF establishes, in HIPS and SIPS, the relationship between survey sensors as logged by the acquisition software. The HVF must reflect any corrections or compensation of logged sensor data performed during acquisition. Some sonar systems require, or perform in a superior fashion, if real-time corrections (e.g., refraction) are used. Any real-time corrections included in the logged data must be accounted for when creating the HVF. The HVF also includes information essential for estimating sounding measurement errors (see section 4.2.3.8). Depth and position errors will be introduced if data are processed using an incorrect HVF.

Proper setup of HVFs is critical for accurate survey data, and this process is usually completed under the direction of senior survey personnel. These files are typically created at the beginning of a field season, but they will need to be amended if configurations change. Guidelines for creating an HVF are described in section 4.1.1. Refer to the CARIS HIPS and SIPS User’s Manual, found on the Hydrosoft website, for addition information.

Once HVF files have been created, the HIPS and SIPS New Project Wizard can be used to specify a Project name, associated vessels, and days for which data was acquired. The “day” name is formatted as YYYY-DOY (year + day of year). Day of year (DOY) refers to a sequential number starting with 001 on January 1 of each year and ending with 365, or 366 in leap years, on December 31 of that year.

Note: DOY is not synonymous with Julian Day Number and should not be referred to as such. The Julian Day numbering system refers to the number of days since noon on January 1, 4713 BC, a system widely used by astronomers.

#### **4.1.1 Creating HIPS Vessel Files (HVF)**

A new HVF is created using the HIPS and SIPS Vessel Wizard, part of the Vessel Editor tool. As the user works through the Vessel Wizard, HVF options must be chosen based on survey systems and configuration. Once the initial HVF is created, additional parameters such as offsets and error corrections must be entered for each individual sensor.

##### **4.1.1.1 HIPS and SIPS Vessel Wizard**

The Vessel Wizard will first prompt the user to enter a name for a new HVF file. HVF naming conventions have been standardized throughout the NOAA hydrographic fleet. The following naming convention shall be used for NOAA hydrographic vessel HVF files:

<ship/field unit abbreviation>\_<vessel hull number>\_<data type + category>.hvf

Table 4.1 contains a list of common data types acquired during OCS hydrographic surveys and example HVF names for each. Note that the field season year is not included in the name; rather, timestamp entries within the HVF are used to track application dates. Only a reference to the principal echosounder or side scan sonar type should be included in the last portion of the HVF name. More detailed equipment specifications and information are recorded within the HVF. For HVFs associated with MBES and SSS data, include the sensor model; for vertical beam echosounder data, use the suffix “VB.”

Once an HVF name is entered, the user will be asked to enter specifications for the applicable sonar system, such as sonar type, number of transducers, number of beams, etc. The information requested is typically either based on the physical system configuration or can be located in the sonar user’s manual.

Data Type	HVF Name Examples
Multibeam Echosounder  Main-scheme Survey Lines or Investigation Lines	“FA_2806_Reson7125” - NOAA Ship FAIRWEATHER launch 1010, Reson 7125 multibeam  “BH_S5501_Reson7125” - BAY HYDROGRAPHER, Reson 7125 multibeam
Vertical Beam Echosounder  Main-scheme Survey Lines or Investigation Lines	“RA_S221_VB” - NOAA Ship RAINIER, vertical beam  “NRT2_1210_VB” - Navigational Response Team 2, boat 1210 vertical beam
Towed Side Scan Sonar - 100% and 200% Coverage  Other Coverage (e.g., additional investigations, buffer lines)	“TJ_S222_Klein5000” - NOAA Ship THOMAS JEFFERSON, Klein 5000 100-percent side scan sonar  “NRT2_1210_Klein3000HF” - Navigation Response Team 2, boat 1210, Klein 3000 high frequency 100-percent side scan sonar
Hull-mounted Side Scan Sonar - 100% and 200% Coverage  Other Coverage	“TJ_3101_Klein5000Hull” - NOAA Ship THOMAS JEFFERSON, launch 3101, hull-mounted Klein 5000, non-100/200 coverage
Echosounder Point Observations  Depth “Detached Positions” (DPs)	“NRT2_1210_EchosounderDP” - Navigation Response Team 2, boat 1210, echosounder DPs  “RA_2801_EchosounderDP” - NOAA Ship RAINIER, launch 2801, echosounder DPs
Non-Echosounder Point Observations  Diver Least Depth DPs  Shoreline DPs	“RA_2801_ShorelineDP” - NOAA Ship RAINIER, launch 2801, Shoreline DPs  “TJ_3101_DiverDP” - NOAA Ship THOMAS JEFFERSON, launch 3101, Diver DPs

Table 4.1: Example HVF naming conventions for NOAA hydrographic vessels.

#### 4.1.1.1.1 Motion Sensor Options

HIPS and SIPS Vessel Wizard will prompt the user to enter what vessel motion data (i.e., attitude data) will be recorded and whether these data should be applied during post-processing. The meaning of “apply in post-processing” for heave is straightforward. If survey data were not logged with heave corrections applied during data acquisition, and heave data (either real-time values or true heave, as discussed in section 3.4.1.2 were recorded separately, then apply this correction in post-processing. The standard practice for OCS hydrography is to not correct survey data for heave during data acquisition; hence, “apply in post-processing” is usually enabled for this sensor in the HVE.

The application of roll and pitch is a bit more complicated than applying heave. The user must keep in mind that options to apply roll and pitch will affect any remote heave calculations. (Remote heave is defined as changes in

vertical position of the transducer due to roll and pitch acting over a non-zero moment arm between the heave sensor and the transducer). If remote heave compensation is to be performed in HIPS, the vessel coordinate system reference point (RP) entered in the HVF will be treated as the center of rotation and, therefore, should be established as close to the vessel's center of motion as possible.

Many MBES sensors can be configured to acquire bathymetry using roll or pitch beam steering. In these cases, the HVF apply roll & pitch options should be set according to the data acquisition configuration. If roll steering was enabled during acquisition, do not apply roll in post-processing. If roll steering was not enabled, the HVF option to apply roll in post-processing should be checked. Likewise, if pitch steering was enabled during acquisition, do not apply pitch in post-processing. If pitch steering was not used, the HVF option to apply pitch in post-processing should be checked.

#### **4.1.1.1.2 Configuration Options**

The Vessel Wizard configuration options enable the user to enter offset parameters for “sound velocity” corrections (more appropriately, sound speed corrections as explained in section 4.2.3.6, a dynamic draft table, and “waterline” value for the vessel. Typically, bathymetry data will require sound speed (i.e., refraction) correction during post-processing and the option to “define parameters for sound velocity corrections” should be checked. If this option is checked, the hydrographer will also be prompted to enter any mounting offsets for the sonar transducer. Only large mounting offsets should be entered here. Small offsets will be accounted for during the patch test. However, some MBES systems correct for refraction during data acquisition. If refraction correction has been performed in real-time during data acquisition, it can be performed again during post processing with more flexibility in how the sound speed correctors are applied to the data. Typically imagery data will not require sound speed correction either, and “defining parameters for sound velocity corrections” is unnecessary for HVFs used only to process data that will not be sound speed corrected during post-processing.

Dynamic draft refers to changes in draft induced by the flow effects of a vessel moving through the water. Corrections for this effect can be applied during post-processing via either a Dynamic Draft table of speed-versus-draft values entered in the HVF or from a “delta draft” time series that is loaded during post-processing. The OCS standard practice is to enter a speed-versus-draft table that is applied in post-processing. Thus, in most cases the option to “create a Dynamic Draft table or speed vs. draft values” should be checked and values manually entered into this table by the hydrographer.

The term “waterline height”, as defined by CARIS, refers to the measured vertical difference between the vessel waterline and the established origin of the local vessel reference frame (RP). This value will be positive if the vessel waterline is below the RP, and negative if the vessel waterline is above the RP. Variations in static draft of the transducer should be accounted for by adjusting the waterline height in the HVF, thus the HVF option to “define vessel waterline height variations” should be checked and the waterline value applied in post-processing.

Note: Some sonar systems must be configured such that depths are reported relative to the waterline, rather than the transducer. In such cases, the value entered for waterline may not be as defined above, and the hydrographer should verify that the combination of values entered in the HVF for transducer vertical offset and waterline do not cause an erroneous vertical correction.

#### **4.1.1.2 HIPS and SIPS Vessel Editor**

Once a new HVF has been created with the Vessel Wizard, sensor offsets and additional sensors, such as CARIS “TPU values,” can be activated using the CARIS HIPS and SIPS Vessel Editor. It should be noted that HVFs use a

left-handed coordinate system, as summarized in Table 4.2. (Be aware that despite the fact that the +Z axis is down, when recording vessel motion positive heave action is up.) The user should verify that offset values determined during the vessel survey adhere to the same coordinate system as the HVF. If this is not the case, surveyed offset values will need to be converted so that the vessel configuration is accurately represented in the HVF.

Coordinate System Component	Direction
+X axis	Starboard
+Y axis	Forward (toward bow)
+ Z axis	Down (into the water)
+Pitch	Bow down
+Roll	Starboard up
+Heave	Up (out of the water)

Table 4.2: CARIS HVF coordinate system (a left handed coordinate system).

Note: Coordinate systems vary among NOAA survey systems and software. This information should be verified in the appropriate user's manual prior to entering offsets into any software or equipment configuration. Coordinate systems for common OCS survey systems are described in Appendix 1, (Coordinate\_Systems.pdf).

The hydrographer may find it useful to create a three-dimensional Vessel Shape when entering sensor offsets.

This image, created using Vessel Editor's Edit > Vessel Shape menu, shows the relative location of sensors as entered in the HVF and can provide the hydrographer with a quick verification that offsets have been entered correctly.

The field unit shall ensure that the vessel offsets, entered in the HVF are fully consistent with those, listed in the DAPR (see section 8.1.5.1 of HSSD). Any inconsistencies shall be addressed in the DR (see section 8.1.4 of HSSD).

#### 4.1.2 Creating CARIS Projects

CARIS Projects shall be created for each survey and include only the survey registry number (e.g. H12345, or F00123). New Projects are created using the CARIS New Project Wizard. When adding a new project, the wizard will request the following data:

- Description – Provide a brief summary of the purpose of the Project and any significant survey-specific information. The bulk of the description can be extracted from the Introduction, Location, and Priority sections of the Project Instructions. Note: Entering a description is important because this is one of the few places in HIPS and SIPS where external metadata can be attached to digital data.
- Owner – List the assigned ship or field party, as well as the Lead Hydrographer (Commanding Officer or Chief-of-Party) and Survey Manager.
- Map Projection – Map Projection establishes the coordinate system to be used for the Project view in HIPS/SIPS. If AUTO\_UTM is specified, the coordinate system of the Project view will be based on the ellipsoid manually entered in the HVF. The AUTO\_UTM option can be used, provided a Universal Transverse Mercator (UTM) projection on the North American Datum of 1983 (NAD83) has been entered for all HVF files associated with the survey.
- Project Extent – Enter the basic boundaries of the survey area. Project Extent is expressed as a regular (i.e., non-rotated) rectangle. Project Extent should completely cover the assigned survey limits. Note that data

brought into a CARIS Project are not automatically clipped to this area; the clipping function is optional and requires user activation. If activated, the default clipping boundary will be the Project Extent, but this may be modified by the user. Refer to the CARIS HIPS and SIPS User's Manual for additional information on clipping data.

## **4.2 Bathymetry Processing**

NOAA hydrographic field units typically acquire bathymetric data using VBES, MBES, or a combination of both. VBES depths are processed using the CARIS HIPS Single Beam Editor tool to review and edit data anomalies. MBES data may be edited in two different ways: using CARIS HIPS Swath Editor tool to edit data in a time-series mode, or using the CARIS HIPS Subset Editor tool to edit data in a spatial mode. In both instances, Bathymetry Associated with Statistical Error (BASE) methods are used to generate, using one or more different algorithms, a digital seafloor model that contains depth and uncertainty information at each model node. In addition to the basic bathymetric layer, auxiliary information layers such as standard deviation of soundings, sounding density, shoal depth, source identification, hypothesis count, and hypothesis strength will be generated depending upon the algorithm used to construct the BASE surface. These BASE surface layers are used to guide the hydrographer to areas that require further examination and/or editing. This concept is explained in greater detail in section 4.2.1

Unlike VBES and MBES data, depth measurements acquired by leadline, sounding pole and/or diver least depth gauge are positioned using a type of target file referred to as a detached position (DP) and depth data is entered manually in CARIS Notebook or Pydro. Since target files are more frequently used to locate point features such as shoreline items and bottom samples than these types of depth measurements, processing details have been included in section 4.4.1.2 .

### **4.2.1 The BASE Surface Concept**

A BASE surface represents bathymetry as a dense grid of statistically derived depth estimates. Various products can be derived from BASE surfaces, including a shoal-biased set of depth estimates for safe vessel navigation. The BASE surface paradigm discussed herein is specifically designed for MBES data, which typically has a high sounding density. Nevertheless, VBES data can also be assimilated into the BASE surface model. The Survey Manager should consult, through his/her chain-of-command, OCS's Hydrographic Surveys Division for the most current guidance on incorporating VBES data into BASE surface data.

#### **4.2.1.1 Base Surface Methods**

There are two different algorithms used by NOAA hydrographic field units for creating BASE surfaces: uncertainty weighted grids and the Combined Uncertainty and Bathymetric Estimator (CUBE) method and uncertainty weighted grids. The preferred method shall be the CUBE method, but uncertainty weighted grids will be allowed. Their use shall be documented in the Descriptive Report. Each of these methodologies is described below.

#### 4.2.1.1.1 Combined Uncertainty and Bathymetric Estimator (CUBE)

CUBE is a gridding algorithm developed at the University of New Hampshire (UNH)/NOAA Center for Coastal and Ocean Mapping Joint Hydrographic Center by Dr. Brian Calder. Its primary advantage over uncertainty weighted grids is that it is less susceptible to noise. CUBE works in two stages:

Integration of Soundings into Hypotheses - During the first stage, all soundings in the area are grouped into internally consistent depth hypotheses, using the uncertainty of the soundings as a threshold.

Disambiguation - After all soundings are integrated, a second stage determines which hypothesis at each node is the most likely to be the seafloor. There are four disambiguation methods available:

- (a) The density option selects the hypothesis with the greatest number of sounding samples.
- (b) The locale option selects the hypothesis that is most consistent with its surrounding nodes that has only one hypothesis.
- (c) The density and locale option selects the hypothesis with the greatest number of soundings and is consistent with neighboring nodes.
- (d) The initialization option selects the hypothesis that is closest to an initialization surface created previously.

The CARIS HIPS integration of CUBE is well documented in the CARIS HIPS and SIPS User's Manual. This manual should be referenced for details on the workings of the algorithm and explanations of the user interface.

When editing a CUBE surface, the user may opt to edit soundings or to edit hypotheses. For NOAA hydrographic survey data, it is critical that only sounding edits be used to correct gridding problems. This is primarily because hypothesis edits exist only in the context of a single grid, and will be lost if that grid is recomputed.

##### 4.2.1.1.1.1 CUBE Parameters

There is a small parameter file called "CUBEParams.xml" that is referenced in the HIPS environment. The values in this file control the behavior of the CUBE gridding and disambiguation processes. The default CUBE parameters are not authorized for NOAA surveys. Instead, field units shall use the CUBEParams\_NOAA.xml file. Each of the following grid resolutions has its own CUBE parameter set: 0.5m, 1m, 2m, 4m, 8m, 16m, and 32m. Field units shall use the parameter set corresponding to the appropriate resolution(s) and depth ranges of their survey data as specified in section 5.2.2 of the HSSD. A description of each parameter and its default value and allowable range of values can be found in the header of the XML file.

Three parameters have been modified from the CARIS default values: Capture Distance Scale, Capture Distance Minimum, and Horizontal Error Scalar.

The Capture Distance Scale value is a percentage of depth used to limit the radius of influence a sounding may have on the grid. The system default value is 5.0. However, for all grid resolutions in the NOAA parameters file, the value has been set to 0.5. Setting the value this low disables the function and forces the Capture Distance Minimum to be used instead over the range of applicable grid resolutions. This fixes the Capture Distance to the grid resolution. A value of 0.5 was determined to be low enough for all grid resolutions, since they grow with depth.

The Horizontal Error Scaler value is used to scale the horizontal error of each sounding when used in the radius of influence computation. It affects the propagated uncertainty of each sounding and how it is combined into each hypothesis. The system default value is 2.95. However, based on discussions with Dr. Calder, the value has been set to 1.96, for all grid resolutions in the NOAA parameters file.

The Capture Distance Minimum value is minimum distance that the CUBE algorithm will search for soundings to contribute to a node. It is used in conjunction with the Capture Distance Scale to limit the radius or influence of a sounding. The system default value is 0.5. The Capture Distance Minimum is the only parameter that varies between the grid resolutions in the NOAA parameters file.

The minimum capture distance radius is specified in sections 5.2.2.1 and 5.2.2.2 of the HSSD and is limited to  $(0.707 * \text{grid resolution})$ , or

$$\text{minimum capture distance} = \frac{\text{grid resolution}}{\sqrt{2}}$$

This value defines the capture distance to ensure that the radius of influence touches the outer corners of the grid resolution but not farther. With this capture distance, no sounding is ever “lost” to the algorithm, but there is not an oversampling of data from areas significantly further than the grid resolution. Because all of the soundings are in close proximity to the node, the grid most accurately depicts the seafloor in that area without losing any soundings.

#### 4.2.1.1.2 Uncertainty Weighted Grids

In order to generate uncertainty-weighted BASE surfaces, TPU must be calculated for each sounding. TPU accounts for either the priori estimate or sensor recorded horizontal and vertical components of uncertainty associated with each sounding measurement. TPU is formulated from the summation of the modeled uncertainties for all sub-systems included in the overall hydrographic survey system (e.g., water levels, tide zoning, attitude sensor error, navigation sensor horizontal position error, sound velocity profile error, sonar bottom detection method, etc.). The sources of uncertainty values include (or may be combination of) manufacturer specifications, theoretical values, and empirical observations from the field. A priori estimates values are entered into the HVF while sensor recorded values are applied from the recorded data during the Compute TPU process.

OCS-recommended a priori uncertainty values are contained in the CARIS HVF Uncertainty Values document in Appendix 4. The uncertainty values described in the appendix are provided as guidance for use in standard NOAA hydrographic surveys. These values do not cover the breadth of operations encountered by all field parties, nor do they cover the range of equipment configurations possible for any particular vessel. As such, these values should serve a starting point in developing a vessel’s error model. Any deviation from the attached values should be completely described in the applicable Descriptive Reports and DAPR.

In general, soundings (observation points) do not coincide with grid nodes (BASE surface estimation points). To account for this, the vertical component of a sounding’s TPU is propagated to a grid node according to a power law that models the increase in uncertainty as a function of three variables: distance between sounding and node, the sounding’s horizontal component of TPU, and grid node resolution. The amount of weight an observation exerts on a given BASE estimation point is inversely proportional to the propagated vertical uncertainty of the observation. See Figure 4.1 .

$$\hat{\sigma}_P = \hat{\sigma}_V \left[ 1 + \left[ \frac{\|x_i - n_j\| + s_H \hat{\sigma}_H}{\min(\Delta x, \Delta y)} \right]^\alpha \right]$$

Figure 4.1: Model for propagated uncertainty in depth

Where V and H are the vertical and horizontal components of TPU (resp.), SH is a scale factor representing the worst case error that horizontal TPU can contribute, xi and nj are the location of the sounding and estimation node (resp.), x and y are the two-dimensional spacing of grid nodes, and the exponent is a heuristic to control overall growth of propagated uncertainty, P . The HIPS BASE surface algorithm uses a value of 1.0 (HIPS has already scaled H by 1.96, for a 95% confidence interval) and a value of 2.0.

Theoretically, every sounding can affect every node in a BASE surface encompassing a survey area. For computational efficiency, HIPS limits a sounding’s radius of influence on surrounding nodes through the following “spreading conditions.” (1) At a minimum, each sounding affects all nodes within a radius of 0.707 times the grid resolution of its position; i.e., within half the distance of the diagonal on a regular (square) grid. Hence, a given sounding will affect at least two to four nodes, depending on where it is situated with respect to the nodes. (2) Each sounding will propagate at most a distance determined by a user-specified threshold of propagated vertical uncertainty. The uncertainty threshold is expressed in HIPS according to an IHO sounding error model (see Figure 4.2 ); that is, an estimate of all constant errors (a) and depth-dependent errors (b times d) are summed in quadrature as shown in Figure 4.3.

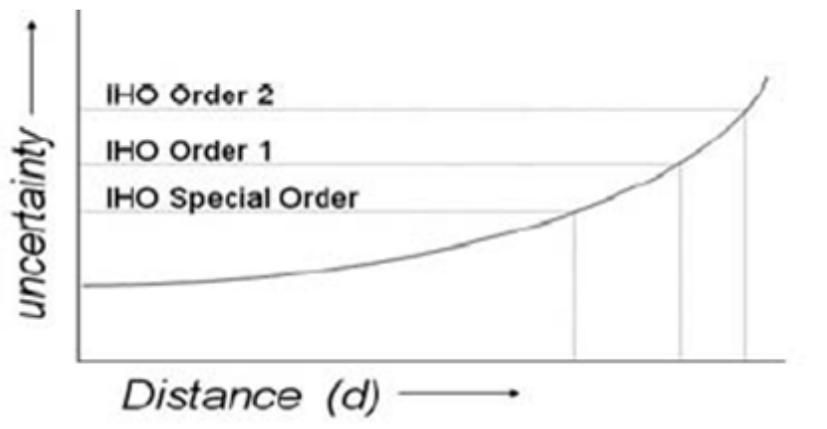


Figure 4.3: Generalized uncertainty growth curve with respect to sounding radius influence (d).

OCS requirements for the accuracy of measured depths, as set forth in the HSSD, are adapted from IHO S-44, Standards for Hydrographic Surveys, 5th Edition, which defines Special Order (a=0.25 meters, b=0.0075), Order 1 (a=0.5 meters, b=0.013 or 1.3% of depth), and Order 2 (a=1.0 meters, b=0.023 or 2.3% of depth) standards. OCS specifies that the total sounding error in a measured depth at the 95 percent confidence level, after systematic and system specific errors have been removed, shall not exceed the IHO Order 1 standard in depths up to 100 meters and shall not exceed the IHO Order 2 standard in deeper waters. If either an IHO Special Order standard or a user-defined accuracy is required for a survey, these requirements will be stated in the Project Instructions.

### 4.2.1.1.3 Other BASE Weighting Methods in HIPS

CARIS HIPS allows BASE surfaces to be generated using either swath-angle weighting, uncertainty weighting, or CUBE discussed in the previous section. Swath-angle weighted BASE surface nodes do not incorporate TPU and, hence, node “uncertainty” is not available therein. Unless specifically stated to the contrary, use of the term “BASE surface” in conjunction with OCS hydrographic surveys refers to those surfaces generated using the uncertainty weighting method or CUBE.

### 4.2.1.2 BASE Node Attributes

The depth at a given BASE surface grid node,  $n$ , is the mean depth (weighted by propagated depth uncertainty) of the set of  $N$  soundings whose domain,  $D_i$ , contains  $n$ . Likewise, the uncertainty at a given node is the mean uncertainty (weighted by propagated depth uncertainty) of all the soundings contained in set  $N$ . See Figure 4.4 Note that the depth at grid node  $n$  is the weighted mean of soundings 1, 2, and 3. Sounding 4 is not included because its radius of influence does not encompass grid node  $n$ .

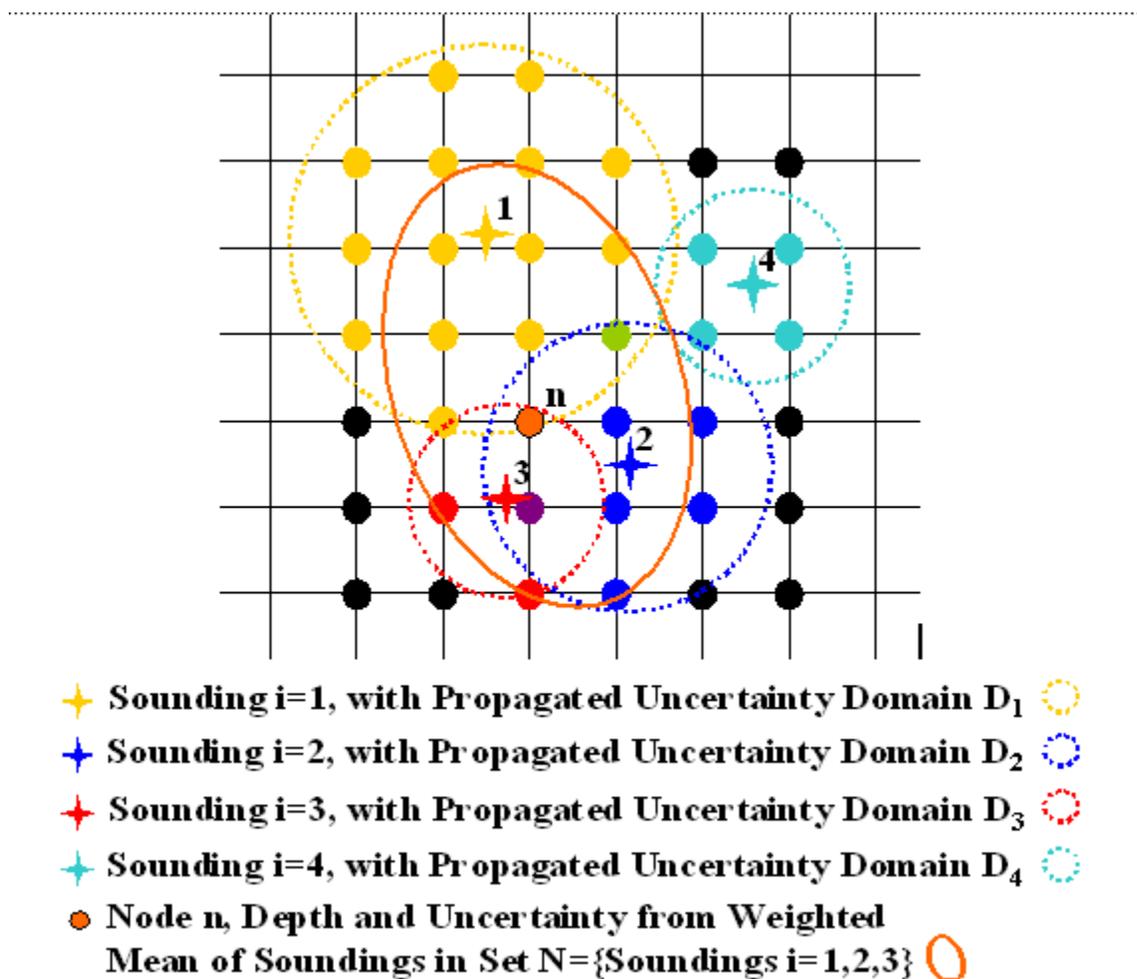


Figure 4.4: Formulation of Base surface nodes from soundings.

In addition to depth and uncertainty, users can include five additional attributes in the BASE surface nodal data. The definitions of the seven nodal attributes are summarized below. Note that all node statistics are computed from the set of surrounding soundings whose propagated vertical uncertainty passes a user-supplied threshold (IHO Order):

- Depth - weighted-mean depth of soundings that contribute to a node; weighting is inversely proportional to the propagated vertical uncertainty of the soundings.
- Uncertainty - weighted-mean vertical component of TPU of soundings that contribute to a node; weighting is inversely proportional to the propagated vertical uncertainty of the soundings.
- Density - number of soundings that contribute to a node.
- Std\_Dev - standard deviation of soundings that contributed to the selected hypothesis at the 68%CI
- Node\_Std\_Dev – standard deviation of the soundings that contributed to the current grid node at the 68%CI
- Shoal - shoalest sounding from the set of soundings that contribute to a node.
- Mean - sample mean of the set of soundings that contribute to a node.
- Deep - deepest sounding from the set of soundings that contribute to a node.

#### 4.2.2 Bathymetry Processing Diagrams

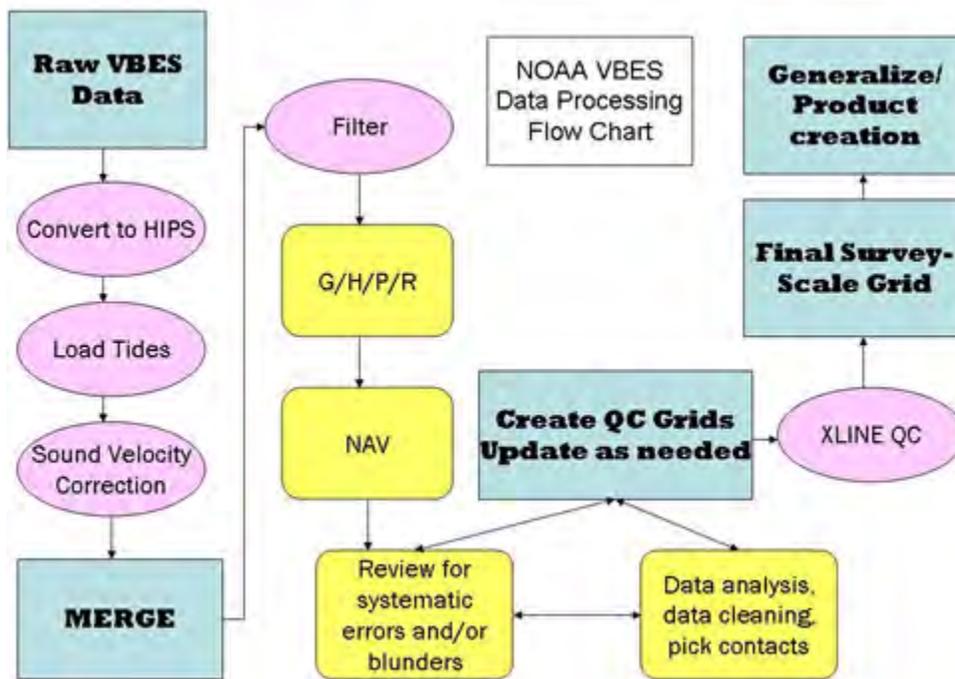


Figure 4.5: Processing flow diagram for VBES data.

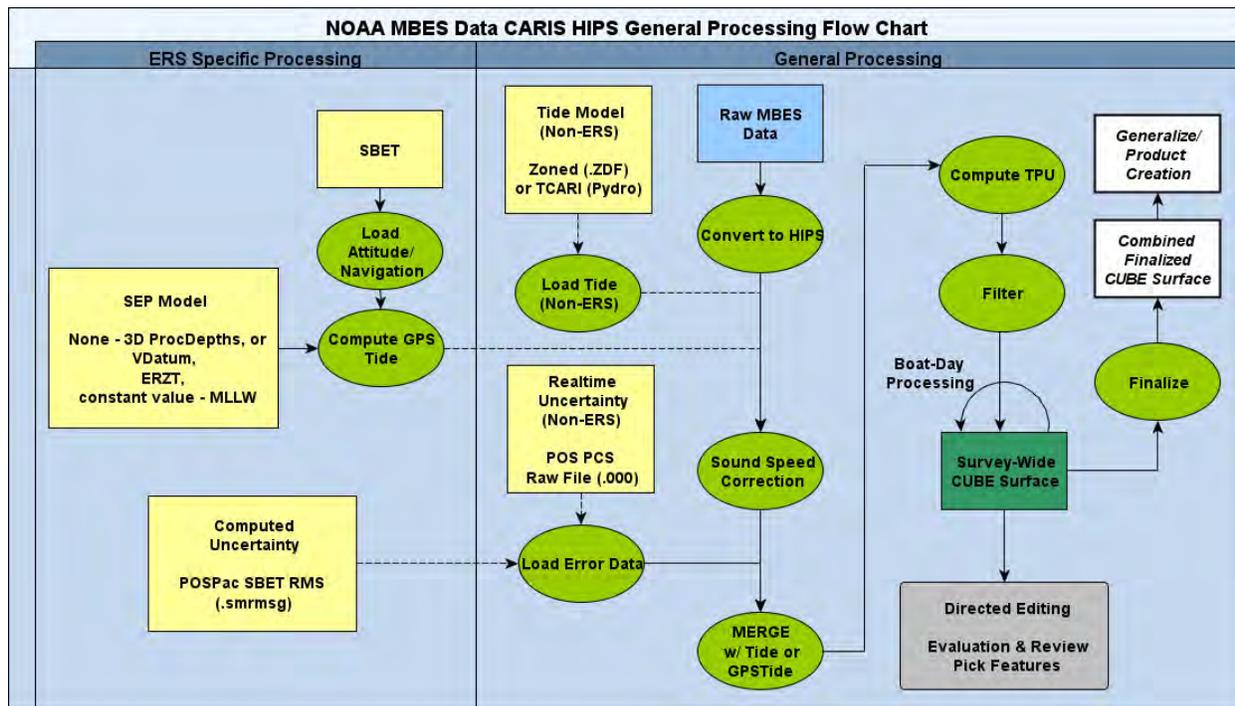


Figure 4.6: Processing flow diagram for MBES data.

### 4.2.3 Daily Batch Processing

A number of processing tasks need to be performed on “raw” bathymetry data (i.e., unaltered data in the format recorded by the acquisition software) before any detailed analysis and evaluation can occur. Some of these daily tasks are interdependent, and the specific sequence is critical. The relevant daily batch processing tasks are listed below. Refer to the Bathymetry Processing Flow Diagram 4.6 for the appropriate ordering of steps.

1. Conversion (Section 4.2.3.1 )
2. Load Attitude/Navigation (Section 4.2.3.2 )
3. Load Error Data (Section 4.2.3.3 )
4. Load Delayed Heave (Section 4.2.3.5 )
5. Load Tides or Compute GPS Tides (Section 4.2.3.4 )
6. Sound Speed Correction (Section 4.2.3.6 )
7. Merge (Section 4.2.3.7 )
8. Compute TPU (Section 4.2.3.8 )
9. Filter (Section 4.2.3.9 )
10. Add to Coverage BASE Surface (Section 4.2.3.10 )

Most of the tasks above can be semi-automated using the HIPS “Batch Processor” tool. Data format dictates how specific batch processing actions should be configured; thus, a separate HIPS Batch Processing File (.hbp) is needed for each raw data format type.

In general, all of the aforementioned tasks should be completed for any type of echosounder data. A basic set of batch processing files can be specified for each data type and reused on the appropriate set of survey lines acquired each day. In some circumstances, either creation of custom batch processing files or manual processing of one or more tasks, line-by-line, in non-batch mode may be necessary. For example, conversion and filtering options may need to be customized to reflect changes in echosounder performance as weather conditions varied throughout a survey day.

#### **4.2.3.1 Conversion**

CARIS HIPS supports numerous different data formats that can be used to record bathymetry. During conversion, HIPS uses the raw data to create a single, proprietary data format that will be used in subsequent CARIS processing routines. These files in CARIS HIPS format are referred to as “HIPS files” or “HDCS files”.

Depending upon the system type and setup, recorded raw data may have been corrected for factors such as vertical (depth or height) offsets, vessel motion, or acoustic refraction during acquisition. It is critical that HVFs account for any real-time corrections performed, so that “double corrections” do not occur during post-processing.

If an HVF error is discovered subsequent to post-processing, it may be necessary to reapply certain correctors and re-merge. Depending upon the error, a re-conversion may be required; however, most HVF settings do not impact the HIPS data conversion process. (HVF settings that can directly affect the data conversion process include VBES draft and MBES beam numbering.) Data processors should not automatically resort to time-consuming reconversion and re-processing of a significant amount of data upon discovering an HVF error. If unsure whether data repairs are necessary, the Survey Manager should consult, through his/her chain-of-command, the Hydrographic Systems and Technology Program for assistance.

The following sections contain guidance for converting common raw bathymetry data formats used by OCS into HDCS files. Relevant background information is provided, followed by a table of guidelines for specific HIPS and SIPS Conversion Wizard settings related to each raw bathymetry format.

Note: HIPS uses the same Conversion Wizard as SIPS for a given raw data format. Options related to conversion of sonar imagery stored in raw MBES data are not addressed in this section; see section 4.3.2.1 for imagery conversion details.

##### **4.2.3.1.1 HYPACK**

HYPACK is the standard data format used by NOAA hydrographic field units to log VBES and MBES data. HYPACK software is used to store data from a variety of MBES systems via an additional software module called HYSWEEP. For OCS hydrographic survey data, HYPACK VBES files should be recorded using a DOY (erroneously termed “Julian Date” in the HYPACK software) file extension. MBES data, recorded using HYSWEEP should be logged as ASCII \*.HSX (HYSWEEP Survey Extension) files.

Within the raw HYPACK file, data recorded from each sensor in the acquisition system is assigned a “device number.” This numbering scheme will vary according to the specific hardware configuration used to record the data. During conversion, device numbers can be specified to correlate each sensor’s data string with a specific type

of data (e.g., echosounder, heading, navigation, etc.). If no device numbers are specified, the converter will look for sensor data using known NMEA device strings. Specifying device numbers during conversion ensures that HIPS does not incorrectly identify a data string. Device numbers can be verified by reviewing a raw HYPACK line file in a text editor, such as WordPad, in which each device number will be listed adjacent to its respective device name.

#### **4.2.3.1.1.1 VBES Data**

When logging VBES data, HYPACK records depth values directly from the echosounder, rather than two-way acoustic travel times. For OCS hydrographic survey data, field units must recalculate VBES depths using an actual measured sound speed profile during post-processing. HIPS will assume an estimated sound speed of 1500 m/s was applied to data during acquisition and uses that value to determine a two-way acoustic travel time for each sounding. HIPS can then recalculate VBES depths using a measured sound speed profile.

Note: If using a VBES system in which the speed of sound through water can be manually entered, the hydrographer must enter 1500 m/s to facilitate the above HIPS process, as noted in section 3.2.3 .

If dual-frequency VBES data are being converted, high- and low-frequency soundings are stored side-by-side in the HYPACK raw data record. During conversion, each sounding will be flagged as either “Primary” or “Secondary” in the order in which it appears in the datagram. For example, if the high frequency depth is listed first in the record and the user chooses “Primary, Secondary” for conversion, the high frequency depth will be flagged Primary and the low frequency depth will be flagged Secondary. Primary soundings are also flagged “Selected” by default in HIPS, and only Selected depths will be carried through to final processing. Users may override the Primary/Secondary flagging assigned during conversion to force a depth into, or remove one from, the set of Selected depths.

Note: In dual frequency systems, the low frequency beam width will be wider than the high frequency beam width. If the low frequency return shows a shoaler depth than the high frequency, it often indicates a feature offset from the vessel trackline. The least depth of such a feature may not have been captured by the low frequency signal; thus, the hydrographer should note the feature’s position and perform a development.

#### **4.2.3.1.1.2 MBES Data**

Converting HYSWEEP MBES data is nearly identical to converting HYPACK VBES data. The primary differences are that the user must select raw \*.HSX files for conversion and choose the “Multibeam” option for soundings, rather than Single Frequency or Dual Frequency as would be required for converting VBES data. Device numbers should still be specified as described in the beginning of this section.

Options	OCS Guidelines
Single Frequency	If Single Frequency VBES data is being converted, it will automatically be classified as “Primary”.
Dual Frequency	The OCS standard is to read in high frequency as “Primary and low frequency as “Secondary”.
Multibeam	For HYSWEEP MBES data, simply choose the multibeam option.
Static Draft Apply during conversion	Typically, static draft should not be applied during conversion. The OCS standard is for sensors to be referenced to a vessel RP and static draft to be accounted for via a “waterline” correction entered in the HVF. Refer to section 4.1.1.1.2.
Device Numbers	If the hardware setup in HYPACK is unambiguous, then blank device numbers may work fine; OCS recommends explicitly stating the device numbers during conversion.
Sound Velocity	Data acquired for OCS hydrographic surveys shall be corrected for sound speed using actual measured sound speed profiles. For HYPACK data, this process is performed in HIPS.

Table 4.3: OCS guidelines for converting HYPACK data.

#### 4.2.3.1.2 Simrad

The Simrad data converter is designed for use with data from Kongsberg Simrad multibeam systems, such as the EM 710, EM1002 and/or EM3000. Two notable options are available when converting Simrad data, shortening line names and decimating attitude data.

Simrad generated survey line names can be quite long. During conversion, the user can opt to modify raw line file names into 12-character HIPS line names using the format YYDDD\_HHMMSS (2-digit year + DOY + integer hour, minute, second, based on the starting date and time of the line data).

To reduce file size, attitude data can be decimated during conversion. Often, the output rate of attitude sensors used during multibeam data acquisition can be unnecessarily large (e.g., higher than 25 Hz), creating very large attitude data files in HIPS. The attitude data decimation factor determines the ratio of attitude data that is converted. For example, using a factor of 1 converts all data; a value of 10 converts every tenth attitude record.

Options	OCS Guidelines
Shorten Line Names	OCS recommends shortening line names.
Attitude Data Decimation Factor	A minimum attitude sample rate of 25 Hz is recommended by OCS. Do not decimate attitude data beyond this value, e.g. if attitude sample rate is 100 Hz, do not decimate attitude data by a factor greater than 4.

Table 4.4: Guidelines for converting Simrad data.

#### **4.2.3.1.3 Generic Sensor Format (GSF)**

Generic Sensor Format (GSF) may be used to store data from a variety of VBES and MBES system configurations. GSF is particularly well suited for storing data that have been subject to real-time corrections during acquisition. As noted in section [sec:Preparation-for-Data], any real-time corrections in the logged data must be accounted for when creating the HVF. Real-time corrections may also affect processing decisions made in HIPS.

As compared to the Daily Batch Processing steps presented in section [sub:Daily-Batch-Processing-SSS], the state of a given GSF dataset may range from raw (i.e., no corrections applied) to a condition where steps 2, 3, and 4 have already been completed. The options for converting GSF data into HDCS files are fairly simple because much of the behavior of the converter cannot be manipulated by the user. The GSF format includes a standard ping flag definition to indicate whether data are “on line” (e.g., data from a planned survey line) or “off line” (e.g., data in between lines, during turns, transits, etc.). The only choice a user must make during HIPS conversion of GSF data is how to treat these off-line data.

#### **4.2.3.1.4 Extended Triton Format (XTF)**

The eXtended Triton Format (XTF), created by Triton Imaging, may be used to store data from a variety of MBES systems. (Imagery data can also be acquired in the XTF format, as discussed in section 4.3.2.1.3 ) XTF datagrams are comprised of a Triton-defined “header” attached to an optional manufacturer-specific sensor data packet. In the past, XTF was a common data format within OCS, primarily due to the widespread use of Triton Imaging’s IsisSonar data acquisition software. However, since ISIS has been replaced by HYSWEEP on NOAA hydrographic field units, MBES data is generally no longer acquired in XTF.

#### **4.2.3.2 Load Attitude/Navigation**

For ERS based projects, the processed Smoothed Best Estimate of Trajectory (SBET) files are loaded using the CARIS/HIPS Load Attitude/Navigation tool. Load Attitude/Navigation will overwrite any previously converted real-time attitude and navigation data. The hydrographer can review/edit the attitude and navigation time series data using HIPS editors. For additional information regarding ERS see the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

#### **4.2.3.3 Load Error Data**

The CARIS/HIPS Load Error Data tool is used to override HVF TPU values with observed/computed uncertainty time-series values. For non-ERS projects the observed uncertainty time series in the POS PCS files (.000) is used. For ERS-based projects, the processed error metrics file that accompanies the SBET file (smrmsg) is used in the CARIS/HIPS Load Error tool. During the CARIS/HIPS Compute TPU step (4.2.3.9) the hydrographer can indicate the uncertainty source: (HVF) Vessel Settings, Realtime Data or a Custom mix of uncertainty sources. For additional information regarding ERS see the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

#### **4.2.3.4 Load Tides**

For NOAA charting purposes, hydrographic sounding data must be merged with water level observations relative to the local “chart datum,” typically mean lower-low water (MLLW). The HIPS Load Tide tool creates a water level height time series in each survey line directory that is appropriate for the position and time of each line.

If tidal effects throughout a survey area are complex or if multiple water level stations are located nearby, an optional zone definition file (.zdf) can be used to express how the amplitude and phase of the tide within a given area is related to available water level station data. For each zone, a reference water level station, time corrector, and range corrector will be provided. This technique called discrete tidal zoning does not account for the effects of spatially varying harmonic and non-harmonic effects on the water levels. The accuracies achieved by this method may be inconsistent from one survey area and/or time periods to others, and the resulting uncertainties may be difficult to quantify.

A tide or water level file must be loaded prior to merging data in HIPS, but actual water level data may not yet be available. Thus for daily data processing, a zero or predicted tide file will often be used. If survey data were compensated for water level variances during acquisition or if water level measurements are not necessary for the survey area (e.g., some non-tidal rivers or lakes), a “zero tide” file must still be loaded to enable the HIPS merge process.

Note: Non-tidal areas are still subject to water level variances due to factors such as wind, rain, barometric pressure changes, and freshwater runoff.

If preliminary or verified water levels are available, the most accurate of these data should be applied (see section 4.2.5.1.1 ).

Note: HIPS currently supports a “weighted averaging” option for zoned tides. This option applies data from multiple water level stations by weighting observed water level measurements based on the inverse of the station to- vessel distance. OCS does not recommend using HIPS “weighed averaging,” because the two-dimensional character of the survey area is not taken into account (i.e., the station-to-vessel distance vector may cut through land).

#### **4.2.3.4.1 Tidal Constituent and Residual Interpolation (TCARI)**

Tidal Constituent and Residual Interpolation (TCARI) was designed for total water levels relative to Mean Lower Low Water (MLLW) at selected hydrographic survey areas along the coast by the spatial interpolation of tidal data. The model spatially interpolates the harmonic constants (used to predict the astronomic tide), tidal datums, and residual water levels (i.e., the non-tidal component or the difference between the astronomically predicted tide and the observed water level) using the values at a combination of operational and historical stations. The method works best in regions where there is an abundance of high quality tidal data surrounding the survey area. TCARI methodology has the potential to yield water level correctors with increased accuracy and reduced uncertainty.

The use of TCARI, just as in discrete tidal zoning, requires the hydrographer to evaluate and understand the tidal characteristics of the survey areas. Success in either method requires information from historical tide stations and other sources. Gaps in information limit both methodologies. And both methodologies require tide stations to be in operation during survey operations. TCARI first requires the development of a model grid to cover the survey areas and then requires a spatial field of harmonic constants from historical stations for the interpolation instead of just the average time and range of tide required by tidal zoning. Finally, TCARI planning requires an analysis of the non-tidal residual across the survey area to determine the location and number of stations to be in operation during the survey. TCARI grid files, interpolation weighting functions, and harmonic constant files are created during planning and sent to the survey platform. Survey vessels must obtain the observed data from the specified tide stations during the survey so that TCARI can apply the interpolated water level residuals in the process.

Both TCARI and traditional tidal zoning will be used and the applicable tool will be determined by CO-OPS in the planning stage on a survey by survey basis. CO-OPS will either send TCARI program files or discrete zoning to the field but not both. Field units receiving a TCARI grid from CO-OPS can load it into Pydro with water level data to create tidal reducers for the survey's bathymetry. Once TCARI has created the tide files, the data can be merged in CARIS (loading tides option is not necessary, you will not need a .zdf file).

For final tide correctors, the survey vessel should generate and submit a request for Final tides, stating on the request that TCARI was used for that particular survey.

CO-OPS will review and quality control the TCARI grid sent to the survey vessel and if no discrepancies or problems are found, will send the vessel a note stating that the preliminary grid can be used for final tidal correctors. If CO-OPS finds discrepancies or problems, then CO-OPS will re-evaluate and determine the best solution.

#### **4.2.3.4.2 Compute GPS Tide**

For ERS based projects, the CARIS HIPS Compute GPS Tide function creates the HDCS GPSTide file using the SBET converted GPSHeight and the loaded Ellipsoid to chart datum Separation Model (SEP, if any). An Ellipsoid to chart-datum model may consist of one of the alternate models described in Section 9.2 in the HSSDM. Computing GPSTide with a "zero" separation is used to maintain merged soundings relative to the Ellipsoid and a vertical datum transformation is applied during grid processing. Additional details regarding the application of GPS Tide can be found in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

#### **4.2.3.5 Load Delayed Heave**

If POS MV TrueHeave was logged during data acquisition, these files should be loaded using the HIPS Load Delayed Heave tool. Loading TrueHeave files will not overwrite real-time heave values that are automatically recorded in a raw file. However, once TrueHeave files have been loaded, CARIS will automatically apply True Heave unless the user manually deletes the TrueHeave files from the PVDL directory. The hydrographer can review/edit the TrueHeave time series data using HIPS Attitude Editor. TrueHeave data will be applied to survey soundings during either HIPS SV Correct (if performed) or Merge, provided the "apply in post-processing" option for heave has been checked in the HVF.

Note: Simrad data is typically compensated for real-time heave during acquisition. To avoid a double-correction, the Simrad-based TrueHeave algorithm in HIPS applies a vertical adjustment equal to the difference between TrueHeave and real-time heave.

#### **4.2.3.6 SV Correct**

Correcting sonar data for the speed of sound (through water) actually refers to performing a refraction correction based on a sound speed profile of the water column. Variations in the speed of sound (primarily due to water temperature variations, or thermocline) result in refraction (bending) of sonar beams. The speed of sound through water will decrease as water temperature lowers, causing a sonar beam to bend downward and creating depth and position errors in any measurement calculated based on travel time and an assumed linear travel path of the sonar beam. Figure 4.7 illustrates the effect of refraction. The sound wave striking the thermocline at point B slows down, while point A on the same sound wave continues at the original speed until it strikes the thermocline at C. As a result, the sonar beam bends downward.

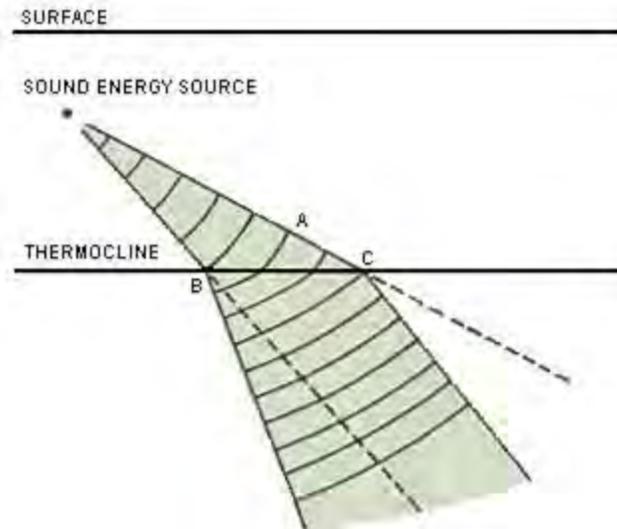


Figure 4.7: Sonar refraction due to thermocline.

Note: Although often referred to as sound velocity correction, bathymetry data are actually corrected for sound speed, as only the scalar magnitude of velocity (i.e., speed) is used by HIPS. However, when referring to a specific manufacturer’s process, the manufacturer’s terminology will be used in this manual, e.g., CARIS’ terminology (sound velocity or SV) will be used when referring the CARIS procedure “SV Correct”.

If sound speed corrections have not been applied in real-time during data acquisition, a HIPS Sound Velocity Correction must be performed using the SV Correct tool. Two stages of sound speed processing are possible in HIPS: (1) Adjustment of sonar beam (reported) launch angle through flat face refraction (FFR), which is not applicable for all MBES systems, and (2) adjustment of sounding horizontal position and depth through geometric beam ray-tracing. During HIPS SV Correct, survey line “ObservedDepths” data (alongtrack/acrosstrack position and depth with respect to the vessel RP) are recalculated from “SLRange” data (beam launch angle, one-way travel time) and corrected for acoustic refraction as well as (if indicated in the HVF) waterline, dynamic draft, heave, roll, and pitch.

Note: the “Apply” box in the HVF must be checked for waterline, dynamic draft, and each attitude sensor for these data to be applied.

If any sensor smoothing was performed during post-processing, the user may choose to apply the smoothed heave, roll, and pitch sensor values during SV Correct.

Note: Choosing the smooth sensor option will not affect survey data if smoothed coefficient data are not present. The unsmoothed sensor data will be applied by default.

FFR is very important to the beam forming process for MBES systems that use flat-faced transducers, and OCS recommends this process be performed during data acquisition. However, for certain Simrad flat-faced multibeam transducer types, HIPS is capable of performing FFR during post-processing.

For Simrad, FFR can be performed in HIPS if beam range and beam angle datagrams are present in the raw data. (Simrad EM data logged in Simrad Merlin/SIS RAW.ALL format includes the necessary datagrams; EM data logged in HYPACK HYSWEEP format does not.) A check box in the HIPS SV Correct dialog to “Perform an additional recomputation of the steered beam angles based on a new surface sound speed that will be interpolated from the sound velocity profile” controls whether or not HIPS will attempt FFR.

If data quality issues dictate that FFR be performed during SV Correct, any SSP files present in the HDCS data must first be manually deleted.

Beam ray-tracing is performed on all MBES data during HIPS SV Correct, regardless of echosounder type. Starting from the initial launch angle (reported or otherwise FFR-corrected), each sonar beam within a given survey line is processed as a ray refracting through the loaded sound speed profile and tracing a non-linear path. The distance of this path is assumed equivalent to the measured one-way travel time for the beam. By calculating a more precise one-way travel time, a more accurate beam position and depth can be determined.

Typically, a concatenated SVP file (generated by NOAA's Velocipy software) that contains multiple sound speed profiles, complete with metadata to indicate when and where observations took place, will be applied to survey data. In such cases, the user will need to choose a method for selecting how individual sound speed profiles are applied. HIPS SV Correct provides four options: previous in time, nearest in time, nearest in distance, nearest in distance within time. The method selected should be whichever will most accurately represent survey area conditions.

#### **4.2.3.7 Merge**

The HIPS Merge process calculates "Processed Depths" (latitude, longitude, depth) by compensating "Observed Depths" (alongtrack/acrosstrack position and depth with respect to the vessel RP) for heading, navigation, and tide data. Merge will also apply vessel attitude, waterline, and dynamic draft if the data were not previously processed with SV Correct.

Note: the "Apply" box must be checked for waterline, dynamic draft, and each attitude sensor in the HVF for these data to be applied.

The HIPS Merge tool can determine what corrections have been applied during SV Correct and will not perform a double correction for these sensors.

If any sensor smoothing was performed during post-processing, the user may choose to apply smoothed sensor values during Merge.

Note: Choosing the smooth sensor option will not affect survey data if smoothed coefficient data are not present. The unsmoothed sensor data will be applied by default.

For ERS based projects, use the "Apply GPSTide" option in the merge dialogue to select the GPSTide file computed in section 4.2.4.3.2 .

#### **4.2.3.8 Compute TPU (Total Propagated Uncertainty)**

Prior to data processing, vessel offsets and total propagated uncertainty values based on uncertainty estimates for survey equipment should have been entered into the corresponding HVF (see CARIS HVF Uncertainty Values document in Appendix 4).

For the most part, uncertainty estimates entered into the HVF file are static over a field season or in the absence of changes to the vessel configuration. Some HVF uncertainty estimate values may need to be adjusted on a case-by-case basis to account for any un-modeled uncertainty in a given component of the sounding. For example, in areas with strong currents, uncertainty in vessel speed can be adjusted in the sensor TPU section of the HVF to

compensate for appreciable differences between speed-over-ground and speed-through-water. Another critical example of TPU values that may need to be updated in the CARIS HVF is depth uncertainty introduced by heave in singlebeam data acquired on vessels without an attitude sensor. Survey days with substantial heave introduce a larger depth uncertainty than calm days, and require a larger TPU value in the heave section of the HVF. An estimation of uncertainty introduced by heave can be calculated by multiplying the heave amplitude (1/2 the wave height) by 0.707. (This formula is equal to 1 sigma of a sinusoidal wave).

Most of the uncertainty estimates that are entered into a CARIS HVF are straightforward and are based on direct measurement techniques or manufacturer provided information. The estimation of the uncertainty value associated with MRU alignment is an exception. There is no direct method to measure or estimate MRU alignment uncertainty. One method to estimate these values is to calculate the standard deviation of a large sample of angular bias values resolved with a patch test. The sample size can be created either by a number of people resolving the angular biases or a couple of people resolving the values numerous times. Angular bias values resolved in a patch test are actually a measurement of the angular bias that exists between the transducer reference frame and the MRU reference frame. Therefore, any uncertainty values derived from the patch test angular biases are based on the same relationship. As it is the angle between the MRU and the transducer that we are measuring, rather than the absolute alignments of both the MRU and the transducer to a vessel reference frame, we can assign this uncertainty to either the MRU alignment or the transducer alignment. CARIS expects this value to be entered into the MRU alignment uncertainty field.

Note: All changes made to HVFs used to process OCS hydrographic survey data shall be approved by the field unit's Chief-of-Party and completely described in the Descriptive Report. Provided the TPU sensor values in the HVF do not require modification as noted above, TPU computation for specific survey lines is completed by selecting a set of survey lines and choosing the Compute TPU process in HIPS. Once the process has been selected, uncertainty values that change on a survey-by-survey basis, such as tide and sound speed, are entered into the Compute TPU dialog box (see below regarding Tide zoning uncertainty values for TCARI tides).

CARIS allows for only one sound speed and one tide value to be entered per survey area, on a survey-wide basis (at BASE surface creation) in the Compute TPU dialog box. HSTP is working with CARIS to adapt a statistical approach which will allow for multiple values per survey.

Certain error values in the HIPS vessel file (HVF) may be overridden with real-time or post-processed error values. Prior to computing TPU, use HIPS Load Error Data from the Applanix POS PCS raw file (.000) or the Applanix POSpac post-processed RMS file (smrmsg ).

Refer to Appendix 4 for an example of the CARIS Compute TPU Dialog menu.

Tide zoning uncertainty values at the 95% confidence level for discrete zoning are provided by CO-OPS in the tide requirements document on the project CD. All error value components entered in CARIS for TPE calculation are assumed to be 1 sigma; therefore, the value provided by CO-OPS should be divided by 1.96.

Tide zoning uncertainty values for TCARI tides are loaded on a line-by-line basis using NOAA's Pydro-TCARI software. Pydro's Tides->CARIS TCARI Tide->"Load TCARI Tide in HIPS PVDLs" is used in place of CARIS HIPS Process->Load Tide. This operation in Pydro-TCARI loads both tide corrector and tide uncertainty data (HDCS "Tide" and "TideErrorFile", respectively) into a given survey line.

For ERS based projects, if a SEP has been used in the HIPS Compute GPSTide step (processed depths relative to MLLW), the associated vertical datum transformation uncertainty is currently entered in place of the tide values in the Compute TPU dialogue. The VDATUM transformation uncertainty is based on the modeled maximum combined uncertainty (MCU) and will be provided by HSD. Additional details regarding the application of Load Error Data and Compute TPU can be found in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

The sound speed component of total propagated uncertainty is a function of environmental variability with respect to space and time and instrument/calibration uncertainty. Of the two, environmental variability has the greatest influence. Sound speed has a complicated dependence on salinity, temperature and pressure with the greatest change in acoustic propagation speed occurring with the change in temperature between the surface and the lower limit of the thermocline.

HSD has determined that the measured sound speed uncertainty may range from 0.5 to 4 m/s. This range depends on the spatial and temporal environmental variability and the frequency at which sound speed casts are taken. Casts taken at a high frequency (i.e. every 15 minutes or less) will capture the spatial variability better and lower the uncertainty values. HSD requires platforms to use the measured uncertainty values (i.e. TPU) for sound speed listed in the CARIS HVF Uncertainty Values document in the Appendix 4.

Field Units should note the 4 m/s uncertainty estimate (listed in the table from HTD-2 and HTD-10) for traditional sound speed casts is a conservative estimated variability value determined via Velocipy. Hydrographers can lower this uncertainty by increasing the number of casts for a given areas. Thus, field units are strongly encouraged to utilize a high frequency cast system (e.g., MVP) whenever possible and especially in highly variable areas.

Sound speed uncertainty is the subject of continuing research and investigation at UNH CCOM/JHC. Velocipy has incorporated some of this research such as the Uncertainty Wedge Analysis (UWA) and statistically estimating sound speed uncertainty (ESS). See the Velocipy Operations Manual (included on the Hydrosoft website)for more information. Future research is underway to create an algorithm to estimate the sound speed uncertainty value more accurately using temporal and spatial separation between the sound speed profiles and soundings. . Field units which have not been trained in the proper use of the UWA and ESS within the Velocipy software should use the uncertainty values listed in the CARIS HVF Uncertainty Values document in the Appendix 4 but are welcome to test out the program.

The TPU values associated with surface sound speed have a smaller range and magnitude than measured sound speed (0.2 m/s to 2 m/s) because sound speed is continually measured at the transducer. The sound speed uncertainty, therefore, is dictated by the sound speed gradient at the velocimeter's sensor head.

If field units wish to deviate from the sound speed uncertainty values listed here, a review of the variability in the surface sound speed will be necessary to estimate the sound speed uncertainty for a given survey. If the field unit can prove through detailed documentation and calculation that their calculated uncertainty is lower than those stated in the CARIS HVF Uncertainty Values document in Appendix 4), then the lower value may be used. As with any deviation from procedures specified in the HTD's, FPM or the HSSD, methods for estimating uncertainty, and

justification for this deviation, should be clearly described in the Descriptive Report as well as the Data Acquisition and Processing Report. The field should be aware, however, that if the processing branches disagree with the method used, any corresponding surveys using these uncertainty values may be returned to the vessel. Therefore, HSD strongly recommends that field units communicate to the branch their proposed approach. If the branch feels the method is adequate, a detailed description of the method, corresponding calculations and data will need to be sent to HSD for verification (and dissemination to other field units if approved). NOAA does not currently conduct sweep surveys, and the lower section of the TPU dialog box is not utilized.

The TPU values for each sounding ( $\hat{V}$  and  $\hat{H}$ , see propagated uncertainty equation in Figure 4.1) will be computed at the 95% confidence interval.

#### **4.2.3.9 Filter**

Depending upon data quality, the hydrographer may choose to filter a dataset during post-processing. HIPS provides several filtering tools that can be used to automatically flag data as rejected or accepted. Filtering methods commonly used for processing OCS hydrographic survey data include TPU (see section 4.2.3.8), sonar quality flags, angle from nadir, and depth threshold. The TPU filtering option can be used to expeditiously reject soundings with uncertainty values that fall outside limits set for either an IHO order survey or some user-defined parameter. However, the hydrographer should keep in mind that it is the grid node depth that must meet survey specifications, not each individual sounding. Thus, the TPU filtering tool may over clean data. MBES data can be filtered based on sonar quality flags and/or angle from nadir. Although filtering by sonar quality flags is not recommended by OCS, filtering based on angle from nadir may be useful when external conditions cause outer beams to degrade to the point of being unusable. Both MBES and VBES data may be filtered based on depth threshold. This method can be used to eliminate anomalous soundings resulting from double-echoes or near-surface reflection such as propeller wash, entrained air, and marine life. Consult the CARIS HIPS and SIPS User's Manual for more information on filtering methods.

#### **4.2.3.10 Add to Coverage BASE Surface**

A BASE surface model should be created to demonstrate data coverage in accordance with section 5.2.2 of the HSSD. Each day, newly acquired data should be added to this surface for a quick coverage assessment and planning of the next day's surveying operations. The hydrographer is reminded that AWOIS radii that extend beyond the basic survey limits must be entirely covered with 200% side scan, complete or object detection multibeam, or a combination thereof to be disproved by sonar data. These radii should be considered when evaluating survey coverage.

Coverage requirements will vary based on the classification of MBES data assigned in the Project Instructions. Three general classifications for NOAA hydrography are Complete Multibeam, Object Detection, and Set Line Spacing. Typically when a BASE Surface is created to evaluate coverage, that day's bathymetric data have not yet been analyzed using directed-editing processes. Thus, the coverage BASE surface may need to be re-gridded periodically to verify that subsequent editing did not affect data coverage.

#### **4.2.4 Boat-day Processing**

"Boat-day Processing" as described in this chapter refers to that portion of hydrographic data processing that is performed on a single vessel's data that were acquired during a single day of data acquisition. Prior to commencing Boat-day Processing, all of the Daily Batch Processing tasks (see section 4.3.3) should have been performed. For ships and launches, Boat-day Processing is typically accomplished during a "night processing" shift. For field parties, this processing step is often saved for foul weather days or is accomplished by a shore party member in

charge of daily data processing. For ERS based projects, boat-day processing includes generating POSPac SBET's for all survey vessels. Additional details regarding POSPac SBET processing can be found in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

Boat-day Processing is based on the natural interpretive power of the human eye to evaluate a BASE surface for anomalous bathymetry, directing attention to areas that require review and/or editing (i.e., "directed editing") by an experienced hydrographer. Vertical exaggeration is a very useful tool to accentuate bathymetric features and artifacts on a "sun-illuminated" BASE surface. However, extreme depth scaling can make small features seem significant and/or make acceptable multibeam data appear riddled with problems. Scaling sun-illuminated depth layers by a multiplier of three to five is generally a good choice for initial data review. If artifacts are perceived, the hydrographer can measure the vertical distance of the artifact (peak-to-trough) and compare this distance to the allowable vertical error for the survey to determine if the data is acceptable. If major data artifacts or issues are observed, the CST, FOO, or Team Lead should be informed in order to identify and resolve the issue.

Note: In navigationally significant areas where no supporting imagery data exist (see section 4.3), special emphasis should be placed on the review and interpretation of bathymetry data and, as needed, supporting sensor time series data.

In most cases, data anomalies can be easily evaluated and edited using HIPS Subset Editor . However, complex areas may require additional line-by-line evaluation and editing via HIPS Swath Editor (see section 4.2.4.3.2 ).

Once data are merged, the hydrographer should review attitude and navigation time series data as described in sections 4.2.4.3.3 and 4.2.4.3.4 , then use the HIPS Single Beam Editor tool to review bathymetry data. Following this review, the most accurate water level data available should be applied (see section 4.2.5.1.1), and then the VBES data can be inserted directly into Pydro.

#### **4.2.4.1 Create Boat-day BASE Surface**

The first step in Boat-day processing is to create a CARIS BASE surface of the vessel's daily data using final gridded data specifications as defined in section 5.2.1 of the HSSD. Initially the Boat-day BASE surface is used to direct the editing process (see section 4.2.4.3 ). Once editing and the appropriate checks are complete the Boat-day BASE surface can be regridded and added to a Survey-wide BASE surface that will, ultimately, be finalized and submitted.

An option exists in the HIPS BASE surface creation process to add comments. These comments are included in the metadata stored in an XML companion file with every BASE surface. In addition to having metadata in a separate file, it is helpful to include some descriptive information in the BASE surface file name. The following BASE file naming convention is an effective way to keep track of Boat-day surfaces:

Registry Number\_Vessel Number\_Day-of-Year\_Resolution\_<Lettered Index>

For example, the names for two Boat-day BASE surfaces created at a 2 meter resolution using RAINIER launch #4 data from day number 152 might look like: "H12345\_RA04\_152\_2m\_a" and "H12345\_RA04\_152\_2m\_b."

#### **4.2.4.2 Review Boat-day BASE Surface**

Once a Boat-day BASE surface has been created, it should be investigated for indications of data problems (artifacts) and features. A bathymetric feature is any object that may be of importance for nautical charting, such as a wreck, shoal, or other item that may need further investigation. Typically, the depth and standard deviation BASE surface

layers are most useful for identifying data anomalies (see list of BASE attributes in section 4.2.1.2 ).

The Properties Window can be used to assist the hydrographer with BASE surface review. This window allows the user to customize a BASE surface color map and adjust the azimuth and elevation of simulated sun illumination. Varying these settings helps highlight artifacts and features that may be hidden when viewed using only one set of display parameters. The hydrographer should systematically inspect all BASE surfaces at least four times, moving the azimuth of the virtual sun 90° each time while maintaining a moderate to low elevation. For example, azimuth values of 045°, 135°, 225°, and 315° (northeast, southeast, southwest, and northwest) with a fixed elevation of 45° is a common, and usually effective, series of settings.

Note: If plotting BASE surfaces, a sun elevation of 45° and azimuth of 315° generally presents artifacts and features most accurately. A particular pixel-color can also be set as transparent. Choosing a transparent pixel of “0” will make the otherwise white background of the image transparent so that underlying data (charts, orthographic photographs, etc.) will be revealed.

Problems that may be encountered in a MBES data set can generally be broken down into the following seven categories: refraction, attitude, position, heading, sonar, environmental, and tide. Each of these data problems is described below. For further guidance on which tools should be used to edit various data problems, see section 4.2.4.3 .

#### 4.2.4.2.1 Refraction

Acoustic refraction-induced errors are caused when the speed of sound through the water column is not adequately modeled over time or space. When viewing data with refraction errors in the across-track direction, the hydrographer will notice a “smiling” or “frowning” characteristic as shown in Figure 4.9 .

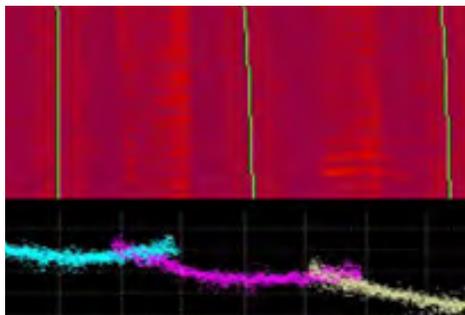


Figure 4.9: HIPS Subset Editor view (bottom) of acoustic refraction-induced bathymetry errors, using BASE surface standard deviation image for reference.

Depending upon the cause of this artifact, it may indicate a need for additional sound speed profiles each day or more profiles spatially over the survey area. Typically, the amount of time required to obtain additional sound speed profiles is far less than that required to edit, or otherwise “fix”, data afflicted with acoustic refraction artifacts.

HIPS Refraction Editor, a tool in Swath Editor, may be used to assist with troubleshooting refraction errors. Refraction Editor allows the user to enter a step sound speed correction at a specified water depth. As sound speed corrections are entered, the effect is reflected in the swath edit display by increasing or decreasing the curvature (smiling or frowning) of the swath.

Note: HIPS does not account for TPU (see section 4.2.3.8 ) introduced by using Refraction Editor; thus, Refraction Editor is not approved for use in OCS hydrographic surveys and shall not be used for deliverable products.

#### 4.2.4.2.2 Attitude

Vessel motion artifacts may arise due to a failing accelerometer within the heave/pitch/roll sensor, a gap occurring in data transmission or recording, an inaccurate patch test (e.g., conducted in insufficiently deep water for the given survey area), or unaccounted latency within the data acquisition system. An example of a gap in the recorded attitude time series is illustrated in Figure 4.10.

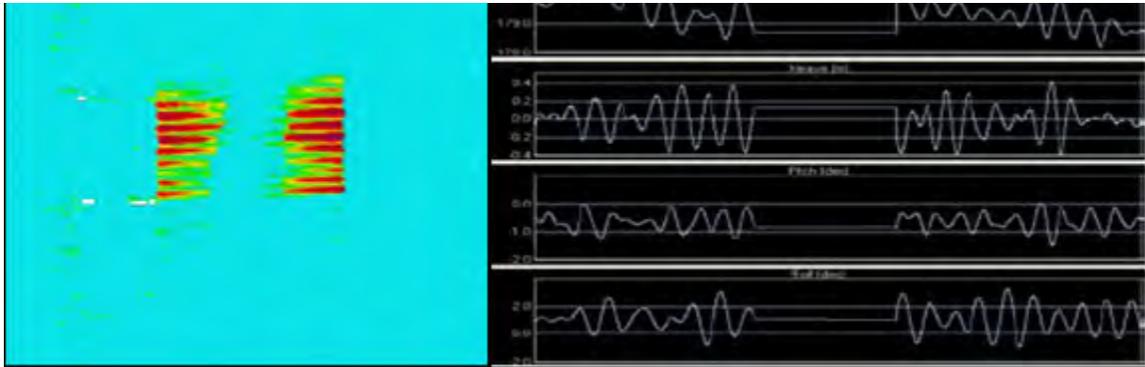


Figure 4.10: BASE surface standard deviation layer (left) of a survey line with data in attitude time series (right).

If a specific cause of vessel motion artifacts can be determined, it may be possible to repair the data. For example, a new patch test could be run, or data could be reprocessed to account for a known latency. In other cases, data may need to be either smoothed to minimize the artifact or rejected entirely. If systematic errors are found in a vessel's attitude data, the time spent trouble shooting the source of the problem will typically far outweigh the time required to continually edit data.

#### 4.2.4.2.3 Position

Gross horizontal positioning errors are uncommon when using modern surveying equipment. Inertially-aided GPS navigation equipment, such as the Applanix POS/MV, uses Kalman filtering to constrain vessel speed, acceleration, and displacement, eliminating the majority of potential positioning errors. The most common cause of error in an inertially-aided system is when the GPS portion of the position solution fails.

Note: Due to the horizontal position accuracies required for OCS hydrographic surveys, loss of differential GPS corrections should also be considered GPS failure. The effects of temporarily losing differential corrections are illustrated in Figure 4.11.

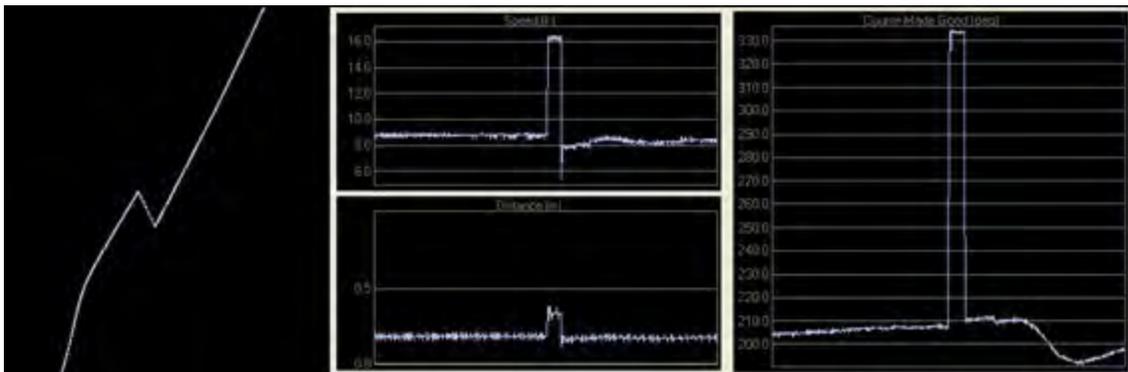


Figure 4.11: HIPS Navigation Editor time-series showing positioning error caused by temporary loss of differential corrections.

During a GPS failure, inertial navigation systems can dead reckon for approximately 30 seconds before errors accumulate to a level that produces unacceptable positioning. The hardware/software interface for an inertial navigation system should be configured to alert the user of failure events so that data acquisition can be suspended if position data becomes unacceptable.

Positioning “problems” associated with horizontal uncertainty may be seen on areas of extreme slopes. For example, if the horizontal accuracy is approximately 4 meters, the vertical depth error on a slope of 60° would be almost 7 meters. Inconsistencies will be observed from swath to swath in these areas due to the horizontal positioning error. Keep in mind that horizontal uncertainty is factored into the BASE node uncertainty calculation, and may adequately account for what appears to be positioning errors on steep slopes (see section 4.2.1.1 ).

#### 4.2.4.2.4 Heading

Heading errors can be induced by a faulty sensor or an incorrect heading alignment correction entered in the HVF. This problem can be easily identified as a break in continuity of linear features from one swath to the next.

During data acquisition, heading values are sometimes included in datagrams from sensors other than the primary navigation system. However, the accuracy of heading data will vary depending upon its source. If heading errors are discovered, it may be possible to re-process the data using heading information from another source. The field unit’s FOO or equivalent should be notified if an alternate heading source (e.g., calculated course-over-ground) is used to process survey data, as TPU (see section 4.2.3.8 values in the HVF may require editing.

#### 4.2.4.2.5 Sonar

Sonar-induced data problems are typically caused by inappropriate settings in the sonar system. These may include unoptimized power, gain, and threshold settings, as well as improper range settings for the depth of water. Any of these circumstances could prevent the sonar from accurately representing the sea floor. The best way to minimize sonar-induced errors is by having a well-trained and attentive operator during data acquisition.

#### 4.2.4.2.6 Environmental

Environmental data problems are those caused by objects or disturbances in the water column, such as marine life, vegetation, entrained air from passing vessels, or weather-induced disturbances from heavy seas or rain. Figure 4.12 shows an example of environmental noise which occurred near the transducer face.

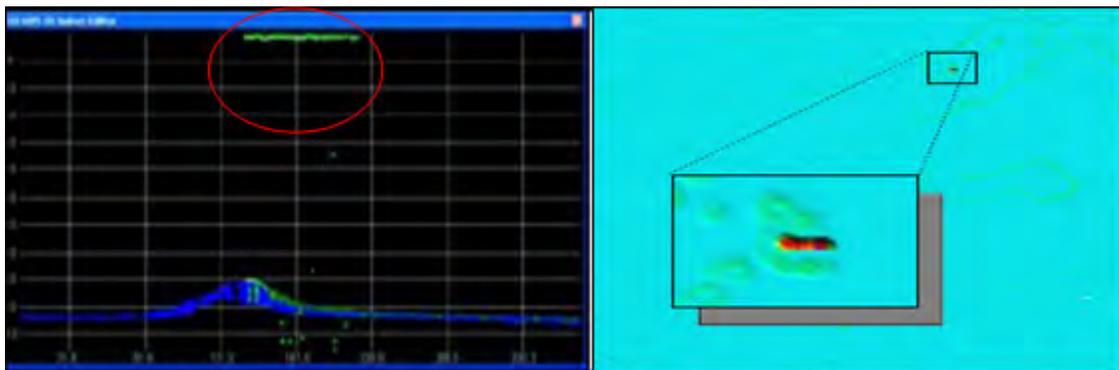


Figure 4.12: HIPS Swath Editor view (left) and BASE surface standard deviation layer view (right) showing water column noise near transducer.

As with all data problems, environmental data issues are most effectively addressed during the acquisition stage rather than during processing. Depending upon the severity of data problems, acquisition may need to be suspended until environmental conditions have improved.

#### 4.2.4.2.7 Tide

Tide errors can result from inaccuracies in any of the source data used in the vertical datum transformation algorithm, such as inaccuracies in the water level observations, tide zoning model, or navigation. This type of error is often identified by a measurable vertical offset visible when data are viewed in the across-track direction, as shown in Figure 4.13 .

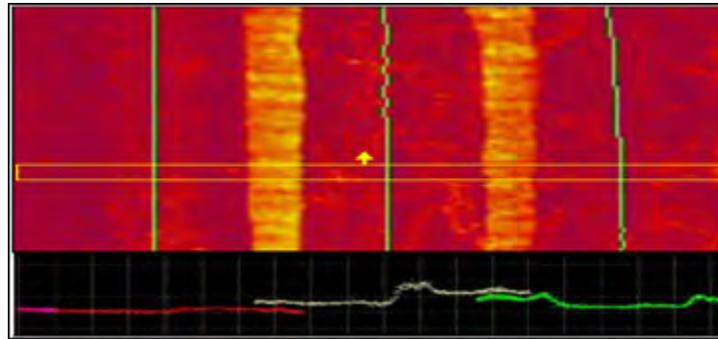


Figure 4.13: HIPS Subset Editor view of tide-induced bathymetry errors (bottom), using BASE surface standard deviation image for reference (top).

If tide errors are identified, the hydrographer should ensure that the correct water level data have been loaded for the suspect dataset. Keep in mind that predicted tide files do not account for water level effects due to non-astronomical forces. Thus, what appears to be a data problem may correct itself once observed water level data are applied. However, the varying accuracies and unquantified uncertainty of tide correctors resulting from discrete zoning have the potential to result in tide-induced bathymetry errors even when using actual tide gauge data rather than predictions. If there are no other hydrographic sources of this error, this would indicate that either the tide gauge locations are inadequate and/or the method of discrete tidal zoning cannot account for the complex hydrodynamics of this survey area.

#### 4.2.4.2.8 ERS SBET Height Errors

This type of error may be identified by a measurable vertical offset visible when data are viewed in the across track direction, similar to a tide error. Additional details regarding ERS SBET quality control can be found in the Ellipsoidally Referenced Survey SOP.pdf in Appendix 4.

#### 4.2.4.3 Directed Editing from Boat-day BASE Surface

One or more of the HIPS data “editors” can be used to analyze data artifacts and features of interest that are identified on the Boat-day BASE surface. With the exception of VBES data, depth values cannot be directly edited or changed in HIPS; rather, soundings can be flagged with various attributes, including “rejected” which will suppress a sounding from further processing steps. Daily review and flagging of features is strongly recommended to maintain an organized and complete survey. Supporting sensor data can also be flagged as being rejected, either with or without interpolation.

Subset Editor is the most frequently used HIPS editing tool and allows the most flexibility in addressing a problem that is concentrated in one geographic area. OCS recommends the use of “Subset Tiles” with 10% overlap to track editing progress in Subset Editor. Once defined, subset tiles may be flagged as either “Complete” (green), “Partially Complete” (yellow), or “Incomplete” (red) to identify areas that have been investigated, need a second review, or have not yet been edited, respectively.

In some cases, it may be beneficial to review individual sonar pings in a specific line of survey data. This type of line-by-line editing can be performed in HIPS Swath Editor. If potential problems in either attitude or position data are noticed, the Attitude Editor or Navigation Editor tool can be used to review individual sensor time series data. Each of these four data editing tools is described in greater detail below. Refer to the CARIS HIPS and SIPS User’s Manual for further information on any of these tools.

#### **4.2.4.3.1 Subset Editor**

Subset Editor enables the hydrographer to review and edit a “subset” of the entire sounding dataset, and corresponding BASE surface data, by geographic area. Subsets are rectangular in shape and will contain all soundings acquired within the geographic boundaries of the subset. Subsets can be created in a north-south or a rotated orientation. Rotating a subset can be useful to obtain a profile view when inspecting data along slopes or dredged channels.

When using Subset Editor, the hydrographer should be aware of the data display settings, particularly vertical exaggeration and whether rejected soundings are displayed. If vertical exaggeration is set to “Auto,” then the display will rescale as soundings are edited. This feature creates a potential for the user to become focused on very fine details in the seafloor and essentially edit data to create a smooth bottom, which rarely exists. The hydrographer must take care not to “over clean” data in this fashion. Displaying rejected soundings allows the user to see data that has been previously rejected, typically by a filtering routine in Swath Editor or editing by another hydrographer. Viewing rejected data is often valuable when investigating the validity of a possible feature.

- Individual soundings or groups of soundings may be selected and flagged in Subset Editor. Available data flags and each flag’s purpose with respect to OCS hydrography are as follows:
- Reject - Flag anomalous soundings as “rejected” to suppress them from being included in subsequent processing steps, such as in the calculation of BASE surface grids.
- Reject Swath - This flag sets the “rejected” flag for all soundings in a selected swath. Use this function to reject a single ping or a continuous section of flawed sonar pings.
- Outstanding - This flag may be set for any data point that holds particular hydrographic significance. Typically, if the identity, extent, or validity of a feature is uncertain, it should be flagged as “outstanding.” NOAA Pydro software treats soundings flagged “outstanding” in HIPS as bathymetry features. Pydro establishes a connection to the HDCS data for all “outstanding” soundings and will automatically update the HDCS data for any subsequent flag changes made in Pydro during feature processing (see section 4.4 ).
- Examined - This flag does not currently have a defined meaning for OCS hydrographic survey data; however, it can be used by the surveyor as a means of marking a sounding for future reference. This flag can also be used to separate a group of soundings for non-standard data analyses.
- Designate - Applying the “Designate” flag to a sounding will force the BASE surface grid node closest to that

sounding to assume the exact depth value of the designated sounding, ignoring all other soundings within the area of influence of this node. Pydro regards soundings flagged “designated” in HIPS as “designated” bathymetry features in Pydro. Pydro establishes a connection to the HDCS data for all “designated” soundings, and subsequent flag changes or edits made to the bathymetry feature in Pydro will automatically be reflected in the HDCS data.

#### 4.2.4.3.2 Swath Editor

Swath Editor enables the hydrographer to review and edit a single swath of data from four orthogonal directions as well as from a three dimensional perspective.

Note: Data viewed in Swath Editor are not geo-referenced, but displayed with respect to across-track and along-track distances from the transducer.

Data problems that appear to be limited to the extent of a single line of data are often best addressed using Swath Editor. As when using Subset Editor, individual soundings or groups of soundings may be selected and flagged in Swath Editor. HIPS data flags and their purpose in OCS hydrography.

Note: “Outstanding” and “Examined” flags can not be applied using Swath Editor.

Swath Editor also allows the user to view amplitude (i.e., backscatter or side scan) data from a multibeam echosounder. Amplitude data can provide valuable insight for determining if a particular sounding or group of soundings is a real feature.

#### 4.2.4.3.3 Attitude Editor

Attitude Editor allows the hydrographer to review and edit heading (gyro), heave, pitch, and roll data. Attitude Editor displays each sensor’s time series data for a single survey line. HIPS provides three means of editing attitude data, rejecting (with or without interpolation), filtering, and smoothing.

For data problems of limited extents in time, rejecting is generally the preferred editing method. There are two options for rejecting attitude data: “Reject-with interpolation” and “Reject-break interpolation.” Rejecting data with interpolation will fit a straight line from the last good data point before the segment rejected to the first good data point after the segment rejected. Caution should be exercised when using this tool. Rejecting and interpolating sections of attitude data across the peaks of a signal will result in distorting the maximum observed amplitude at that time, as illustrated in Figure 4.14 .

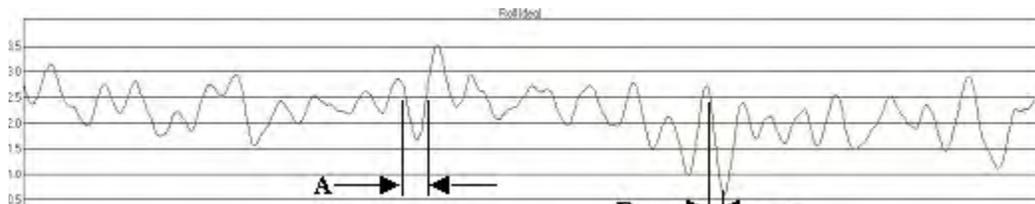


Figure 4.14: interpolation across region ‘A’ will most likely create an artifact of its own, whereas interpolation across region ‘B’ will not adversely impact the sounding data.

Rejecting without interpolation should be used to edit attitude data corruption occurring over an extended period of time. A general rule of thumb is to divide the allowable data gap distance for the survey by the vessel speed in meters-per-second to determine when to begin breaking interpolation. For example, if a 5 meter resolution grid is required to demonstrate adequate data coverage and the vessel speed is 5 m/s (~10 knots), regions of bogus data

greater than or equal to 1 second ( $5 \text{ m} \div 5 \text{ m/s} = 1 \text{ s}$ ) should be rejected without interpolation. The Hydrographer should note that breaking interpolation will create a gap in the data. When the files are merged, this option rejects all sounding data recorded during the time period in which sensor data were rejected, thus leaving a holiday in data coverage.

For attitude data problems that are systematic throughout the time series, filtering or smoothing is typically the best editing approach. The hydrographer is cautioned that filters are powerful tools and should be used sparingly and with great care. Attitude Editor provides two filtering options: “Moving Average” and “Fast Fourier.” The Moving Average option calculates a mean for each data point according to a user-specified number of neighboring data points (in time or number) or “box size.” The Fast Fourier method performs low-pass filtering on the sensor data according to a user specified signal period (in time or number-of-points).

#### **4.2.4.3.4 Navigation Editor**

Navigation Editor allows the hydrographer to review and edit the vessel’s navigation time series. The navigation time series can be edited in HIPS using rejection with or without interpolation. When rejecting data, the Navigation Editor tool offers two interpolation methods: Linear and Bezier. Linear interpolation is suitable if the majority of navigation positions are clean and do not deviate significantly from neighboring positions. Bezier interpolation is suitable if the original data is noisy. Linear interpolation simply calculates new positions over the rejected segment by connecting bounding positions with a straight line. Bezier interpolation calculates new positions over the rejected segment by fitting a Bezier curve through bounding positions, producing a resultant curve that may not necessarily connect or pass through all navigation positions on the line.

To help expedite data inspection, Navigation Editor provides “spike detection.” This tool will search the navigation time series for user-defined “jumps” in speed and time. Each jump will be highlighted so that the hydrographer can decide how best to edit the data. Large jumps in speed, calculated as distance traveled divided by time between fixes, can detrimentally affect the vessel’s dynamic draft computation. Data artifacts due to speed jumps will be more pronounced if the slope of the vessel’s speed versus dynamic draft is steep. A general rule-of-thumb is to interpolate speed jumps if they exceed the TPU (see section 4.2.3.8 modeled for vessel speed in the HVE, but this becomes less critical if a vessel’s speed versus dynamic draft slope is small. Since speed and time jumps are directly related and speed is used to determine dynamic draft, it is not necessary to separately edit time jumps.

#### **4.2.4.4 Update Survey-wide BASE Surface**

Once directed editing has been completed, the Boat-day BASE surface should be recomputed to verify that all edits were successful. If no further editing is necessary, the Survey-wide BASE surface should be updated, using final gridding parameters, to reflect the current survey status.

For ERS based projects, if no SEP has been used in the HIPS Compute GPSTide step (processed depths relative to the Ellipsoid), then boat day and survey-wide BASE surfaces must be transformed to chart datum for sounding review and the determination of DTON’s. See section 4.2.5.1.2 for guidance.

#### **4.2.5 Survey-wide Processing**

“Survey-wide Processing” includes many of the steps and skills discussed previously in this chapter. The difference is the context in which these steps are accomplished. During Boat-day processing, a single “boat-day’s” worth of bathymetric data is being viewed, edited, and flagged for internal consistency, gross errors, and any features that

warrant further investigation. During Survey-wide processing, survey bathymetry and imagery data are examined in context with existing chart information and any additional supporting data available. Survey wide data analysis can be performed relative to Ellipsoid or chart datum as most appropriate.

Many of the steps involved in processing hydrographic surveys are iterative and may be conducted in parallel with each other. Efficiency can be increased by conducting many of the Survey-wide processing steps concurrently with Boat-day processing for global quality control and general survey completeness. These processes would include verifying adequate investigation of charted features within the survey sheet limits, reviewing the data for DTONs, and verifying that data coverage meets the assigned specifications. Reviewing these points on a daily basis will help to ensure a complete survey and a timely submission.

#### **4.2.5.1 Vertical Datum Transformation**

##### **4.2.5.1.1 Apply Water Level Correctors (non-ERS)**

Preliminary water levels are 6-minute water level measurements that have undergone rudimentary data consistency checks in the CO-OPS Data Processing and Analysis System (DPAS). Any gaps in data coverage will remain in these preliminary data, and measurements may, or may not, have been reduced to the local MLLW datum. Preliminary water levels should be available within hours, if not minutes, of data acquisition. Verified water levels have gone through CO-OPS' processing, analysis and quality assurance processes, and any gaps in data have been recovered or interpolated through a process which utilizes nearby gauge data. After a preliminary or accepted datum has been computed, 6-minute verified water levels are made available referenced to MLLW.

Note: Field units shall submit, via email, a request for final tides to [final.tides@noaa.gov](mailto:final.tides@noaa.gov) within 24-hours of completing data acquisition for a survey (see section "5.2.2.3.3").

Once a request for tides is received, CO-OPS will review the survey tide requirements to determine if adjustments or corrections are required. If CO-OPS needs to make any modifications, they will provide final water level correctors to the field unit. If no changes are required, CO-OPS will provide the field unit with an official final tide note stating that preliminary zoning, (and associated .zdf file) will be accepted as the final zoning; thus, verified water levels applied using preliminary zoning will be equivalent to final water level correctors. CO-OPS should respond to the field unit within two weeks of receiving a Request for Tides. Verified 6-minute water levels and final water level correctors should be applied as soon as these data are available. See sections 4.2.3.2/ and 4.2.3.5 for details regarding the application of water levels in HIPS.

##### **4.2.5.1.2 Apply Ellipsoid to Chart Datum Separation Model (SEP)**

For the 2014 field season, the processes and tools for applying SEP to CARIS processed bathymetry grids are being developed. The process will involve the following basic steps:

1. Ellipsoidally referenced grid surfaces are read from CARIS.
2. Grid math is performed (currently outside of CARIS) to apply the project SEP model (VDATUM or ERZT) datum and datum uncertainty.
3. The adjusted surface data is read back into CARIS now referenced to chart datum (MLLW) with appropriate vertical datum transformation uncertainty applied.

#### 4.2.5.2 Assess Bathymetry Features

Throughout the survey process, bathymetric contacts should be periodically assessed and a determination made as to whether “development” is necessary. Developing a bathymetric contact typically refers to acquiring additional MBES data over the feature to increase sounding density and determine, or verify, a least depth. However, other methods of obtaining a least depth may be used, such as VBES or DLDG.

Bathymetric contacts are often easily identified and corresponding HDCS data can be flagged during examination of the BASE surface depth or standard deviation layers. Soundings flagged “examined”, “outstanding”, or “designated” can then be highlighted using the HIPS “Display Critical Soundings” command. However, bathymetric features should also be assessed in Pydro, which enables the hydrographer to analyze each item in context with other available data sources such as the chart, imagery data, DPs, and AWOIS records/search radii. (Refer to section 4.4 for additional details.) Within Pydro, the hydrographer can easily evaluate bathymetric features to determine if any are DTONs. Comparisons should also be made between sounding data and existing charted depths. If survey soundings indicate deeper water than the charted depth(s), the charted depth should be treated as a feature and additional data acquired, as necessary, to verify that the charted depth is incorrect. (This process is often referred to as a charted sounding investigation.) Bathymetric features should be evaluated for significance and data coverage and, if appropriate, flagged within Pydro for “investigation,” as detailed in section 4.4 .

#### 4.2.5.3 Review Survey-wide BASE Layers

The final Survey-wide BASE surface to be submitted shall be created in accordance with section 5.2.1 and 5.2.2 of the HSSD. Prior to finalization, BASE layers should be reviewed to ensure that the gridded surface truly reflects the conditions in the survey area, meets specifications assigned in the Project Instructions and that all features have been adequately investigated. Both mainscheme lines and crosslines should be included in the final BASE surface.

#### 4.2.6 Finalize Bathymetry Data

For survey submission, BASE surfaces must be finalized in HIPS. This process is explained in detail in the CARIS HIPS and SIPS User’s Manual. Finalizing BASE surfaces serves three purposes:

- To apply Designated soundings: In some instances, due to the nature of the weighting algorithm, a BASE surface does not accurately represent the least depth of a navigationally significant feature (typically a fine item such as a tall, narrow coral head or a shipwreck’s mast). In such cases, a sounding can be flagged as Designated to force the nearest BASE surface grid node to honor the depth of the designated sounding. Refer to the following subsection for guidance on selecting Designated soundings. Designated soundings are applied to the BASE surface during the Finalize step in CARIS by checking the “Apply designated soundings” option.
- To assign grid nodes a final uncertainty: A grid node’s final uncertainty can be assigned as one of three options: 1) that node’s a priori uncertainty-weighted uncertainty, i.e., predicted error, 2) the grid node’s standard deviation scaled to a 95% confidence interval, i.e., observed error, or 3) the greater of the two. For OCS hydrographic survey data, the “greater of the two” option shall be used to maintain a conservative uncertainty estimate.
- Define depth thresholds: A single-resolution grid will generally not be appropriate for an entire survey area. To maintain the optimal resolution for a given depth range, the finalize process filters out a desired depth range for each different grid resolution created.

#### 4.2.6.1 Designate Bathy Features

Since the calculated depth at each grid node of a BASE surface is influenced by multiple soundings, the least depth of a feature may not always be accurately represented in the gridded data. Prior to creating a finalized BASE surface collection, the hydrographer must systematically review significant feature least depths to ensure they are accurately portrayed by the BASE surface.

If a specific least depth sounding is preferred over the weighted mean-depth calculation for the associated BASE surface grid node, that sounding should be flagged Designated. The Designated flag can be applied in either HIPS or Pydro. If a sounding is made Designated in one software package, this flag will automatically carry through to the other application. Designated soundings shall be selected in accordance with section 5.2.1 and 5.2.2 of the HSSD.

A common area of confusion is the preferred spatial density of designated soundings. It is easy to lose one's sense of scale when viewing data in subset editor. Sand ripples can look like mountains and small rocks appear like house sized boulders. The hydrographer shall take a holistic view of the surrounding bathymetry to help determine the hydrographic significance of a feature before designating a sounding. When there are a group of features near each other (e.g. they would be shown as a single sounding or charted feature at the scale of the survey), only the shoalest sounding on the feature with the most representative shoal depth shall be selected.

As discussed in the Specifications and Deliverables section 5.2.1.2, the hydrographer should use discretion in designating soundings on features. In the example below, the pile of rocks on the left hand side of the image would only require one designated sounding although there are two 'peaks' in the rock pile. The single designated sounding would be adequate to chart the least depth of the group of features. The next feature to the right (a submerged piling) would have a designated sounding at the least depth. The buoy, anchor chain, and buoy block should have no designated soundings. The pair of pilings which are exposed and charted as pilings would not have designated soundings, they are not features that would be charted with a sounding. The pilings on the pier on the far right would not have any designated soundings, nor would any objects under the pier as they would not be charted.

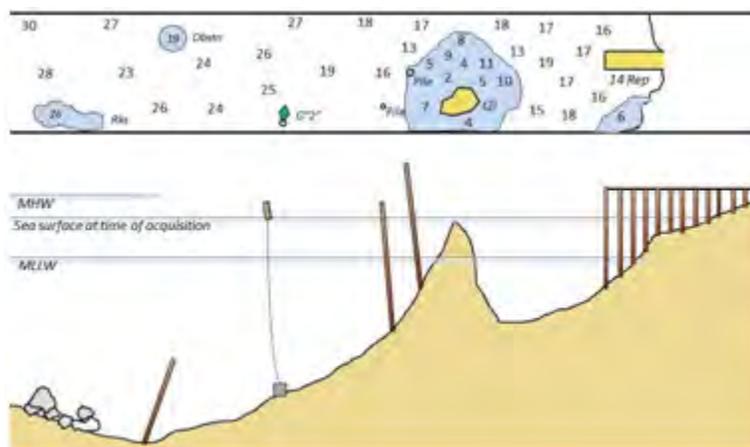


Figure 4.15: Designated Bathy Feature

### 4.3 Imagery Processing

NOAA hydrographic field units typically acquire three types of imagery data: side scan sonar (SSS), MBES backscatter, and MBES "side scan" which is available as an option on some systems. True side scan sonars produce superior imagery for object detection purposes and are used to meet object detection requirements for OCS hydrographic surveys.

Note: Backscatter data and side scan imagery acquired in conjunction with MBES bathymetry, is often processed as an aid for data analyses but is not approved by OCS for meeting hydrographic survey object detection requirements.

The procedures outlined in this section are required only for SSS imagery being used to meet OCS object detection criteria, and are not applicable to MBES imagery data unless noted as pertaining to a specific MBES system or “backscatter” data.

### 4.3.1 Imagery Object Detection

Imagery data are acquired and processed with the purpose of detecting objects that may be of navigational significance. This determination is typically based on contact type, position, and height above the sea floor estimated from the item’s acoustic shadow on the SSS record. Imagery data acquired for OCS hydrographic surveys are geographically referenced; thus, a position can be determined for each contact identified. The accuracy of this position will vary depending on whether the sonar was towed or hull-mounted, but either method should be sufficient to locate the item for further investigation. If a contact is determined to be significant, a “development” should be conducted to determine the item’s least depth and a more accurate position for charting.

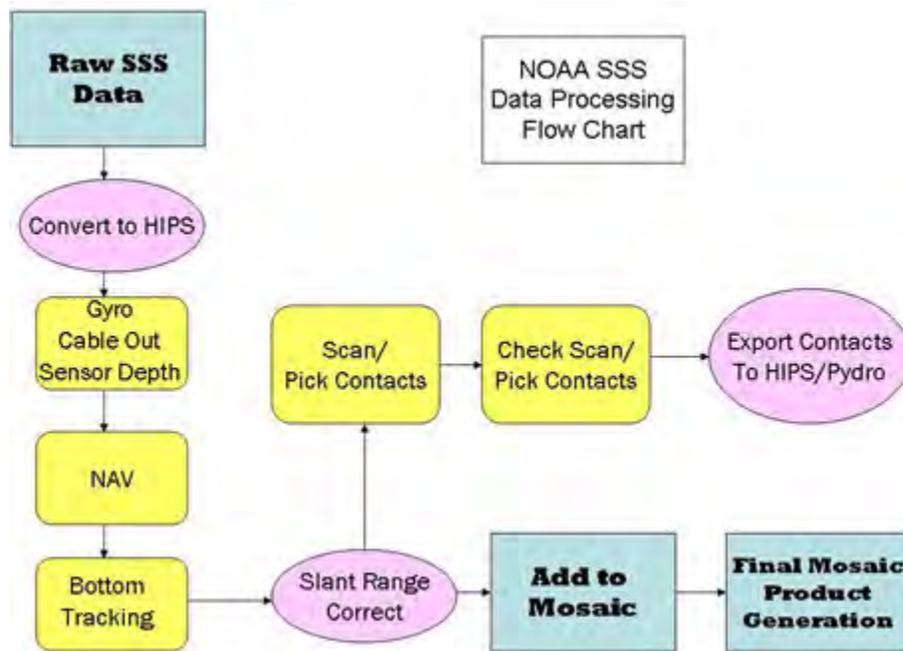


Figure 4.16: Basic data processing flow chart for SSS data.

### 4.3.2 Daily Batch Processing

Several processing tasks need to be performed on “raw” imagery data (i.e., unaltered data in the format generated by the acquisition software) before any detailed analysis and evaluation can occur. Some of these daily tasks are interdependent, and the specific sequence is critical. The recommended ordering of daily batch processing tasks is as follows:

1. Conversion 4.3.3.1
2. Filter, if applicable 4.3.3.2

### 3. Recompute Towfish Navigation 4.3.3.3

### 4. Slant Range Correction 4.3.3.4

### 5. Add to Mosaic 4.3.3.5

Most of the tasks above can be semi-automated in HIPS/SIPS using the “Batch Processor” tool. Data format determines how specific processing actions need to be configured; as such, a separate Batch Processing File (.hbp) is needed for each raw data format type.

In general, all of the aforementioned tasks should be completed for any type of imagery data being used to meet OCS hydrographic survey specifications. A basic set of batch processing files can be specified for each sonar type and reused on the appropriate set of survey lines acquired each day. In some circumstances, either creation of custom batch processing files or manual processing of one or more tasks, line-by-line, in non-batch mode may be necessary. For example, conversion and filtering options may need to be customized to reflect changes in sonar performance as weather conditions varied throughout a survey day.

#### **4.3.2.1 Conversion**

CARIS SIPS supports many different data formats that may be used to record imagery. During conversion, SIPS uses raw data to create files in CARIS’ proprietary format which will be used in subsequent CARIS processing routines. These files in CARIS SIPS format are referred to as “SIPS files” or “HDCS files.”

For towed SSS configurations, a calculated “towfish position” may have been recorded in the raw data depending upon the acquisition software being used. This calculation requires cable out and towfish depth (or water depth minus towfish altitude). If cable out and either towfish depth or water depth and towfish altitude were logged during acquisition, towfish position can be re-calculated during post-processing via SIPS Recompute Towfish Navigation (see section 4.3.2.3 . Either method of positioning should be adequate for standard SSS operations. However if recomputing towfish navigation, the hydrographer should first review and edit, if necessary, cable out and towfish depth. For hull-mounted configurations, sonar offsets should be accounted for in the HVF as vessel RP-to-towpoint values.

Note: Recompute Towfish Navigation must be performed for vessel RP-to-towpoint to be applied. For hullmounted configurations (i.e., no cable out data recorded), towfish navigation will be recomputed using a cable out value of zero.

If an error is discovered in the HVF during SSS post-processing, re-conversion may not be required to correct the data. If unsure whether data repairs are necessary, the Survey Manager should consult, through his/her chain-of-command, the Hydrographic Systems and Technology Program for guidance.

The following sections contain guidance for converting common raw imagery data formats used by OCS into HDCS files. Relevant background information is provided, followed by a table of guidelines for specific Conversion Wizard settings related to each raw imagery format.

#### 4.3.2.1.1 Sensor Data Format (SDF)

Sensor Data Format (SDF) may be used to store data from Klein System 3000 or Klein System 5000 side scan sonar systems. Conversion parameters will vary slightly depending upon the SSS system used to acquire the data. The SDF data format is generated by Klein Associates' proprietary software package SonarPro.

If data were acquired using a Klein 3000 dual frequency (100 kHz and 500 kHz) side scan sonar, the user must choose which frequency to convert. Choose the "high" option to convert 500 kHz data and "low" to convert 100 kHz data. Typically, higher frequency data will provide better imagery resolution, while lower frequencies travel further and can be used at larger range scales.

If data were acquired using a Klein 5000 dynamically focused multibeam side scan sonar, the user must choose whether or not to convert hidden beams. There are five beams on each channel (port and starboard) of the Klein 5000. Based on range scale and towfish speed, the system will determine the number of beams necessary to achieve 100% coverage. Typical range scales and speeds used for hydrographic surveying require that 3 - 4 beams be used. Selecting "convert hidden" forces all 5 beams to be converted and may improve imagery in high yaw-rate conditions (e.g., in turns or for hull-mount configurations) or aid in detection of very small objects during activities such as search and recovery. However, for the purposes of a basic OCS hydrographic survey, converting hidden beams is not necessary to meet survey specifications and can introduce data management problems by significantly increasing file sizes.

Towfish depth is used to calculate towfish navigation in SIPS. Both the Klein 3000 and 5000 systems are equipped with a pressure sensor installed in the towfish body to determine towfish depth. Each towfish will have a pressure sensor rated for 100, 300, or 1000 psi, depending on the anticipated operating depths. The hydrographer must know the pressure sensor rating for the specific towfish used to acquire data.

Both the Klein System 3000 and System 5000 towfish are equipped with a magnetic-based heading sensor. This sensor's data are logged as SSGyro. Typically, a magnetic compass does not indicate true headings and must be corrected for magnetic declination (variation) and deviation to obtain a true heading. Electrical interference could also contribute to a loss of both accuracy and precision of the SSGyro. Due to these inaccuracies, OCS does not recommend using towfish heading sensor values (SSGyro) for processing survey data.

Various side scan sonar systems may record imagery at different resolutions. Both Klein System 3000 and System 5000 imagery data are recorded at a resolution of 12 bits. When converting SDF files, choosing an 8-bit conversion will reduce the data resolution. Even though the recorded resolution is 12 bits, choosing the option to "Preserve 16-bit" will retain the original resolution.

Options	OCS Guidelines
Klein 3000 Frequency - High or Low	High frequency data should be used unless range scale requirements are such that the higher frequency is ineffective.
Convert Hidden	Do not convert hidden beams as a standard practice.
Pressure Sensor - 100, 300, or 1000 psi	Choose the pressure sensor rating for the specific towfish used to acquire data being converted.

Convert SSGyro	Do not convert SSGyro
16-bit Sonar Conversion - Preserve 16-bit - Convert to 8-bit: Scale or Shift	Choose to “Preserve 16-bit” resolution.

Table 4.5: OCS guidelines for converting SDF data.

#### 4.3.2.1.2 Simrad

Kongsberg Simrad multibeam systems, such as the EM1002 or EM3000, used for bathymetric data acquisition as discussed in section 4.2.3.1.2, are also capable of recording backscatter data. Simrad backscatter imagery is not an acceptable object detection method for OCS hydrographic surveys. However, these backscatter data may be useful for verifying objects detected in bathymetry data or identifying changes in seafloor texture to guide bottom sampling operations.

Converting Simrad angle-dependent backscatter imagery into HDCS files is simple. When converting the Simrad bathymetry data in HIPS, the user simply makes a choice whether or not to “Convert Side Scan/Backscatter” data. No other choices are associated with imagery conversion.

Options	OCS Guidelines
Convert Side Scan / Backscatter	Choose this option and convert imagery data.

Table 4.6: OCS guidelines for converting Simrad data.

#### 4.3.2.1.3 Extended Triton Format (XTF)

The eXtended Triton Format (XTF) can be used to store data from a variety of side scan systems. Both imagery and bathymetry data from MBES systems can also be acquired in the XTF format (although this is uncommon on NOAA hydrographic field units), and the same CARIS XTF converter is used for all three data types. XTF datagrams are comprised of a Triton-defined “header” attached to an optional manufacturer-specific sensor data packet.

NOAA hydrographic field units acquiring SSS data with a Klein 5000 dynamically focused multibeam side scan sonar will typically log data in XTF format. Since the CARIS converter accommodates an extensive variety of sonar systems capable of logging XTF data, the user is required to make multiple decisions so that this raw sonar data is properly interpreted by CARIS. Each critical conversion choice is discussed below, with OCS guidance summarized in section 4.3.2.1.3.2.

##### 4.3.2.1.3.1 Convert Side Scan

Some SSS systems, such as the Klein 3000, will simultaneously log data from multiple frequencies. During conversion, each frequency will be associated with a pair of sonar channels and the user must indicate which channels are to be processed. If the SSS operates on only one frequency, the data will always be associated with sonar channels 1 and 2.

Navigation data can be recorded in two separate datafields (“ship” navigation and “sensor” navigation) within the XTF side scan datagram. The primary difference between the “ship” and “sensor” fields is how the data is time stamped. “Ship” navigation is associated with the time logged in the XTF header, while each “sensor” navigation string is individually time stamped. Applying “Sensor” navigation is recommended to avoid potential timing errors.

Heading (gyro) data can not only be logged in multiple datagrams within the XTF record, but may also be recorded in multiple locations within the side scan datagram. While this sensor data may appear redundant, sources and data quality can vary. Typically, NOAA hydrographic field units will apply heading data stored in the “ship” field of the side scan datagram, which will correspond to the vessel’s instantaneous heading. Heading data from the attitude packet will also correspond to the vessel’s instantaneous heading, but the logging rate for attitude data is often set much higher than the update rate for heading. Thus, using attitude packet heading data will be effective but could be considered “overkill”. If vessel crab angle is large and the SSS is being towed, the hydrographer should remember that a towed body will not be experiencing the same crabbing effect. In this scenario, course-made-good (CMG) from navigation often provides the best imagery. This option uses an interpolated heading value based on recorded vessel position fixes. If acceptable towfish navigation was logged, “CMG from SSSNavigation” should provide similar results. OCS does not recommend using heading data from the “sensor” field. This data is logged from the towfish’s magnetic compass, which is subject to both magnetic variation and electrical interference.

If data were acquired using a Klein 5000 dynamically focused multibeam side scan sonar, the user must choose whether or not to convert hidden beams. There are five beams on each channel (port and starboard) of the Klein 5000. Based on range scale and towfish speed, the system will determine the number of beams necessary to achieve 100% coverage. Typical range scales and speeds used for hydrographic surveying require that 3 - 4 beams be used. Selecting “convert hidden” forces all 5 beams to be converted and may improve imagery in high yaw-rate conditions (e.g., in turns or for hull-mount configurations) or aid in detection of very small objects during activities such as search and recovery. However, for the purposes of a basic OCS hydrographic survey, converting hidden beams is not necessary to meet survey specifications and can introduce data management problems by significantly increasing file sizes.

Various side scan sonar systems may record imagery at different resolutions. Both Klein System 3000 and System 5000 imagery data are recorded at a resolution of 12 bits. When converting XTF files, choosing an 8-bit conversion will reduce the data resolution. Even though the recorded resolution is 12 bits, choosing the option to “Preserve 16-bit” will retain the original resolution.

#### **4.3.2.1.3.2 Convert Layback/CableOut Data**

NOAA hydrographic field units typically record cable out during towed SSS acquisition to facilitate recomputing navigation, if necessary. The XTF format provides two datafields (“cableout” and “layback”) in which this information can be stored. The primary difference in these fields is that “cableout” will only accept integers, while a decimal number can be logged in the “layback” field. To preserve decimeter accuracy for cable out values, the field unit may use one of the two following options:

- Configure the vessel’s cable counter to output values in decimeters and log an integer value to the “cableout” field. However, SIPS assumes cable out data is in meters when recomputing. During conversion, the user can enter a “multiplier” of 0.1 to the “cableout” data that would reconvert the values to meters. For example, if acquiring SSS data with 10.6 meters of cable out, a cable counter integer output of 106 (decimeters) would be stored in the XTF “cableout” field. When converting the data in SIPS, the “cableout” value would be multiplied by 0.1 to recreate a value of 10.6 that SIPS assumes is in meters.
- Configure the acquisition system to log cable out, in meters and decimal meters, to the XTF “layback” field. In this scenario, the user must remember to convert data from the “layback” field, even though the data are actually values for cable out. SIPS will assume data from either datafield is cable out if towfish sensor depths are non-zero. (Similarly, if no towfish depths are converted, SIPS will interpret this as a zero sensor depth and assume data from either datafield are layback values.)

To determine towfish depth, both the Klein 3000 and Klein 5000 SSS systems calculate a value from an integrated pressure sensor. If the hydrographer intends to use cable out to recompute navigation for a SSS system that does not have a pressure sensor, the towfish depth will need to be calculated based on water depth logged to an AUX field and towfish altitude. Typically, NOAA hydrographic field units will not need to calculate a sensor depth in this fashion.

Options	OCS Guidelines
Convert Side Scan - Sonar channels (1,2 or 3,4)	For single frequency systems, convert channels 1 and 2. When using multiple frequency systems, the user must determine which channel pair corresponds to the frequency they wish to convert.
- Navigation Datafield (ship or sensor)	Use navigation data stored in the “sensor” datafield to avoid potential timing problems.
- Gyro Datafield (ship, sensor, attitude packet, CMG from navigation, CMG from [sss] navigation)	Typically, use heading data from the “ship” datafield. If vessel crab angle is large, CMG may provide better imagery. Do not apply heading from the “sensor” datafield
- Convert Hidden Data	Do not convert hidden beams as a standard practice.
- Apply image enhancement	Do not apply image enhancement as a standard practice.
- Convert single beam from AUX field num	Logging VBES data to an AUX field is not recommended. Thus, this option is not checked as a standard practice.
- 16 bit sonar conversion (preserve 16 bit, convert to 8 bit (scale or shift))	Choose to “Preserve 16-bit” resolution.
Convert Layback/CableOut data - From layback field - From cableout field (multiplier)	Convert cable out data from either field, depending upon the acquisition system configuration. If converting from the Cableout field, apply a multiplier to preserve decimeter accuracy.
- Calculate sensor depth using AUX field	This option is necessary only if recomputing navigation for a system that does not have a pressure sensor.

#### 4.3.2.2 Filter

SIPS does not provide filtering tools to automatically flag/reject “bad” imagery data. However, as when processing bathymetry, filtering can be performed on attitude and navigation data. Refer to sections 4.2.4.3.3 and 4.2.4.3.4 for details on Attitude Editor and Navigation Editor. Time-series data for gyro (heading), cable out, and sensor depth, as well as bottom tracking must be reviewed line-by-line and edited as necessary. If the SSS system is configured to calculate sensor depth based on sensor height and an auxiliary VBES depth, these sensors will also need to be reviewed.

#### 4.3.2.3 Recompute Towfish Navigation

OCS typically uses one of two side scan sonar configurations, a towed sonar body or a hull-mounted sonar body. Regardless of system configuration, the hydrographer has the option of either computing the sensor position

during data acquisition or recomputing towfish navigation during SIPS processing. If a towfish position is computed during acquisition and stored in the raw data format, this information can be converted directly into the SIPS towfish navigation data structure. If, in addition to ship navigation, either cable out and towfish depth or horizontal layback is recorded, the side scan sensor position can be calculated in SIPS via Recompute Towfish Navigation. OCS strongly recommends recomputing towfish navigation using cable out and towfish depth to determine towed sensor position. This process enables the hydrographer to review and edit, if necessary, the ship position data, cable counter data, and towfish depth or bottom tracking (if used to determine towfish depth) prior to calculating a towfish position.

Note: If horizontal layback or tow cable length data are not available or if the Recompute Towfish Navigation step is not executed, then the towfish navigation data recorded during acquisition will be used to georeference imagery. If, additionally, towfish navigation was not recorded during data acquisition, then the side scan sensor position data are assumed to be the same as the ship navigation data.

When using a hull-mounted configuration, navigation data for the sensor is typically determined by using ship navigation data and entering the vessel RP-to-towfish offset in the towpoint section of the HVF. However, SIPS will only apply the towpoint offset when navigation is recomputed. For this type of configuration, Recompute Towfish Navigation must be performed with a cable out value of zero.

Note: If no cable out data was converted, SIPS will assume cable out to be zero.

#### **4.3.2.4 Slant Range Correction**

Side scan sonar is initially logged as a series of time-indexed intensity values for each ping, i.e., the across-track axis represents time. These data are considered “raw” side scan and are displayed with the central portion of the image representing the water column and a digital line along either the port or starboard leading edge indicating the logged bottom track. Some sonar systems will track bottom very accurately, while others require that these data be edited or redigitized. Any errors in bottom track should be edited prior to slant range correcting, as these data determine sonar height during the slant range correction process.

When data are slant range corrected, an estimate of the speed of sound through sea water is applied to the two-way travel time for each intensity value. This produces an estimated ray length that, when combined with the known sonar height (from the digitized or logged bottom), is used to produce the across-track distance to a pixel using simple trigonometry. Slant range corrected data are displayed with the water column removed and the across-track scale representing distance from nadir. It should be noted that this method presupposes that the bottom is flat across the ping and can result in the across-track misplacement of objects over varied or steeply sloping terrain. If available, SIPS can use a BASE Surface, grid, or tile in the slant range correction operation to supply depth values and improve the across-track positioning of pixels. This process is explained in detail in the CARIS HIPS and SIPS User’s Manual.

During the process of slant range correction, the resolution value will default to the minimum value appropriate for the sonar system. If this resolution is not feasible, it will default to 0.10 meters. Resolution may be manually increased, but keep in mind that increased resolution means a larger file size. The hydrographer will be required to make some arbitrary decisions regarding beam pattern correction and despeckling. The “Beam Pattern” function attempts to equalize the differences in pixel intensity from nadir to the outer ranges of the sonar swath. The “Despeckle” function detects isolated bright spots and streaks in the raw sonar file and smooths them by averaging the neighboring pixels. Applying these options will produce a more attractive mosaic when creating constituent products, and should not hide small contacts during data processing. If SSS data were converted using the “Preserve 16-bit” option, the user can choose to “Create 8-Bit Processed Side Scan” to generate a slant range file requiring less

storage space, if necessary. When slant-range correcting 16-bit data to create 8-bit side scan, a shift factor should be applied to spread out the histogram and improve imagery. The user can apply either the 16-bit shift factor stored with each line or a single bit shift factor to be applied to all lines. Generally, the bit shift factor stored with each line is a good choice.

#### **4.3.2.5 Add to Mosaic**

A survey-wide side scan mosaic should be created and maintained during Daily Batch Processing to evaluate data coverage, identify any gross systematic errors, and plan future data acquisition.

Note: If a 200% side scan survey is being conducted, a separate mosaic should be created to demonstrate coverage for each hundred percent.

In addition to planning future SSS acquisition, the first 100% mosaic can be used to delineate areas of high contact density where complete MBES coverage is more appropriate than 200% SSS. The hydrographer is reminded that AWOIS radii that extend beyond the basic survey limits must be entirely covered with 200% side scan, complete or object detection multibeam, or a combination thereof to be disproved by sonar data. These radii should be considered when evaluating survey coverage.

When creating a mosaic, the hydrographer will be prompted for several pieces of information. In accordance with section 5.2.2 of the HSSD, resolution shall be 1m by 1m or less. Maximum across-track and altitude ratios can be used to systematically remove areas of poor quality data from the mosaic, such as when outer edges are affected by thermocline. Note: These features will not actually reject the imagery data, but they will remove portions indicated for all lines in the mosaic.

Options such as interpolation and shine-thru may be used at the hydrographer's discretion. These features may enhance the overall mosaic and can be desirable for creating constituent products.

### **4.3.3 Boat-day Processing**

Boat-day Processing" as described in this chapter refers to that portion of the hydrographic data processing that is performed on a single vessel's data that were acquired during a single day of data acquisition. It is assumed that all the processes described in section 4.3.2 of this chapter have already been performed. For ships and launches, this portion of the processing is typically accomplished during the "night processing" shift. For field parties, this processing step may be either saved for foul weather days or accomplished by a shore party member in charge of their unit's daily data processing.

The goal of imagery Boat-day Processing is to identify contacts that warrant further investigation and record these contacts in the digital data. This process is completed using SIPS Side Scan Editor.

#### **4.3.3.1 Side Scan Editor**

Imagery data should be reviewed twice using CARIS SIPS Side Scan Editor. The initial review process is referred to as "scanning" the data. The second review is performed by a different person and is called "check scanning." The initial reviewer should identify any object that warrants further investigation, often referred to as a "significant contact", and record these items into the digital data. The second review serves as a quality control, and should add any significant contacts that were overlooked during the initial check. SIPS provides several tools to assist in determining if a contact is significant. Two of the most frequently used are "Measure Shadow" and "Measure Distance."

“Measure Shadow” can be used to determine the height of an object by measuring its acoustic shadow and calculating the object’s approximate elevation off the seafloor. This tool can only be used when viewing data in slant range corrected mode. “Measure Distance” is used to measure the distance between two points. This tool is helpful in determining the overall size of contacts, which may determine significance. For example, a very large item, even if it does not protrude significantly from the seafloor, may be listed in the AWOIS database and should therefore be investigated. The Measure Distance tool can be used when viewing both “raw” (i.e., not slant range corrected) and slant range corrected data.

All significant contacts should be recorded in the digital data by creating a contact in SIPS. (Refer to the CARIS HIPS and SIPS Users Guide for detailed information on how to create a contact.) The general OCS practice for determining significance of an imagery contact is stated in the HSSD.

The hydrographer must always consider the location of a contact when determining significance. For example, in a major channel where vessels transit with minimal underkeel clearance, a contact less than one meter high could be significant.

When a contact is recorded in SIPS, the item is geo-coded and attributes are attached to it in the Side Scan Editor. Each contact should be attributed as thoroughly as possible. A contact file is created for each survey line and is stored in the line folder within the Project directory structure.

#### **4.3.4 Survey-wide Processing**

“Survey-wide Processing” for imagery data consists of evaluating total coverage and assessing side scan contacts in NOAA’s Pydro software to determine which items warrant further investigation or development, and attributing each contact accordingly in Pydro. Efficiency can be increased by conducting many of the survey-wide processing steps concurrently with Boat-day processing for global quality control and general survey completeness. These processes would include verifying adequate investigation of charted features and assigned AWOIS items within (or partially within) the survey sheet limits, reviewing the data for Dangers to Navigation (DTONs), and verifying that data coverage meets the assigned specifications. Reviewing these points on a daily basis will help to ensure a complete survey and a timely submission.

##### **4.3.4.1 Review Survey-wide Mosaic**

Survey-wide mosaics are typically reviewed during Boat-day processing to assess coverage and insure that no significant data gaps, referred to as “holidays,” are present in the imagery. Once 100% side scan coverage has been attained and demonstrated via the survey-wide mosaic, this “final mosaic” should be saved as a CARIS Fieldsheet and exported as a GeoTiff in UTM NAD 83 format. Both the Fieldsheet and GeoTiff image should be digitally filed for submission with the completed survey data. If the survey requires 200% side scan coverage, a separate final mosaic should be created for each hundred percent.

##### **4.3.4.2 Assess Imagery Features**

Throughout the survey process, imagery contacts should be periodically assessed and a determination made as to whether “development” is necessary. Developing an imagery contact typically refers to investigating the item with MBES to determine a least depth. However, other methods of obtaining a least depth may be used, such as VBES or DLDG. Some types of side scan sonar systems are able to acquire co-located imagery and bathymetry data. However, these systems are a developing technology, and SSS bathymetry has not yet been approved for OCS hydrographic surveys.

Imagery contacts should be assessed using either CARIS Notebook or Pydro, which enables the hydrographer to analyze each contact in context with other available data sources such as correlating contacts, the chart, bathymetry, DPs, and AWOIS records/search radii. Contacts should be evaluated and, if confirmed to be significant, flagged for “investigation” within Pydro. This flag enables the user to export that item to MapInfo MIF/MID and HYPACK TGT formats to plan for further investigation or development. (Once a contact has been exported, its Pydro record will indicate this via the “Tgt Exported” flag.) If correlating contacts or features exist, the image which best represents the contact should be flagged “Primary”, and all correlating contacts, AWOIS items, or charted features should be flagged “Secondary”.

Note: Any significant contact suspected to be a Danger to Navigation, as described in section 4.4.2.1 , shall be expedited through the investigation/development process and a DTON report submitted, if necessary.

Contacts which, upon further analysis, are determined not to be significant should be flagged “Resolved” and a note added to the Remarks tab of the Editor’s Notebook stating that the item is considered insignificant. Any contact which was erroneously inserted into the survey data, and can not be efficiently removed, should be flagged “Rejected” and an explanation entered in the Remarks tab. For additional information on analyzing and flagging contacts in Pydro, refer to section 4.4

The determination whether or not to develop an item from imagery data is considered a preliminary assessment of contacts. Once this decision has been made, significant contacts are considered imagery “features” and should be further processed as described in section 4.4 This preliminary contact evaluation should not be confused with finalization of imagery data, where the goal is to verify that all contacts have been addressed and flagged either “resolved” or “rejected.”

#### **4.3.4.3 Finalize Imagery Survey Data**

Once all significant contacts have been developed, analyzed, and flagged in accordance with section 4.4 the hydrographer should verify that no “Unresolved” imagery features remain in the Pydro PSS and a final mosaic, created in accordance with section 8.3.1 of the HSSD, has been generated and digitally filed for each 100% SSS data acquired.

### **4.4 Feature Processing and Analysis**

In OCS surveys, a feature is an object that merits individual attention distinct from the bathymetric model of the sea floor.

In a general sense, the bathymetric model of the sea floor will be represented on the chart using soundings and contoured depth areas. Everything else: buoys, rocks, wrecks, piles, docks, etc. are features. During the acquisition of a hydrographic survey, the hydrographer will encounter many objects that may merit individual attention and treatment.

In some cases, this object will be of significant navigational interest and will eventually be portrayed as a distinct cartographic symbol on a chart. An example of this type of feature is a prominent wreck. Once discovered, the wreck will likely require further investigation. This may involve high resolution multibeam, side scan sonar, or diver investigation. This additional information is collected together and used to fully describe and categorize the wreck. Once processed, this information is passed to the Atlantic and Pacific Hydrographic branches and cartographers using formatted reports and digital data files. These data will aid the cartographer in correctly charting the feature.

In other cases, further investigation may indicate that the feature is not navigationally significant, and should not be charted as a distinct cartographic symbol. An example of this type of feature might be an object detected with side scan sonar that subsequent multibeam coverage found to be not of navigational concern (a patch of gravel perhaps). This feature would still be handled through the same methods as the wreck described above. This process serves as a record that the hydrographer properly inspected and handled all indications of an item of potential navigational significance.

In some other cases, the hydrographer may wish to call out an object for individual cartographic treatment even if the depth of the object is well represented in the bathymetric data set. For example, a large glacial erratic boulder on an otherwise flat and featureless sandy bottom may be of particular navigational significance, especially if there is a bottom trawl fishing fleet in the area. This object may be selected by the hydrographer and recommended for charting as an isolated feature rather than simply through soundings and contours.

We can see from these examples that the feature processing pipeline is used to: (1) gather together information on features that may eventually be added to the chart, (2) aid in assessing the feature's navigational significance, and (3) provide a mechanism for reporting this feature analysis to the Atlantic and Pacific Hydrographic branches.

Five basic sources of feature information must be analyzed and resolved when processing an OCS hydrographic survey: Bathymetry, side scan imagery, detached positions (DPs), AWOIS items, and geographic positions (GPs). The ability to resolve a feature depends heavily on viewing data in its full context. GIS (Geographic Information System) software can be used to spatially correlate a set of features both within the contemporary survey data and from other (prior) data sources, enabling the hydrographer to quickly identify redundant data on a single "real world" feature. Correlating information allows the hydrographer to confidently determine a feature's significance with respect to marine safety and nautical charting. The most important features that can be identified in a survey are those that pose a danger to navigation (DTON). Data should be reviewed daily to identify items that are DTONs, as described in section 4.4.2.1 DTON processing shall be expedited to the greatest extent possible.

Non-DTON features should be evaluated and classified periodically as the survey progresses toward completion. Ultimately, all features should be evaluated, classified, developed (if necessary), and resolved.

NOAA hydrographic field units shall use NOAA's Pydro software package, CARIS Notebook, CARIS Bathymetry DataBASE (BDB), and/or HYPACK ENC EDITOR to analyze and document survey features. CARIS BDB and Pydro are generally used for feature correlation for side scan sonar (SSS) contacts. Pydro is also used for generating survey reports for DTONS and the Final Request for Tides. All four software packages can be used to process S-57 features and populate their attributes. The user may switch between software by importing and exporting S-57 .000 files. The capabilities of these software packages are described further in section 4.4.1.

The feature processing workflow is illustrated in figure 4.17.below:

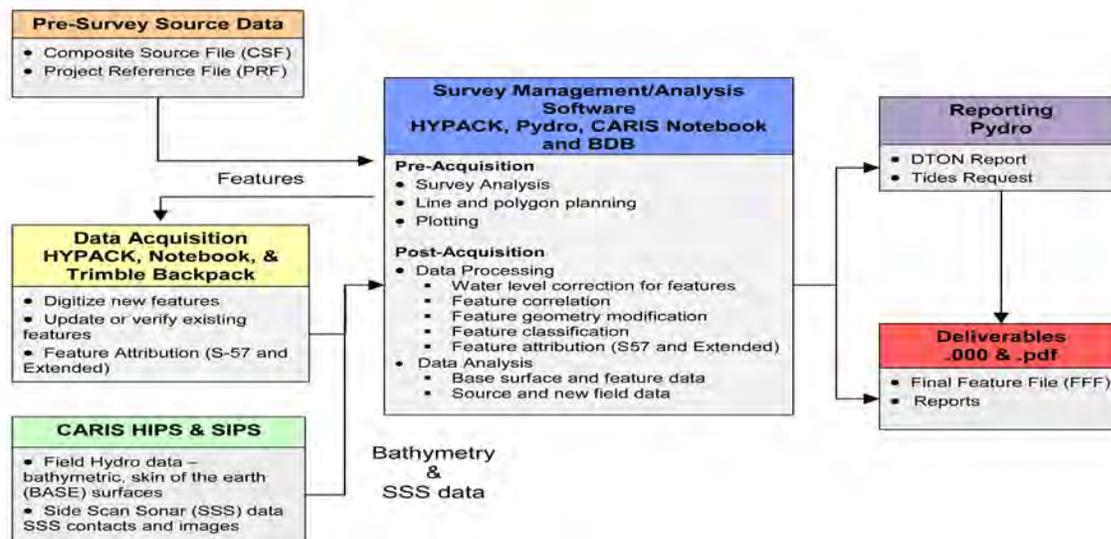


Figure 4.17: Feature Processing Workflow

#### 4.4.1 Processing Software

##### 4.4.1.1 NOAA Pydro Software

NOAA's Pydro software package is used to bring the various source data for potential features, (side scan Sonar contacts, designated soundings, detached positions etc.) together in a georeferenced interface. In most cases, Pydro maintains links to the source data which results in certain flags and edits applied in Pydro being automatically written into the source dataset. Similarly, some types of editing performed in the raw data processing program (i.e., CARIS HIPS/SIPS) will be automatically carried through to Pydro.

Note: Some edits performed in CARIS, such as rejecting/accepting sounding data or imagery contacts, will require that the source data be re-inserted into Pydro.

- Pydro has the ability to read several data types, including the following:
- Side scan imagery contacts created in CARIS SIPS.
- Bathymetry features in CARIS HIPS; i.e., soundings flagged “outstanding” and/or “designated”.
- Bathymetry soundings in CARIS HIPS; shoal-biased binned line-by-line.
- Gridded bathymetry data created in CARIS HIPS; BASE surfaces (.csar) or weighted grids (.def/.sum/.weight) files.
- Target files from HYPACK (.tgt), Trimble Pathfinder (.mdb, etc.), and other generic data sources.
- The AWOIS database, in MS Access format.

- ENC (.000 files).
- Other “generic” geographic position data in many database formats, such as ESRI Shapefiles (.shp), MapInfo Interchange Files (MIF/MID), MS Excel, dBase (.dbf), ASCII, etc.
- ENC S-57 base cells (.000) rendered according to S-52 and various raster formats for background data, including GeoTIFF (.tif), MrSID (.sdf), and NOAA/BSB raster nautical charts (.kap)
- Once these data are imported into Pydro for a specific survey, the combined data package is referred to as a Pydro Survey Session (PSS).

Note: The Pydro PSS is not to be confused with the historical “preliminary smooth sheet”, which was a plotted presentation of survey data formerly required for submission.

Within the PSS, items can be marked with digital notes, various flags, and attributes to aid in decision making and reporting. Items are automatically correlated according to a user-specified radius or can be manually recorelated and grouped to form sets of observations that represent the same physical item. The best data for reporting a feature, e.g., the most accurate least depth observation from the available bathymetry and/or most descriptive picture from the available imagery, is designated via a defined flagging schema.

Pydro is also the mechanism for creating reports such as DTONs and Requests for Tides. These reports are automatically generated from the digital data which eliminates error prone “cut and paste” actions and standardizes report formats which maintains quality control throughout the hydrographic data pipeline.

PSS files from Pydro are interoperable with CARIS Notebook, BDB, and HYPACK by importing and exporting S-57 .000 files.

#### **4.4.1.2 CARIS Software**

CARIS Notebook and Bathy DataBase (BDB) are used to bring together various data types, including features, images and bathymetry into a georeferenced user interface. CARIS Notebook and BDB are good tools for managing line and area features such as reefs, foul areas, piers etc. Notebook also has GPS logging and tide correction capabilities for point features. The GPS logging enables the user to digitize point and line features from a launch or backpack in real time. The tide correction enables the user to tide correct all features in Notebook instead of HIPS & SIPS.

Notebook and BDB have the ability to read several data types, including the following:

- ENCs, or other S-57 databases (.hob, .000)
- Raster displays: (.kap, .tif)
- Vector files (.shp, .dxf, .des)
- Gridded CARIS Surfaces (.csar)

- Pydro .000 files
- Pydro XML files (Notebook only)
- CARIS Mosaics
- CARIS Contours
- CARIS Sounding Plots

Once these data are imported into Notebook or BDB for a specific survey, they are saved into a Notebook or Bathymetry DataBASE session, which can be opened as a cohesive unit.

Within each Session, there can be numerous types of information to assist in processing and analyzing potential features. Charts, georeferenced images, CARIS HIPS and SIPS generated data products etc. assist in feature analysis while the features themselves are housed in non-standard .000 files called HOB files. Each feature within a HOB file follows the S-57 encoding specifications and has extended attributes to provide further flexibility in processing and to support data interoperability between the various workflows that may be used in the field.

HOB files from CARIS Notebook and BDB are interoperable with Pydro and HYPACK by importing and exporting S-57 .000 files.

#### **4.4.1.3 HYPACK Software**

HYPACK contains a module that is embedded into the main HYPACK Shell called HYPACK ENC Editor. This software is capable of making direct edits to the S-57 .000 file and takes advantage of the NOAA extended attributes to support data interoperability between the various workflows that may be used in the field. The field may utilize this option to perform feature verification in the field as well as adding new features to the .000 file (similar to Notebook's GPS logging function). Edits in the extended attribution are retained in the .000 file. HYPACK target files (tgt) acquired as features can also be imported into ENC Editor and translated into S-57 objects.

HYPACK ENC Editor has the ability to read several data types, including the following:

ENCs (.000)

Raster displays: (.kap, .tif)

Vector files (.shp, .dxf, .dgn, .tgt)

S-57 .000 files from HYPACK are interoperable with Pydro and CARIS by importing and exporting S-57 .000 files.

## 4.4.2 Significant Features

### 4.4.2.1 Dangers to Navigation (DTONs)

The most important features to identify in a survey are Dangers to Navigation (DTON). A DTON is defined as any uncharted or incorrectly charted natural feature (e.g., shoal, boulder, reef, rock outcropping) or cultural feature (e.g., wreck, obstruction, pile, wellhead) that poses an immediate threat to surface navigation. General chart discrepancies can be addressed at the conclusion of a survey, but items that meet DTON criteria should be reported as soon as practicable after discovery.

The primary characteristic of a DTON is navigational significance. When reviewing survey data for potential DTONs, the hydrographer must consider the types of vessels operating in the area as well as vessel routes, both typical and seasonal. Much of the final selection of DTONs is subjective and requires a bit of cartographic interpretation as well as a navigational perspective of the chart. Examination of newly acquired survey data for potential DTONs should be performed on a daily basis.

The following guidelines can be used to identify potential DTONs; however, each item should be further evaluated for significance within that specific geographical area.

#### 4.4.2.1.1 Water Depth

Historically, selection of DTONs has been concentrated in areas with water depths of 20 meters or less. While this remains a good rule of thumb, this depth range should be evaluated in the context of vessel traffic and typical routes through the area. For example, features in water deeper than 20 meters may be DTONs along routes for supertankers.

#### 4.4.2.1.2 Potential DTON Height

Typically, survey features and soundings indicating a depth discrepancy of 1 meter or greater are first evaluated for DTON potential. Again, this guideline should not be followed blindly. Vessel traffic must be considered. If vessels transit the area with minimal underkeel clearance, a discrepancy of only 1/3 meter could be critical; or, if a deep inland bay or harbor is accessible only by shoaler restricted channels, a large feature within the deep water area may not be a hazard since only small vessels could access the area. Figure 4.18 illustrates a potential DTON located within a channel. If the channel's tabulated depth is listed as 40 feet for the right outside quarter, then this charting discrepancy would only be 1 foot. Typically, a 1-foot discrepancy would not be considered a DTON. However, the hydrographer must consider what type of vessels transit the area and how much water they draw. This channel might be the entrance to a major port facility where vessels drawing 40 feet arrive on the rising tide. In such a case, this 1-foot difference is critical, particularly if the item is a rock or cultural feature as opposed to a sandy shoal.

Figure 4.19 shows a small bay with depth discrepancies of 2 fathoms (12 feet). Although this depth difference is significant, the bay is accessible only by passing through a 5 or 6 fathom channel. Thus, the 7 fathom sounding inside the bay is insignificant, i.e., not a DTON. Similarly, a very large object identified in a river accessible only by small craft may not be a DTON. Figure 4.19 shows a potential DTON located in a deep section of a small river. The object in question protrudes over 10 meters from the seafloor. However, this river happens to be accessible only by small craft, due to a shoal at its mouth. Despite this large depth discrepancy, the item is navigationally insignificant when the hydrographer considers the draft of vessels capable of operating in the area.

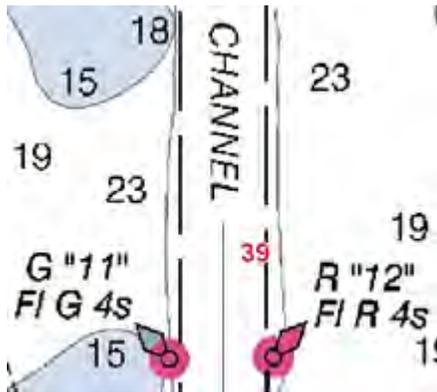


Figure 4.18:  
Potential DTON in Channel

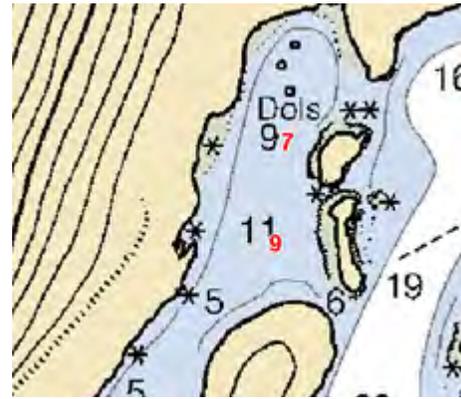


Figure 4.19:  
Potential DTON in small bay

#### 4.4.2.1.3 Proximity to Existing Features

Many new or uncharted features are potential DTONs. The hydrographer must consider each new item's proximity to existing features (rocks, reefs, fish havens, shoreline, foul areas, etc.) and the item's significance with respect to these adjacent features. Figure 4.20 illustrates a case where an existing feature (Fish Haven with an authorized minimum of 15 feet) affects the significance of a potential DTON. In this example, an item intended for the fish haven may have been erroneously deposited outside the haven's geographical bounds, a very realistic scenario. Despite the discrepancy with regard to the charted 43 foot depth, the adjacent Fish Haven to the south/southwest and shoal to the east would deter prudent mariners from approaching the area. Likewise, a large depth discrepancy adjacent to a reef or foul area would quite possibly not be a DTON, again, as a prudent mariner would operate in the area only with extreme caution.

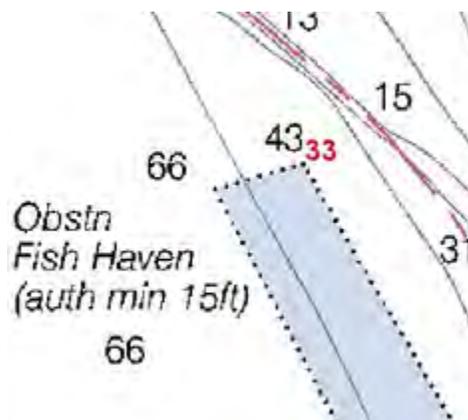


Figure 4:20:  
Potential DTON adjacent to fish haven.

#### 4.4.2.1.4 Dense Groups of DTONs

The density of DTONs reported should not exceed what can be legibly portrayed on the largest scale chart of the area. If numerous DTON candidates are identified in close proximity, the hydrographer could report either the most significant item or the group of DTONs as an area feature, e.g., designate the entire area "foul." When determining the most significant DTON in a group, the item having the shoalest least depth will typically be chosen. However, this may not be the case if, for example, the item is located on a slope. Typically, if two potential DTON are adjacent on a slope, the most seaward sounding will be selected for submission. The prudent mariner

will assume that depths will decrease as shore is approached. An example of this exception is shown in Figure 4.21. The 2 fathom sounding is shoaler, but the 4 fathom sounding extends further offshore. In this case, the 4 fathom sounding would be submitted. Although both soundings would supersede the 5¾ fathom charted depth, it can be reasonably inferred that there is a continuous slope toward shore, therefore depths shoaler than 4 fathoms would be expected.

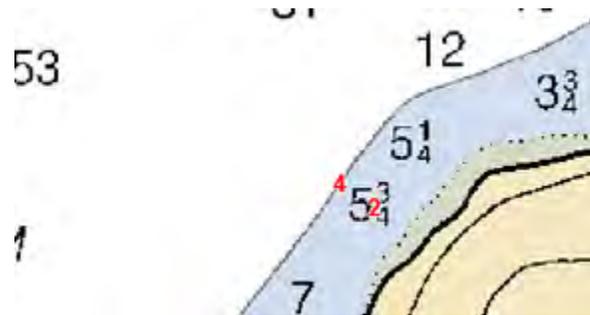


Figure 4.21:  
Two potential DTON's located on close proximity.

#### 4.4.2.1.5 Charted Feature Removal Request

A Charted Feature Removal Request, often referred to as an “anti-DTON,” is used to expeditiously remove charted features that are hindering operations in major shipping corridors and have been adequately disproved. Only navigationally critical items should be submitted as Charted Feature Removal Requests. These requests should be submitted using the same procedure indicated for DTONs in this manual.

#### 4.4.2.1.6 DTON Submission (see section 8.1.3 of HSSD)

Typically, DTON selections should be reviewed by the Chief-of-Party prior to submission. If approved, DTONs must be flagged properly in Pydro, which can then generate a DTON report. Note: All Pydro PSS Metadata should be completed prior to generating a DTON report so that this information will be included in the report. Additionally, the DTON must be stamped with the actual ping time and not the time they were discovered in boat or office processing. The Pydro DTON report is generated in a Zip archive which contains an Adobe \*.pdf text report, an \*.xml file containing the survey data for that feature, and a DTONImages folder containing all the relevant report images and chartlets (if applicable). The Zip archive should be submitted to NOAA's Marine Chart Division (MCD) via email (ocs.ndb@noaa.gov), with courtesy copies to the Chief of OPS and to the Chief of the appropriate hydrographic branch.

Chartlets are not a required deliverable. However if applicable, field units may use either Pydro or ESRI to generate a chartlet for the DTON report. If the chartlet is generated externally to Pydro, users must add those chartlets to the \*.pdf report manually. Note: The Pydro report includes a zip file of the \*.pdf so field units must make sure the report to MCD is updated before submittal if the HydroMI chartlet is going to be used.

Additional actions, as noted below, are required when reporting DTONs in the following two cases.

1. If the potential DTON will directly impact commercial shipping routes and/or is located within an area of Army Corps of Engineers' authority, the appropriate NOAA Navigation Manager shall be consulted prior to submitting the DTON. If the Nautical Data Branch of MCD discovers a DTON located in a Corps of Engineers' authority that has not been submitted to the Navigation Manager, then NDB personnel will cease processing the DTON and recommend that the submitting party inform the Navigation Manager.

2. If a DTON report includes a potentially historically-significant wreck, the field unit shall provide a courtesy copy of the report sections pertaining to that specific feature to the corresponding NOAA Navigation Manager and State Historic Preservation Officer. If a potentially historically-significant wreck is identified outside of state waters, notify the current Sanctuaries Historical/Archaeological contact.

Once submitted, all DTONs will be expedited through MCD to the Coast Guard for publication in the Local Notice to Mariners. Within three days of DTON report submission, MCD's Nautical Data Branch (NDB) will send an email to the field unit confirming that DTON data has been received and processed. If a DTON submission is not confirmed by NDB within one week, the hydrographer should promptly contact MCD (via an inquiry email to ocs.ndb@noaa.gov) to verify that the report has been received and processed. MCD will also notify the submitting party of any changes made to the Dangers to Navigation Report by return e-mail. For additional reference and guidance, refer to section 8.1.3 Dangers to Navigation in the HSSD.

#### **4.4.2.2 AWOIS**

Automated Wreck and Obstruction Information System is a database of wrecks and obstructions in the coastal waters of the United States. These items have been found during previous hydrographic surveys or have been reported by miscellaneous sources. The HSD OPS Project Manager or the NRB Technical Assistant will assign AWOIS items to the field unit for investigation. The hydrographer shall investigate the items and document the results according to the AWOIS requirements. For further information on AWOIS see sections 7.3 of the H S D and 2.2.2.2 of the FPM.

#### **4.4.2.3 Maritime Boundary Points**

OCS is responsible for depicting the Three Nautical Mile Line (old territorial sea), Territorial Sea at 12 nautical miles, Contiguous Zone at 24 nautical miles, and Exclusive Economic Zone (EEZ) at 200 nautical miles on NOAA nautical charts. These maritime zones, defined by Maritime Boundary "baseline points", define areas of U.S. jurisdiction for a variety of regulations. The HSD OPS Project Manager or the NRB Technical Assistant will assign Maritime Boundary rocks to the field unit for investigation. The hydrographer shall investigate the items and document the results according to the Maritime Boundary requirements. For further information on Maritime Boundary see sections 7.3 of the HSSD and 3.5.6 of the FPM.

#### **4.4.2.4 Cultural or Historical Submerged Features**

In the course of acquiring or processing hydrographic data, features on the seafloor may be discovered which are of potential cultural or historical significance. These include wrecks of ships or aircraft, the recognizable debris from wrecks, or other items which may appear anthropogenic in origin and have some associated cultural or historical significance.

Chiefs-of-Party must always promptly assess the discovery of any features for significance to local surface navigation and report these accordingly. Any feature determined to be a Danger to Navigation shall be immediately reported through the standard DTON reporting process (see section 4.4.2.1).

It is Marine Chart Division (MCD) policy that all features recommended for charting by the Chief-of-Party be applied to the appropriate nautical charts. Chiefs-of-Party must continue to recommend for charting all features determined to be significant to surface navigation, as well as features determined to be significant or hazardous to other marine chart users engaged in activities such as fishing or trawling. This includes features which may have

potential cultural or historical significance. This policy is unchanged and in accordance with the MCD Nautical Charting Manual.

All features which appear to be of cultural or historical significance, and appear anthropogenic in origin, do require special consideration during the hydrographic surveying process. Data and information from these features must always be protected and may only be released in accordance with OCS policies and procedures. Unless specified by the Project Instructions (or other written instructions from OCS):

1. Do not attempt to determine the cultural or historic significance of any features. And, do not expend any operational effort toward identification beyond what is necessary for assessment as a Danger to Navigation.
2. Do not speculate about a known or newly discovered feature's potential cultural or historical significance, either publicly or in writing.
3. Do not identify by name or otherwise associate with a name, any cultural or historical feature in the Descriptive Report (DR) or any part of the survey's data.
4. DO include an image, SSS or bathymetry, of the feature in the Hydro feature report for recognition by a historian or preservation official.

OCS, as a unit of a federal agency, has responsibilities under section 106 of the National Historic Preservation Act (NHPA, 16 U.S.C. 470 et seq.) to take into account the effects of its undertakings on historic properties. The process for federal agencies in complying with the NHPA is laid out in 36 C.F.R. Part 800, which prescribes consultation with the State Historic Preservation Officer (SHPO). In addition, OCS may also consult with other NOAA offices or governmental agencies.

OCS consultations for hydrographic projects provide information about planned survey activities, and about survey outcomes. A pre- or post-survey consult will allow these Historic Preservation Points of Contact (HPPOCs) at least 30 days to respond. In general, NOAA field units are not required to submit any data to a HPPOC. All consultations will be conducted by OCS.

#### **4.4.2.4.1 Pre-survey Consultation**

A pre-survey consult will be initiated during the project planning process by OCS HSD Operations Branch or NSD Navigation Response Branch. Any responses or special handling that may be required of a NOAA field unit will be provided in the Project Instructions.

A pre-survey consultation may be anticipated to result in one of three general outcomes:

1. No Response – No special data handling is required.
2. Informational response – Information received from the HPPOC is provided without any restriction for public release. No special data handling is required.
3. Actionable response – Specific information received from the HPPOC may prevent the public release of all or part of the survey data or products. The specific information will be evaluated by HSD OPS, and clear instructions for data handling will be provided will be provided in the PIs.

#### **4.4.2.4.2 Post-survey Consultation**

A post-survey consult will be initiated by HSD's Atlantic Hydrographic Branch (AHB) or Pacific Hydrographic Branch (PHB). No additional action should be required by the Field Unit.

#### **4.4.3 Survey Feature Management and Analysis**

##### **4.4.3.1 Pre-acquisition**

HSD Operations provides the field units with a Composite Source File (CSF) and Project Reference File (PRF) on the Project CD for field verification. The CSF is in a .000 format and consists of all of the source features (i.e. ENC's, Preliminary ENC's and GC's if applicable). The hydrographer clips the project CSF to the size of the survey and this file is renamed to Final Feature File where all updates occur. The Final Feature File is one of the final deliverables to the processing branch.

The PRF is in a .000 format and consists of survey reference items such as: survey limits, investigations items (AWOIS and Maritime Boundary), bottom sample targets, and junction survey outlines. The PRF is clipped to the size of the survey to support survey analysis and processing. The PRF is for reference only and is not one of the final deliverables to the processing branch.

##### **4.4.3.2 Post-acquisition**

###### **4.4.3.2.1. GPS Data Post-Processing**

As described in section 3.5.3 , high accuracy GPS positioning frequently requires that the data acquired be post processed to apply all available corrections. This must be accomplished before the resulting feature positions are imported into the feature management environment for attribution and analysis. Most NOAA GPS post processing is accomplished by one of the following two methods.

###### **4.4.3.2.1.1 OPUS GPS Processing**

The National Geodetic Survey's Online User Positioning Service (OPUS) is the most commonly used tool for post-processing dual frequency GPS data for positions requiring sub-meter accuracy. OPUS allows the surveyor to submit GPS data files in receiver-independent exchange (RINEX) format to NGS via the internet. The data are post-processed, using NGS's PAGES software, with respect to three Continuously Operating Reference Stations (CORS). OPUS will try to select the three sites nearest to the user's location but will expand the search based on data availability and quality. Positions computed by OPUS are usually emailed to the user within a few minutes. Currently, OPUS can only process one position at a time, so multiple sessions must be submitted individually. A good solution will have an overall root mean square (RMS) value below 0.03m, using 90% of the observations, with over 50% of the ambiguities fixed.

The performance of precise orbits generally yields marginal improvements in accuracy than its rapid orbit counterpart. Therefore rapid orbits can be used extensively during time challenged surveys.

Additional information and specific instructions for OPUS processing are included in the Users Guide for GPS Observations in Appendix 3 and on the OPUS web page <http://geodesy.noaa.gov/OPUS/>.

#### **4.4.3.2.1.2 Trimble Pathfinder Office**

Trimble Pathfinder Office includes a Differential Correction Utility which is used by many field units equipped with the Trimble ProXRS backpack GPS receiver. This utility makes use of the carrier phase data logged by the ProXRS and the NGS CORS network to produce positions of meter-level accuracy or better.

#### **4.4.3.2.2 Target File Processing**

Several types of survey data, such as shoreline features, manually measured depths, and bottom samples, are positioned using target files. These files can not be read directly into CARIS; thus, Pydro has been developed to handle the bulk of target file processing. A HYPACK target file can be easily inserted into Pydro via Data > Insert > HYPACK DPs. Pydro's Data > Insert > Trimble/Pathfinder Database GPs+DPs imports a Microsoft Access database (.mdb) according to a specific, S-57 based Pathfinder data dictionary format developed in conjunction with NOAA Ship FAIRWEATHER. Separate tables are used in this Pathfinder database for separate S-57 object classes and geometry. For example, "OBSTRN\_P", "OBSTRN\_L", and "OBSTRN\_A" tables may be present in a given database file for point-, line-, and area-geometry obstructions acquired in the field. And both GPs and DPs may be present in a given table; the "Tide - DP/GP" field is used by Pydro to segregate those observational types. Other "generic" target files can be read into Pydro via Data > Insert > Generic GPs/DPs, wherein users may configure a template for importing other data sources on a routine basis. Once inserted into Pydro the DP observational data can be edited, and the various attributes present in Pydro are added. Pydro automatically writes or "converts" (in the same sense of the term used by CARIS HIPS) DP datasets to CARIS HDCS data during data save operations. See section 4.4.2.1 for more information.

Once a target file is written to the HDCS data, it can be opened in CARIS to continue processing DPs which correspond to depths. In CARIS, a tide file and, if necessary (i.e., for echosounder determined depths) a sound speed profile can be applied to DP data. The DPs must then be merged as per standard HIPS processing to create processed depths. If any subsequent edits to DP position or depth values are performed in Pydro and saved, the standard CARIS HIPS "outdated" status is active and data will need to be re-SV Corrected and re-merged in HIPS.

#### **4.4.3.2.3 Water Level Correction (for features only)**

Preliminary and final water levels for tidally affected features such as rocks or piles are applied in either Pydro or CARIS Notebook. To apply tides in Pydro insert DPs and load appropriate tide file (i.e. TCARI or Zoned). To apply tides in CARIS Notebook select the feature(s) and load appropriate tide file (i.e. TCARI or Zoned).

#### **4.4.3.2.4 Attribution and Geometry**

##### **4.4.3.2.4.1 S-57 Standard**

S 57 is shorthand for the International Hydrographic Organization (IHO) Special Publication No. 57, "IHO Transfer Standard for Digital Hydrographic Data". S-57 standard details what S-57 objects and related attributes and geometry are permissible for official navigational charts produced by hydrographic offices around the world allowing hydrographic data to be transferred seamlessly from one user to another. The primary final product of S-57 data within NOAA is the Electronic Navigational Chart (ENC).

An S-57 file is a database of feature object classes and associated attributes that utilize a 6-letter acronym naming convention. For example a buoy (BOYLAT) is the feature object class and the description such as color (COLOUR)

are the associated attributes. Multiple object class “instances” are often required to describe a single real-world feature. For example, a lighted lateral buoy with a horn is described with three object classes in S-57: BOYLAT (buoy, lateral), LIGHTS (lights), and FOGSIG (fog signal).

Attribute types under each object class are used to indicate the specific makeup of the feature; e.g., COLOUR (colors), COLPAT (color pattern; applicable if dealing with more than one color), CATFOG (category of fog signal), etc.

#### 4.4.3.2.4.1.1 S-57 Objects

S-57 feature designation and attribution are assigned in HYPACK, CARIS Notebook and BDB through the feature editing function. In CARIS select the feature type (i.e. point, line, area) on the Feature Creation menu. Select the appropriate feature object class in the Object Acronym list. The details of the object class are displayed below in the Dictionary Information. The S-57 attributes are in upper case, the extended attributes are in lower case, and the mandatory attributes are distinguished with red color (Note: this is only true if the hydrographer is using the NOAA customized extended attribute files for CARIS which include the mandatory attribute settings). Certain attributes do not require manual editing; instead, the attribute is linked to the digital data present in the CARIS feature data (e.g. VALSOU - value of sounding - is associated with the depth).

In HYPACK select the feature type (i.e. node, chain, and region) and appropriate feature object class. The HYPACK Object Catalog uses whole words instead of acronyms (e.g. to create a PILPNT, you select PILE). The S-57 mandatory attributes are distinguished with a “M”.

In Pydro S-57 features are designated and attributed via an S-57 Editor dialog. **Only the primary item requires flags and attributes because they are propagated through to the flags of all Secondary items.** Select an object in the “Object Classes” list by checking the box adjacent to the desired object class description. The corresponding 6-digit acronym for any highlighted class name in the list is shown in the mouse pointer tooltip while hovering over the “Object Classes” button; and, clicking on the button opens up a help file detailing the meaning of the object class. The mandatory and additional attributes per the ENC Product Specification are shown on separate notebook pages in the Pydro S-57 Editor. Certain attributes do not require manual editing; instead, the attribute is linked to the digital data present in the Pydro XML feature data (manual editing for such attributes is in fact disabled). For example, if the S-57 attribute VALSOU (value of sounding) is associated with the feature, the Pydro XML <depth> element value will automatically appear in the depth editing box. Fill out the other boxes on the Additional Attributes notebook page in the S-57 Editor dialog according to your field observation.

#### 4.4.3.2.4.1.2 S-57 Attribution

S-57 feature attribution is required for features to be compiled to an ENC. S- 57 feature attribution is required for all new and updated items that represent a real-world feature recommendation for inclusion on the official navigational chart. The hydrographer should edit the S 57 object/attribute instances to describe each real world feature as completely as possible.

In addition to S-57 Attribution, NOAA requires customized flags and attribution to support H-Cell (preliminary ENC) compilation by the cartographers and to highlight features that need to be included in the appropriate reports. These extended attributes and flags are mirrored through all three processing software applications allowing for interoperability between the software using .000 files.

Refer to the S-57 and NOAA Attribution Guidance.pdf, Attributing and Flagging for Automated Feature Reports.pdf, and Customized Attribute Equivalencies.pdf in Appendix 4 of the FPM for more information.

#### **4.4.3.2.4.2 New Features and Feature Geometry Modification**

The most appropriate tools for creating and modifying line and area features are CARIS Notebook, BDB, and HYPACK ENC Editor. Notebook and HYPACK ENC Editor have the ability to digitize data in real time with the GPS logging functionality. Features can also be created or modified during post processing. BDB updates must occur during post processing as BDB does not have the GPS logging functionality.

New features are added as S-57 attributed objects through the feature editing function. The feature geometry shape and extents of existing features), such as ledges, foul areas etc, can also be modified using the same function. Line or area objects that require modification may be delivered as points or lines of the new extents.

All additions and modifications require specific attributes which are described in detail in the S-57 and NOAA Attribution Guidance.pdf in Appendix 4section 8.2 of the HSSD.

All new and modified features are submitted in the Final Feature file. See section 4.4.4 for details.

#### **4.4.3.2.4.3 Attributing and Flagging**

Features must be attributed/flagged correctly in the processing software for the processing branch cartographers to compile the survey to an HCell and create the Feature Report Appendices of the DR. For processing and QC the hydrographer may use the Query functions in CARIS BDB and Notebook or the \*treetemplates files in Pydro. Refer to section 8.2 of the HSSD for attribution requirements.

#### **4.4.3.2.4.3.1 Additional Attribute/Flagging Definitions & Examples**

##### **4.4.3.2.4.3.1.1 Pydro Combination Flag Definition**

The following subsections describe the most common Pydro flagging combinations for survey items, grouped by data acquisition type: items from bathymetry (HIPS processed depths flagged Outstanding and/or Designated), imagery (SIPS contacts), DPs, AWOIS, and other geographical positions (GPs). Note that all descriptions listed below are for Primary items. The Primary attribute/flag is no longer mandatory. In addition, the term “Feature Report” refers to the feature report created at the processing branch.

##### **1. Items from Bathymetry**

- Resolved - This indicates any bathymetry feature that is not intended for the feature report (note the absence of the Report flag). This should be used for all designated soundings that were selected to force the uncertainty surface to honor the true sea floor—but not otherwise elevated to the level of desire for an explicit feature symbology on the chart.
- Chart, Resolved - This flag combination indicates any bathymetry feature that is included as an explicit feature on the PSS, but not intended for the feature report (note the absence of the Report flag). This flag combination is uncommon, but sometimes used when depicting complex shoreline with a series of DPs. Further information and reasoning should be detailed in the item’s Remarks tab.
- Chart, Report, Resolved - This flag combination indicates any bathymetry feature that is included as an explicit feature on the PSS and is intended for the feature report. Further information and reasoning should be detailed in the item’s Remarks tab.

- Chart, DTON, Report, Submitted, Resolved - This flag combination indicates any bathymetry feature that is included as an explicit feature on the PSS, is specifically intended for the feature report, and has been submitted to MCD as a DTON. Further information and reasoning should be detailed in the item's Remarks tab.

## 2. Items from Imagery

- Resolved - This flag combination indicates any insignificant contact that was not developed (otherwise imagery item should be Secondary to a bathymetry-based feature). Further information and reasoning should be detailed in the item's Remarks tab. This flag combination often indicates a contact that, after further evaluation, was determined to be insignificant.
- Tgt Exported, Resolved - This flag combination denotes a contact that was exported, presumably for subsequent investigation, and found to be insignificant (otherwise imagery item would be Secondary to a bathymetry-based item). The item is not intended for the feature report. Further information and reasoning should be detailed in the item's Remarks tab.
- Chart, Report, Resolved - This flag combination indicates any imagery item that was determined to be a significant contact, but was not investigated. The item is intended for the feature report. Further information and reasoning should be detailed in the item's Remarks tab. Imagery items should typically not be flagged Chart since they do not provide an accurate depth for charting. Except in extenuating circumstances, significant items from imagery should always be Secondary to a (Primary) bathymetry-based item. An example of when this flagging scenario could be used is when the field unit acquired SSS imagery, but left the area before a significant contact could be developed with bathymetry or diver investigation. This scenario is not common, but is sometimes unavoidable.

## 3. Detached Positions (DPs)

- Rejected, Resolved - This flag combination indicates any detached positions that the hydrographer does not want to be part of the survey. Further information and reasoning as to why it was rejected, such as because it was a blunder or a DP on an unassigned AWOIS item, should be added in the feature's Remarks tab.
- Resolved - This flag indicates any detached positions included for informational purposes only, which are not intended for the feature report. Further information and reasoning should be detailed in the item's Remarks tab.
- Chart, Resolved - This flag combination indicates any detached positions that are depicted on the PSS as features but not intended for the feature report. Some examples of when this flagging scenario might be used are as follows: (i) recording bottom sample locations, (ii) positioning shoreline features, and (iii) verifying positions of aids to navigation.
- Chart, Report, Resolved - This flag combination indicates any detached positions that are depicted on the PSS as features and are intended for the feature report. Some examples of when this flagging scenario might be used are as follows: (i) least depths determined by DLDG that either do not have supporting echosounder bathymetry or any correlating echosounder bathymetry is flagged Secondary, and (ii) portraying complex shoreline, including issues such as changes to MHW and shoreline feature disapprovals.

## 4. AWOIS Items

- Resolved - This flag indicates an AWOIS item that was disapproved using one of the investigation methods

assigned in the database record. It can also be used to indicate an AWOIS item that does not fall directly into a survey area, but whose search radius partially falls within the survey area, and has been or will be addressed by an adjoining survey. Further information should be added to the item's Remarks tab.

- Secondary—to [Primary] Bathymetry Item or DP (see section 4.4.4 for information on correlation) - This flag combination indicates any AWOIS item that was located/verified during the survey.
- Geographic Positions (GPs)- GPs are any point data that do not fit into another feature category. As Secondary items, they can be used to convey information that is outside the scope of standard features in Pydro. GPs may be either inserted into Pydro from some “generic” ASCII or database format or manually digitized via the context menu in a Pydro Chart Window. GPs can optionally be assigned under the sub-categories “ChartGPs” and “Checkpoints”. An explicit function exists in Pydro to insert S-57 ENC features as ChartGPs into the PSS for evaluation of survey items in context with the (official) chart.
- Secondary ChartGPs are used to indicate the connection of the associated Primary item to an existing charted feature. Such a relationship instructs Pydro's DR document builder to file a Report feature under the “Charted Features” chapter; absence of a Secondary ChartGP (and no Secondary AWOIS) directs a Report feature to the “New Features” chapter.
  - Checkpoint GPs can be created in Pydro if survey features do not exist at desired comparison locations for (say) a Pydro Points/Surface Stats Report.
  - GPs can be created as placeholders for the information necessary to disprove a feature, without the need for an item to be explicitly logged during data acquisition. Photographs and other details about the techniques used to disprove a feature (e.g., search radius and method) are important pieces of information to include with such a disproof GP.

#### **4.4.3.2.4.3.1.2 Examples of Feature Attribution Using the NOAA Customized Attributes**

##### **Assigned Features – Not Addressed descrp=5**

Features that were “Assigned” in the CSF but not addressed. The reasoning should be detailed in the item's Remarks attribute. These features maintain the original SORDAT and SORIND.

Example 1: An obstruction area was Assigned but not addressed due to high sea state making the area unsafe for operations. The feature is attributed as Not Addressed and an explanatory statement is included in the Remark field.

Example 2: A charted rock was Assigned but not addressed due to the feature being inshore of the navigable area limit line of the survey. The feature is attributed as Not Addressed and an explanatory statement is included in the Remark field, such as “inshore NALL”.

##### **Addressed Features with No Attribution Change descrp = 4**

Features that were addressed and not edited in any way, maintain the original SORDAT and SORIND. Descriptive attribution of Retain along with an explanatory Remark should be added. This will alert the processing branch to either retain the charted feature or that the feature is depicted accurately if from another source.

Example: A GC rock is Assigned and investigated during shoreline verification, it was found to correctly portray the feature. No existing attribution, such as height is changed. The feature is given descriptive attribution of Retain and a Remark .

### **New Features descrp=1**

New features that are identified are given a descriptive attribution of New along with an explanatory Remark and the SORDAT and SORIND populated with current survey entries.

Example: A charted rock is found to be the high point of a large new navigationally significant reef. A SBDARE line (NATSUR = Rock) is digitized into the Final Feature File using the observed reef extents as a guide, assigned the new SORDAT and SORIND, given a Remark and the descriptive term New. The processing branch will create an area object of the SBDARE line.

### **Updated Features descrp=2**

Updated features are comprised of features that have a change in Attribute or Object class, but do not have a change in position. The field modified something about the feature without moving it. Examples of the two main update types are below:

#### **Update Feature, Attribute Change:**

Example 1: A height measurement is taken for a GC rock. The rock is retained in the Final Feature File, VALSOU field populated, the feature is assigned the new SORDAT and SORIND and given the descriptive term Update. A Remark is included to note the addition of the height attribution.

Example 2 : The color of a mooring buoy is found to be orange rather than the yellow shown on the chart. The COLOUR attribute is changed for the MORFAC feature, and the feature assigned the new SORDAT and SORIND and given the descriptive term Update. A Remark is included to note the change of the color attribution.

#### **Updated Feature, Object Class Changed (geographic primitive unchanged)**

Example: A charted pile is found to be a dolphin. The PILPNT designation is changed to MORFAC, dolphin, and the new SORIND and SORDAT are assigned to the new feature. The feature object change is noted in Remarks and the feature is attributed with the descriptive term Update.

#### **Re-positioning features, changing a Geographic Primitive and altering or adding to the extents of an area feature:**

The above scenarios all require two sets of features, one with a descrp =1 for the new position/primitive/extents, and the other with a descrp = 3, for the old position/primitive/extents. This indicates to the cartographer/ reviewer what has changed. The following are examples of these changes.

Repositioned Features – Altering Geographic Position or Shape descrp= 1 for feature at new position, descrp=3 for feature at old position

For features that were repositioned or the geographic position or shape is altered, the original feature that has a position error is attributed with the descriptive term Delete, maintaining the original SORDAT and SORIND, given an appropriate Remark and Recommendation. The repositioned feature in the Final Feature File is assigned the new SORDAT and SORIND, will contain a Remark stating that it was repositioned and be given the descriptive term New.

Example: A charted pile is discovered to be a dolphin 200 m to the west of the charted position. The new dolphin is digitized and given the new SORDAT and SORIND, a Remark, and descriptive attribution of New; the pile is

given the descriptive term Delete and it maintains the original SORDAT and SORIND, and the Remarks field is populated regarding the disproval of the pile. Because it is a charted feature a Recommendation is also required **Geographic Primitive Altered** (i.e. from point to area, or area to point)

descr= 1 for feature with new geographic primitive, descr= 3 for feature with old geometry

In any case where the geographic primitive is altered (i.e., point feature modified to a line; point modified to an area, etc.), the feature with the new geometry contains the descriptive attribution New and the feature with the old geometry is attributed with the descriptive term Delete.

Example 1 : A charted obstruction area with snags/stumps is discovered to be the intact wreck of the privateer Black Pearl. The OBSTRN object is given the descriptive term Delete and it maintains its original SORDAT and SORIND. It is given a Remark, and because it is a charted feature disproval, it is also given a Recommendation. A new WRECK point object is collected in the field or digitized to the Final Feature File, assigned the new SORDAT and SORIND, given the descriptive term New and a Remark.

Example 2: A charted reef is found to be correctly positioned, but is determined to be a small islet rather than a reef. A LNDARE point object is used to depict the islet, and height given using a LNDELV object. The LNDARE and LNDELV objects are assigned a descriptor of New, are given a new SORDAT and SORIND and a Remark. The original reef is attributed with the descriptive term Delete maintaining its original SORDAT and SORIND. Because it is a charted feature disproval both a Remark and a Recommendation are added to the feature.

### **New or Adjusted Extents – Line or Area**

descr = 1 for new or adjusted extent, descr = 3 for old extent

The Final Feature File includes line features digitized to define new or modified limits of kelp beds, foul or rocky areas, ledges and reefs, where the extents were obtained using DPs, GPs, buffer lines, or surfaces from VBES and/or MBES. The new SORDAT and SORIND are assigned and a Remark added, for instance “New ledge”.

Example 1 : The BASE Surface is used as a back drop to digitize the extents of a rocky seabed area using a SBDARE line object. The SBDARE line object (which will be created as an area object during branch processing) is included in the Final Feature File and assigned the new survey SORDAT and SORIND. Remarks are added to the line feature and it is attributed as New.

Example 2: A maritime boundary MLLW water point is investigated, it is found to be at a more seaward location of an already charted ledge. The new extents are digitized using a SBDARE line object. The SBDARE line object is included in the Final Feature File and assigned the new survey SORDAT and SORIND. Remarks are added to the line feature and it is attributed with a descriptor of New and a special feature type of Maritime Boundary. The old extent of the ledge may need to be attributed as Delete and retains its original SORDAT and SORIND, and includes a Remark and Recommendation.

### **Deconflicting Features**

descr= 4 best position feature, descr= 3 for features determined to be at incorrect position

Where features from multiple sources are given in the composite source for deconfliction, the feature that is selected as the best representation is attributed as Retain in the Final Feature File, maintaining its original SORDAT and SORIND. A statement as to why the feature was selected to be retained and what methods were used to make this determination is included in the Remarks field. The remaining features are attributed with the descriptive term Delete. Each disproved feature keeps its original SORDAT and SORIND and a Remark. A Recommendation must also accompany any currently charted features attributed with the descriptive term Delete.

Example 1: The composite source includes two features for deconfliction, one from the raster chart and one from GC, positioned in close proximity to each other and to a prior survey feature included in a reference file. The prior survey rock is found to be the best representation of the position of the rock. The prior survey rock is imported into the Final Feature File and given the descriptive term Retain along with a Remark. The prior survey feature maintains its original registry number and date for SORIND and SORDAT. The remaining two features, the GC and chart rocks, are attributed as Delete. The features retain their original SORDATs and SORINDs. Remarks are included for both, and a Recommendation accompanies the chart rock.

Example 2: Where a LIDAR item is found by the field to be a charted feature, choose the better representation of the item and attribute it as Retain. If the LIDAR item is selected over a charted item, the LIDAR item remains in the Final Feature File and the charted feature is attributed as Delete. If the charted item is selected over a LIDAR item, the charted item remains in the Final Feature File and the LIDAR feature is attributed as Delete.

### **Disprovals descrp=3**

Features from Composite Source that have been disproved should be attributed with the descriptive term Delete, and should maintain the original SORDAT and SORIND. A Remark should indicate the reason for disproof. Disproved chart features also require a Recommendation.

Example 1: A charted rock is disproved using MBES. The charted rock is given the descriptive term Delete where it maintains the original SORDAT and SORIND, the Remarks field is populated regarding the method of disproof, and a Recommendation to remove the feature from the chart is made.

Example 2: A charted pier in ruins is not seen in the SSS imagery or in the MBES data. The pier is given the descriptive term Delete and should maintain the original SORDAT and SORIND. The remark field is populated with information regarding the method of disproof and a Recommendation to remove the pier from the chart is made.

Example 3: LIDAR coverage over a charted feature shows no indication of the charted feature. The feature has subsequently been disproved using VBES, SWMB, etc. The charted feature is attributed as Delete and maintains its original SORDAT and SORIND, and the method of Disproof is indicated in Remarks. A Recommendation is also required for all Disprovals

#### **4.4.3.2.4.4 Feature Correlation**

In a NOAA hydrographic survey new features can be automatically correlated (i.e. associated or connected) with existing data using Pydro software. or manually correlated with CARIS Notebook, BDB or HYPACK. The manual correlation in CARIS and HYPACK is achieved through NOAA extended attributes. For further information, refer to section 8.2 of the HSSD

The existing data are typically classified in one of the following five categories:

- Items from Bathymetry – Sounding data (MBES or VBES) which has been identified as a measurement of a least depth on a feature in CARIS HIPS or Pydro. "Designated" soundings can also be selected to force the gridded surface to honor the true depth of the seafloor.
- Items from Imagery – A potentially significant feature which has been identified in SSS data, chosen as a contact in CARIS SIPS during post-processing, and to be evaluated for further investigation and/or development.

- Detached Positions (DP) – Detached positions are used to position point features such as shoreline items, bottom sample locations, DLDG depth determinations, and lead line or pole soundings. DPs are subdivided into echosounder and non-echosounder types. Echosounder DPs are used for data with a corresponding depth determined by VBES, MBES, or another system which is referenced to a point other than the water’s surface and require the application of vessel offsets. Non-echosounder DPs are used to provide positions for data either with no associated depth information or referenced to the water’s surface, such as DLDG determined depths and heights of shoreline features.
- AWOIS Items – AWOIS items represent features which have been previously reported or surveyed and are generally included on the current chart. Specific AWOIS items within, or partially within, each survey area will be assigned for investigation.
- Geographic Positions (GP) – Geographic positions refer to point data used for various purposes and not otherwise classified. These points are typically uploaded from a portable GPS system, manually digitized in CARIS, HYPACK, or Pydro, or created by inserting “generic” data into Pydro.
- Two sub-types of GPs exist in Pydro: “Chart GPs” and “Checkpoints”. The principal use of Chart GPs in Pydro is to indicate those survey items which represent new observations on existing charted features, or otherwise disprovals thereof. Checkpoints provide for a way to steer some comparison of survey data at discrete locations.

As each feature is evaluated, standard classification flags should be set. (A Pydro data flagging decision tree is provided in Figure 4.22 to assist the hydrographer with this process.) The basic process involves systematically reviewing survey data for features, by segregating correlating groups of items into a best- representative “Primary” item + supporting “Secondary” item(s). This decision process involves examining survey items in context with all supporting data available: any previously known items (AWOIS and other currently-charted features) and bathymetry (current survey, prior survey, charted soundings, etc).

Note: An item from bathymetry representing the least depth of a navigationally significant real-world feature should always be marked Primary.

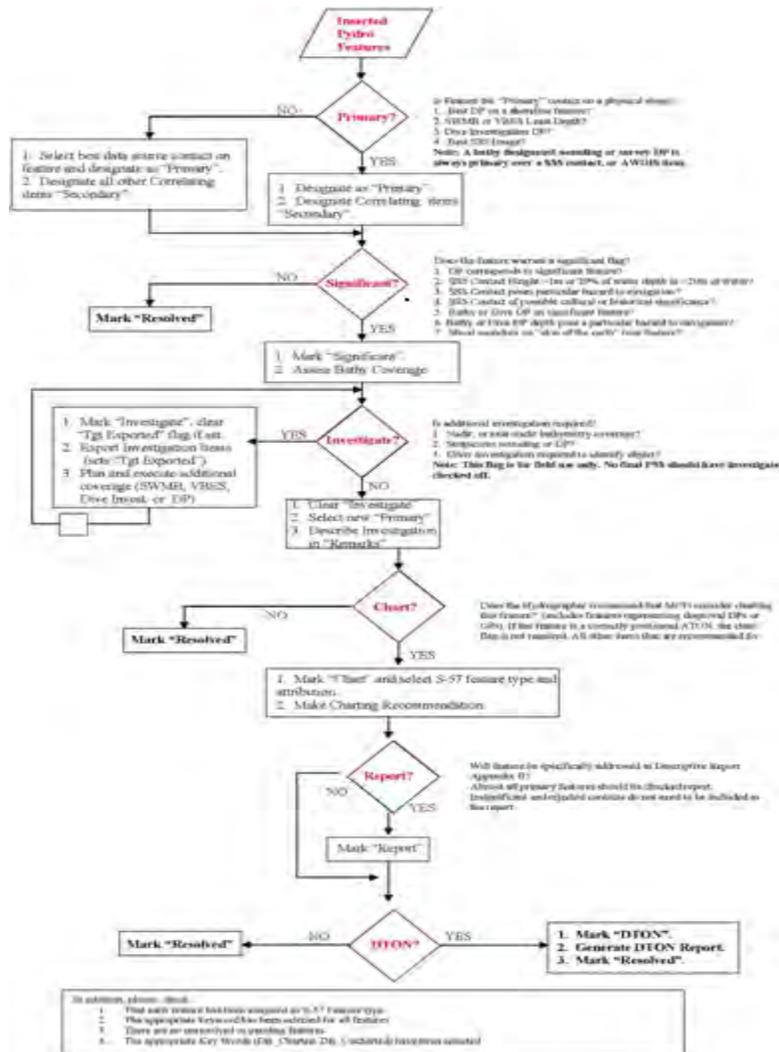


Figure 4.22: Pydro data flagging decision tree.

For all the correlating items that represent the same feature as the Primary item, set the status flag to Secondary. If an item has been automatically correlated to a Primary item, but does not appear to be the same feature, assign it as Primary. That is, use the Primary item status to segregate features. If your survey makes use of side scan sonar, this means you will often encounter disparate features through items from imagery before having supporting item(s) from bathymetry. Set the status flag to Primary for such items, knowing that if they prove to be navigationally significant, a bathy item will take precedence as the Primary item when available. If there are items that represent a common feature that have not been automatically correlated by distance, use Pydro's Group Features tool to manually associate those items.

In Pydro only, certain subsequent flagging actions on a feature need only be carried out on the Primary item because they are propagated through to the flags of all Secondary items. Each feature should be reviewed to determine if it is significant based on either the NOAA contact height criteria or some other criteria determined by the field unit. Other criteria include, but are not limited to, proximity to a maintained channel, predominant ship/boat traffic in the area, proximity to other significant features etc. If so, check the "Significant" flag. If the feature requires additional data acquisition to be resolved, also check the "Investigate" flag. The purpose of the Investigate flag is to remind the field hydrographer that more information, possibly involving additional data acquisition, is necessary to adequately resolve the least depth or nature of a feature. All items marked "Investigate" may be exported to MapInfo Interchange Format files (MIF/MID), HYPACK Target files (.tgt), or HYPACK S-57

files (.000) to facilitate additional data acquisition; the “Tgt Exported” flag is set upon item export.

#### 4.4.4 Deliverables

The following feature files shall be delivered with a survey. The hydrographer shall adhere to Appendix 12 of the HSSD: Data Directory Structure for the proper directory structure:

##### 1. Feature Data:

(a) Final Feature File in .000 format - (HXXXXXX\_Final\_Features\_File.000) - The .000 final features layer contains the original source data with survey updates. This is the primary file the branch cartographer will use to compile the survey to the HCell.

(b) Final Pydro File (if applicable) in a .pss format (HXXXXXX\_Final\_Features\_File.pss) – The .pss final features layer contains the original source data with survey updates. The .pss is a supplemental file which may or may not be used by the branch cartographer to compile the survey to the HCell.

2. Multimedia - Photographs and images are very helpful to the cartographers during compilation. Multimedia is delivered with the final feature file in the Multimedia folder. The photographs and images are correlated or linked (depending on software) to the features.

(a) Photographs – ex: new extents of piers, piles, rocks, etc.

(b) Images

i. MBES – ex: least depth on rock or wreck from CARIS 3-D viewer

ii. Side Scan Sonar Contact Images

Note: A copy of the Side scan sonar contact images shall be delivered in the CARIS HDCS line file.

3. Side Scan Sonar (SSS) Contacts in .000 format – All SSS contacts, both significant and insignificant, shall be delivered in .000 format and submitted in the S-57 Features Folder. The side scan sonar contact points shall be delivered as the S-57 feature object cartographic symbol (\$CSYMB) with the attribution described above in Section 8.2 of the HSSD.

- Example 1 : The BASE Surface is used as a back drop to digitize the extents of a rocky seabed area using a SBDARE line object. The SBDARE line object (which will be created as an area object during branch processing) is included in Final\_Features and assigned the new survey SORDAT and SORIND. Remarks are added to the line feature and it is attributed as New.
- Example 2: A maritime boundary MLLW water point is investigated, it is found to be at a more seaward location of an already charted ledge. The new extents are digitized using a SBDARE line object. The SBDARE line object is included in Final\_Features and assigned the new survey SORDAT and SORIND. Remarks are added to the line feature and it is attributed as New. The old extent of the ledge may need to be attributed as Delete and retains its original SORDAT and SORIND, and includes a Remark and Recommendation.

#### Deconflicting Features

**descrp= 4** best position feature, **descrp= 3** for features determined to be at incorrect position

Where features from multiple sources are given in the composite source for deconfliction, the feature that is selected as the best representation is attributed as Retain in Final\_Features, maintaining its original SORDAT and SORIND. A statement as to why the feature was selected to be retained and what methods were used to make this determination is included in the Remarks field. The remaining features are attributed with the descriptive term Delete. Each disproved feature keeps its original SORDAT and SORIND and is given a Remark. A Recommendation must also accompany any currently charted features attributed with the descriptive term Delete.

- Example 1: The composite source includes two features for deconfliction, one from the raster chart and one from GC, positioned in close proximity to each other and to a prior survey feature included in a reference file. The prior survey rock is found to be the best representation of the position of the rock. The prior survey rock is imported into the Final Feature layer and given the descriptive term Retain along with a Remark. The prior survey feature maintains its original registry number and date for SORIND and SORDAT. The remaining two features, the GC and chart rocks, are attributed as Delete. The features retain their original SORDATs and SORINDs. Remarks are included for both, and a Recommendation accompanies the chart rock.
- Example 2: Where a LIDAR item is found by the field to be a charted feature, choose the better representation of the item and attribute it as Retain. If the LIDAR item is selected over a charted item, the LIDAR item remains in the Final\_Features layer and the charted feature is attributed as Delete. If the charted item is selected over a LIDAR item, the charted item remains in the Final\_Features layer and the LIDAR feature is attributed as Delete.

### **Disprovals descrp=3**

Features from Composite Source that have been disproved should be attributed with the descriptive term Delete, and should maintain the original SORDAT and SORIND. A Remark should indicate the reason for disproof. Disproved chart features also require a Recommendation.

- Example 1: A charted rock is disproved using MBES. The charted rock is given the descriptive term Delete where it maintains the original SORDAT and SORIND, the Remarks field is populated regarding the method of disproof, and a Recommendation to remove the feature from the chart is made.
- Example 2: A charted pier in ruins is not seen in the SSS imagery or in the MBES data. The pier is given the descriptive term Delete and should maintain the original SORDAT and SORIND. The remark field is populated with information regarding the method of disproof and a Recommendation to remove the pier from the chart is made.
- Example 3: LIDAR coverage over a charted feature shows no indication of the charted feature. The feature has subsequently been disproved using VBES, SWMB, etc. The charted feature is attributed as Delete and maintains its original SORDAT and SORIND, and the method of Disproof is indicated in Remarks. A Recommendation is also required for all Disprovals.

## **4.5 Chart Comparison**

Compare each hydrographic survey to the latest versions or editions of the largest scale ENC's and raster charts that cover the project area. Conduct the comparison in accordance with section 8.1.4., D.1 of the HSSD. The specific method of comparison is left to the discretion of the hydrographer, though the comparison is typically done using Pydro, CARIS, or MapInfo software. When performing a chart comparison, the hydrographer shall use the most current official charts available. If necessary or required by the Project Instructions, additional evaluation methods such as junction survey comparisons or prior survey comparisons may also be used.

### 4.5.1 Obtaining and Identifying Current Charts

The hydrographer should keep in mind that the most current official charts may not be the ones provided on the Project CD/DVD. Often, versions of raster and/or ENC charts used for vessel navigation will be more current. Any chart corrections from the National Geospatial Intelligence Agency’s (NGA) Notice to Mariners (NTM), the United States Coast Guard’s Local Notice to Mariners (LNM), and Canadian Hydrographic Service (CHS) that have not yet been applied should also be considered. For additional chart correction information, the database of NTM corrections can be queried online at: <http://msi.nga.mil/NGAPortal/MSI.portal> LNM corrections can be reviewed online at: <http://www.navcen.uscg.gov/>

#### 4.5.1.1 Raster Navigational Charts (RNC)

Prior to chart comparisons, the most current RNC can be downloaded from MCD at <http://www.charts.noaa.gov/>. For raster charts, the edition, corrections applied, and date of notices through which the chart has been “cleared” will be included in the \*.KAP file header information, which can be viewed using a text editor such as WordPad. The term “cleared” means that all notices up to, and including, the one issued on the cleared date have been reviewed and any corrections have been applied to that raster chart. Edition and correction information has been identified in the example header file section in section 4.2.4 .



Figure 4.23: Section of a \*.KAP file (opened in WordPad) identifying chart edition and corrections that have been applied to the digital file. Note: CHS does not issue corrections for this chart area, so no cleared date is listed.

Note: Some of the chart information identified in Figure 4.24 is repeated in the header line beginning with “NTM.” In this example, NE=10.56 refers to what the raster manufacturer calls the “Notice Edition.” It is the number of digital patches (56) applied to that chart edition (10). ND refers to the “Notice Date,” and repeats the NGA NTM cleared date. BD is the “Base Date” and repeats the chart edition date.

#### 4.5.1.2 Electronic Navigational Charts (ENC)

The most current ENC can be downloaded from MCD at <http://www.charts.noaa.gov/>.

The ENC Update Application Date is the date that the full ENC Cell was first posted or re-posted. This date is similar to the Edition Date of a raster chart. ENC Cells are re-posted when the updates grow too large or a large section of the Cell is re-built. The Issue Date identifies when the last correction was applied. All notices have been applied through that date, similar to a “cleared” date for raster charts. If using an ECDIS system or viewer software to read the ENC, these dates can be found in the ENC Cell properties.

Note: Some viewer manufacturers have erroneously reversed the Update Application Date and Issue Date. Since an edition must exist before it can be corrected, the later of these two dates will always be the Issue Date.

#### **4.5.2 Junction Survey Comparisons**

If the designated limits for a survey junction with modern data from another survey, the area of overlap should be compared and discussed in the Descriptive Report. OCS considers a standard junction comparison acceptable if sounding variance is 1 meter or less between the present and junctioning surveys. Agreement is considered poor if sounding variance is greater than 1 meter. In such cases, the hydrographer should attempt to determine the cause(s) of significant discrepancies and explain these variances in the Descriptive Report.

#### **4.5.3 Prior Survey Comparisons**

Due to the advances in survey technology and data coverage capabilities, modern survey data will nearly always supersede historical data. Thus, prior-survey comparisons are generally not required by field personnel, but may be used at the discretion of the hydrographer for quality control purposes. If the present survey has numerous conflicts with charted soundings and/or features, then the hydrographer should consider conducting a prior survey comparison. If a prior survey comparison is performed, the reason it was deemed necessary should be discussed in the Descriptive Report and the applicable prior survey(s) should be identified by registry number, date of survey, and scale.

## Chapter 5

### Data Management and Survey Deliverables

The purpose of this chapter is to define data management and deliverable requirements for NOAA field units conducting OCS hydrographic surveys. These requirements have been established to safeguard hydrographic data during field operations, support efficient office processing, and expedite the application of survey data to NOAA's navigational products.

#### 5.1 Data Management

A typical OCS hydrographic survey produces an extensive amount of data; thus, proper data management is critical. Two primary components of data management are addressed in this chapter: data security, releasability, storage, and data filing and organization. It is the field unit's responsibility to manage all survey data such that its security and integrity are not compromised during operations, and to efficiently transmit these data to AHB, PHB, or other designated recipient(s).

##### 5.1.1 Data Security, Releasability and Storage

Hydrographers should take special care to ensure that hydrographic data security is carried out and released according to OCS policy. All hydrographic personnel should always consider possible liability issues that may be associated with dissemination of preliminary data. Further guidance is given below in this section and contact information for these authorities will be identified in the Project Instructions.

Additionally, data and reports generated while conducting OCS hydrographic surveys are official records that must be cataloged and archived. Since the majority of these data and reports are in digital format, a field unit's digital data storage systems must be configured, operated, and maintained with care. Precautions should be taken against data loss due to careless handling, accidental corruption, or system failure.

###### 5.1.1.1 Data Security

It is the field unit's responsibility to maintain all survey records in a manner that ensures data is accessible only to the appropriate survey personnel and system administrators. Tracking procedures should be used to identify which personnel have performed specific tasks for all data acquisition, processing, and manipulation. Data secure can be maintained within a field unit via a combination of procedural checklists and logs, as well as establishing computer user accounts with password protection.

Field units may receive requests for survey data from constituents and private parties. Field units shall obtain approval from the Chief-of-Party prior to releasing any preliminary data or products to parties outside of OCS.

Note: Any preliminary data product released must be clearly annotated in accordance with section 5.2.2.4 of this manual.

A copy of all products released to the public shall be included in the Public\_Relations\_&\_Constituent\_Products folder of the survey submission package. The field unit shall document all survey records or constituent products officially transmitted using a digitally signed NOAA standard form Letter Transmitting Data (NOAA Form 61-29), which can be created in Pydro. A record of all transmittal letters created and received should be maintained by the field unit.

### 5.1.1.1.1 Special Data Handling Requirements

Special handling requirements will be described in the Project Instructions from HSD Operations Branch. Examples of situations requiring special data handling are below.

All newly discovered uncharted shipwrecks are to be treated as significant and vulnerable historic resources. This treatment entails following the data handling guidance in section 4.4.2.4 of this manual. Raw or processed data from sources external to NOAA are not to be made available to the public at any time.

Certain homeland security survey data have special handling requirements prescribed by the US Naval Oceanographic Office and OCS as described in the NAVMETOCCOMINST 3142A documents included in Appendix 2:

### 5.1.1.2 Data Releasability

Field units or HSD/NSD office personnel should be aware that the policy information mentioned here is set forth such that the release of raw or working data do not provide a company an unfair competitive advantage within its industry or carry with it liability issues that may be associated with the dissemination of this data. These policies are also set to adhere to the National Historic Preservation Act of 1996 and the Archaeological Resources Protection Act of 1979. Information about all newly uncharted navigationally significant and potentially historical man-made features, particularly position coordinates, is considered sensitive material. The field shall not release this information to the general public without permission from HSD.

Figure 5.1 illustrates a general flow diagram of HSD's processes to plan hydrographic surveys, acquire, process, quality control and compile hydrographic data to create products.

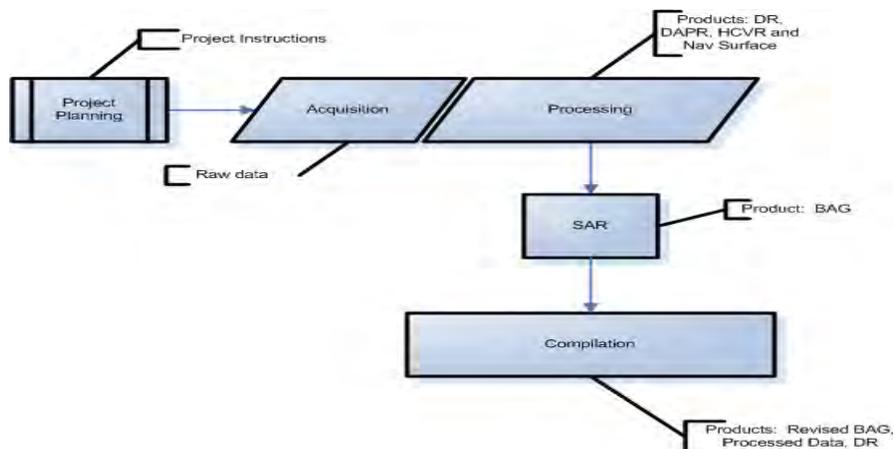


Figure 5.1: General flow diagram of HSD's processes.

According to the OCS Policy for the Release of Mission Data, there are three defined stages for Mission Data (see the OCS policy for more information about each of these stages):

- Raw Data: data as it is originally collected manually, from sensors, or received from other sources such as other federal agencies.
- Working Data: data on which processing has been performed that changes the information contained in the data but which is not yet processed to a level deemed as complete and suitable for public release (e.g. data that has undergone a Survey Acceptance Review (SAR)).
- Data Product: data which has been processed or accepted without further processing which is considered to be suitable for release to the public and which OCS acknowledges as official (e.g. BAG after approval).

Due to the increase in requests for digital data at all stages, HSD has been working with the National Geophysical Data Center (NGDC), which stores this data, to release the data to the public at the following stages in HSD's pipeline:

1. After the ships have sent the raw data to NGDC.
2. After the working data has undergone a SAR and AHB/PHB has sent it to NGDC (Post-SAR).
3. After OCS acknowledges the data as official

Note: All personnel should note that all new data will be in the BAG format instead of the previously archived ascii xyz format. The BAG format was developed to create an open source exchange format for gridded data therefore any public requester should be able to use data in this format (see section 5.2.1.1 of the HSSD)

**ONLY DATA AT NGDC CAN BE RELEASED TO A REQUESTER.** HSD/NSD office personnel, responding to a request, should direct the requester to a point of contact at NGDC (which can be identified by HSD). Official data is available via NGDC's website <http://map.ngdc.noaa.gov/viewers/index.html> (NGDC will have a website for the public to retrieve raw or post-SAR data in the future).

It should be noted that field units shall NOT release raw or processed data to a requester outside of OCS. Also field units shall NOT create specialized products in response to a data request unless authorized by their supervisor. Data requests for processed data which are still on the vessel must comply with the guidance in section 5.2.2.4 of this manual and ensure that an effort should be made to meet the needs of the requester without being unduly time consuming.

If the Chief Hydrographer feels the requester has reasonable cause to warrant the release of raw data which are still on the ship and have not been sent to AHB/PHB then, (s)he must obtain written approval by the appropriate Division Chief (i.e. the Chief, Hydrographic Surveys Division or Chief, Navigation Services Division) to release these data. Raw data, if release is approved, should be distributed with a disclaimer describing, in general:

- Things that have not been done (e.g. list correctors that haven't been applied).
- Uses of the raw data that are not appropriate.
- Anything else the Chief Hydrographer or Chief of HSD feels necessary to include.

Additionally, metadata should be provided in conformance with applicable standards and such metadata should be entered in to the appropriate national metadata data base. Finally, an official record of raw data distributions shall be made and preserved (contact the Chief of HSD/NSD for more information).

Likewise, if the Chief of AHB/PHB is forced to distribute Post-SAR (working data) or feels the requester has reasonable cause to warrant the release of processed data which are in line to undergo a SAR, field units or HSD/NSD office personnel responding to a request must obtain written approval by the appropriate Division Chief to release this data. Post-SAR data, if release is approved, should have a strong disclaimer letter that accompanies the data and indicates enough major flaws to discourage its use and further requests. Additionally, before releasing this data three steps should be taken:

1. The data or a transmittal document shall be marked appropriately taking into consideration the recipients intended use. Suitable markings might be: 'Preliminary Data – contents may change', or 'Draft – not to be used for navigation', or 'Working file – processing has not been completed and significant corrections may yet be applied'.
2. The recipient shall be counseled as to the known condition of the data, the nature of possible changes, and other known considerations that would help the recipient use the data in a prudent manner.
3. The provider should mark the data set or accompanying transmittal document indicating to whom the file was provided, and that the recipient was counseled as to the status of the data. The provider shall then prepare and preserve an official record (contact the Chief of HSD/NSD for more guidance – this should be in line with how NGDC records requests) that data was provided, to whom, for what use, on what date, that counseling was provided, and who made the determination and released the data.

### **5.1.1.3 Data Storage**

All storage devices and media used for OCS hydrographic survey data should be approved by HSD and/or HSTP. Field units shall not implement new data storage technology or media without first consulting HSD and/or HSTP to verify that the system is both based on proven technology and is compatible with equipment at other NOAA sites that may need to access the survey data.

NOAA's hydrographic survey ships are typically equipped with Network Appliance (NetApp) data storage systems. The NetApp system consists of dual Redundant Array of Independent Disks(RAID) arrays with independent control heads. Each NetApp system should be set up in a mirrored crossover configuration with daily and weekly snapshots to provide data redundancy and recoverability in case of partial system failure. With this type of system redundancy, if one control head fails, the second will assume control of both RAID arrays; if one RAID array fails completely, a copy of the data will remain on the second RAID. Data recoverability is provided by "point-in-time" snapshots of the data that can be used to restore directories that have been inadvertently deleted or become corrupt. OCS strongly recommends physically separating the two NetApp control heads to prevent catastrophic data loss due to a point event such as an isolated fire.

Navigation Response Teams use a different type of data storage system to meet their specific mission needs. typical NRT data storage systems consist of one Network Attached Storage(NAS) unit that is regularly backed up onto an external hard drive. This type of system combination should be configured to automatically compare the two drives for differences periodically throughout the day. If any new data are found on the NAS, those files should be automatically mirrored onto the external hard drive.

### **5.1.1.3.1 Data Backup Requirements**

Regardless of the data storage system used, each NOAA hydrographic field unit must ensure that all survey data that have not been previously submitted to, and accepted by, either AHB or PHB are routinely backed up. Backups shall be performed such that a complete systems failure would result in no more than one day of data lost. For example, weekly full backups and daily incremental backups would ensure that the maximum loss of data would only be those files modified or created in the time between the previous incremental backup and the failure. The method used to backup data may vary and could include CDs, DVDs, or redundant drive system. Many backup systems, such as the NetApp, can be configured to perform scheduled backups automatically. It is the responsibility of the field unit to verify that their backup solution is operational throughout the field season.

Note: If using a NetApp system, OCS recommends it be configured to retain 6 daily snapshots and 2 weekly snapshots, providing access to files up to 20 days old (best case).

### **5.1.1.3.2 Data Transfer**

Data can be transferred from field units using a variety of media or portable hard drives. However, field units should ensure that data transfer media is compatible with the data recipient's equipment. Regardless of the method used for data transfer, there will always be a risk of damage, loss, or corruption of data during the transfer process. OCS recommends that field units retain a backup of any data transmitted until a successful transfer has been confirmed by the recipient.

When survey data have been submitted to NGDC, AHB or PHB, field units are required to retain a backup of this data until NGDC or the hydrographic branch has acknowledged that the data have been successfully archived and the Survey Acceptance Review has been completed (the Survey Acceptance Review only pertains to processed data). Even after data has been successfully transferred, OCS recommends the field unit retain copies of final survey products created (e.g., PSS, DR, MapInfo tables, public outreach materials, etc) on removable storage media if additional operations will be conducted in that general project area.

## **5.1.2 Data Filing and Organization**

Due to the quantity of data generated during an OCS hydrographic survey, standardized data filing and organization practices should be used. These methods may vary among field units during data acquisition and processing, but it is imperative that a standardized system be used across all field units for data submission to AHB and PHB. Clearly named files, standardized directory structures, and common practices will all contribute to efficient data management and survey processing.

### **5.1.2.1 Field Unit Data Directory Structure**

It is very important for a field unit to establish a working data directory structure that is consistent across the data acquisition and processing computers and storage devices throughout the unit. When designing a working directory structure, any specific software requirements must be considered. For example, CARIS HIPS/SIPS data must be configured with a specific directory structure so that referenced information can be accessed by the software. An expanded view of a sample CARIS directory structure is shown in Figure 5.2.



Figure 5.2: Field unit directory structure.

OCS recommends that field units store raw and post-processed data in separate directories. Typically, raw data will be organized by survey registry number with subfolders further sorting the data by acquisition system type, then by vessel (HVF name), by day, and finally by line. This type of file structure is referred to as PVDL (Project/Vessel/Day/Line).

Note: The “vessel” subfolder name must be identical to the CARIS HIPS Vessel File (HVF) name for the data it contains.

Post-processed data are typically organized by survey registry number and then subdivided according to the directory structure required by CARIS HIPS/SIPS software.

Raw data files are often quite large. As a result, storage of raw data may become unmanageable if many surveys are in progress at once. Therefore the field unit shall transmit a project’s survey sheet to NGDC prior to submission of the remaining survey records to AHB or PHB. The field unit shall follow standard data submission procedures as documented in section 8.4 of the HSSD and the standard data directory structure as shown below in figure 5.3. The Raw Public folder shall contain all pre-processed sonar (bathymetry and backscatter if applicable) and sound speed profile data acquired for the survey. Raw sonar data should be organized by acquisition system, vessel (HVF name), and day number. For example, if mainscheme MBES data was acquired by NOAA Ship Thomas

Jefferson on 27 June 2006 for survey H12345, the file structure might be: H12345\_MBES > TJ\_S222\_Reson7125 > 2006\_178. If rejected and/or non-converted sonar files are submitted they should be contained in a separate folder designated for that purpose. Raw sound speed profile data should be separated into subfolders by vessel hull number and day. The configuration file (\*.con) for each sound speed profiling instrument used for survey operations must be included in the Preprocess folder.

Once the field unit receives notification from NGDC that all data have been successfully archived, the field unit may remove the corresponding raw data from their system.

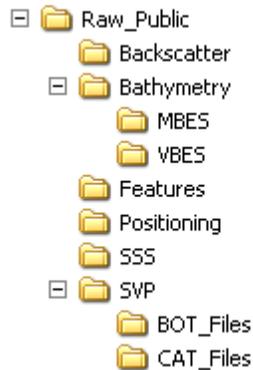


Figure 5.3: Field Unit Raw Data Directory Structure.

### 5.1.2.2 Survey Data Submission Directory Structure

Since surveys are submitted to the hydrographic branches from several NOAA field units and each survey includes data from numerous sources, standardized data submission practices shall be used to support efficient office processing and verification. The standard file structure to be used by NOAA field units when submitting OCS hydrographic survey data to either AHB or PHB is outlined below, with a brief description of each section. A pictorial representation of this file structure is shown in Figure 5.4. Specific survey deliverables are discussed in section 5.2 See Appendix 5 for a (Digital Data Submission Checklist).

Note: If files to be included in a specific subfolder have either not been generated at the time of data submission or are not required for a specific survey, the subfolder shall not be eliminated from the directory structure even though it is empty. By maintaining the complete submission directory structure, a data recipient can quickly verify that no items have been overlooked or inadvertently moved/deleted.

#### 5.1.2.2.1 Field Unit\_YYYY (e.g., RAINIER\_2006)

This folder shall be named to identify the field unit and year of data submission. It should contain any pertinent information that applies to all hydrographic survey data acquired by that unit over the course of the year specified. At a minimum, the following subfolder shall be included:

HSRR - Include a digital copy of the field unit's Hydrographic Systems Readiness Memo and corresponding Hydrographic Systems Readiness Acknowledgment as defined in Chapter 1 of this manual.

### 5.1.2.2.2 HXXXXX

This folder shall be named to identify the registry number of the survey being submitted. It should contain only survey-specific data and reports that have been approved for submission by the Chief-of-Party. At a minimum, the following subfolders shall be included

- **Checksum File** - The MD-5 Checksum files (.md5) shall be included directly under the HXXXXX folder (not in a subfolder) in order for the file verifying software, FileVerifier ++, to work properly during verification at NGDC, AHB or PHB.
- **Data** - NOAA field units shall deliver the following in the Data folder:
  - **Processed**

**Fieldsheets** - This folder shall include the following CARIS fieldsheet(s). All preliminary fieldsheets should be removed from this folder prior to data submission.

**H12345** - This fieldsheet should contain all finalized BASE surfaces and mosaics for the survey. If, for data management, multiple fieldsheets are necessary to represent final survey data, fieldsheets shall be named such that the contents are easily inferred (e.g. H12345\_SSS). Each BASE surface shall be named such that the survey registry number and BASE surface resolution are identified (e.g., H12345\_50cm\_A, H12345\_1m\_B, or H12345\_2m\_B). There shall be absolutely no periods or special characters used in the surface names.

Each side scan mosaic shall be named such that the survey registry number, mosaic resolution, and SSS percentage are clearly identified. For example, a first 100% SSS mosaic at three meter resolution would be named H12345\_3m\_100. A corresponding 200% SSS mosaic would be named H12345\_3m\_200. There shall be absolutely no periods or special characters used in the mosaic names.

**HDCS\_DATA** -This folder shall contain all post-processed data generated in CARIS for the survey being submitted. Data shall be further organized using subfolders to create a Project Vessel/ Day / Line PVDL structure, as required for use with CARIS software. All extraneous data shall be removed from this folder prior to data submission.

**VesselConfig** - This folder shall include copies of each HIPS Vessel File (\*.HVF) used to process data for the survey and any applicable DeviceModels.xml files. Any modifications made to these files during survey operations should be documented in the corresponding Descriptive Report and/or DAPR.

**S-57\_Features** - Include in this folder the Final Feature File and the side scan sonar (SSS) contacts file in .000 format.

**PSS** – This folder shall include Pydro .pss files. Do not include images in this folder.

**Multimedia** - This folder shall contain 3-D bathymetric images or digital photographs that are associated with a feature in the Final Feature File (FFF). In addition, this folder shall contain a copy of the side scan sonar (SSS) contact images for both significant and insignificant contacts. A copy of the SSS contact images shall remain in the CARIS HDCS line file.

**GNSS Data** – This folder shall include the Post-Processed Kinematic (PPK) GPS data, SBET QC Log, and SBET folder.

**SVP** - This folder shall include only the processed CARIS \*.svp files applied to the survey data being submitted. Files should be separated into subfolders by vessel hull number and day.

**Tide** - This folder shall include only the project tide files (tide zone file (.zdf), TCARI (.tc), GPS tide files (SEP Models), etc..) and tide/water level (\*.tid) files applied to the survey data at the time of submission. Files should be named so that the type of tide/water level data (i.e., predicted, preliminary, verified or fiis identified

- **Separates** - This folder shall contain a subfolder for each Separate report identified below.

### **Acquisition\_& Processing Logs**

**Acquisition Logs** - This folder shall contain all acquisition log files associated with the survey being submitted (Note: Acquisition and Processing Log files may be combined into one file and delivered in one combined folder).

**Processing Logs** - This folder shall contain all Processing log files associated with the survey being submitted (Note: Acquisition and Processing Log files may be combined into one file and delivered in one combined folder).

## **II. Digital Data**

**Checkpoint\_Summary\_& Crossline Comparisons** - This folder shall contain documentation to support a mainscheme to crossline comparison performed in accordance with section 5.2.4.3 of the HSSD.

**Sound\_Speed\_Data Summary**- Include all digital DQA records associated with the survey being submitted. Velocipy software automatically generates a digital DQA record for each project (e.g., OPR-###- AA-YY.DQA) and appends to this file nnn when DQA tests are performed. Refer to section [sub:Documentation-and-Reporting-LeadLine].

**Descriptive Report** - This folder shall contain the Descriptive Report for the survey in a .pdf format which includes the digitally signed DR approval sheet, DR body, and DR Appendices.

**Public Relations and Constituent Products** - This folder shall contain survey related products generated by the field unit for dissemination to other NOAA offices or outside organizations. Include any final Map- Info tables and workspaces for plots, “one-pagers” (in \*.pdf format) created for public relations, and any other preliminary products released to constituents, navigation managers, or the public in the native format provided.

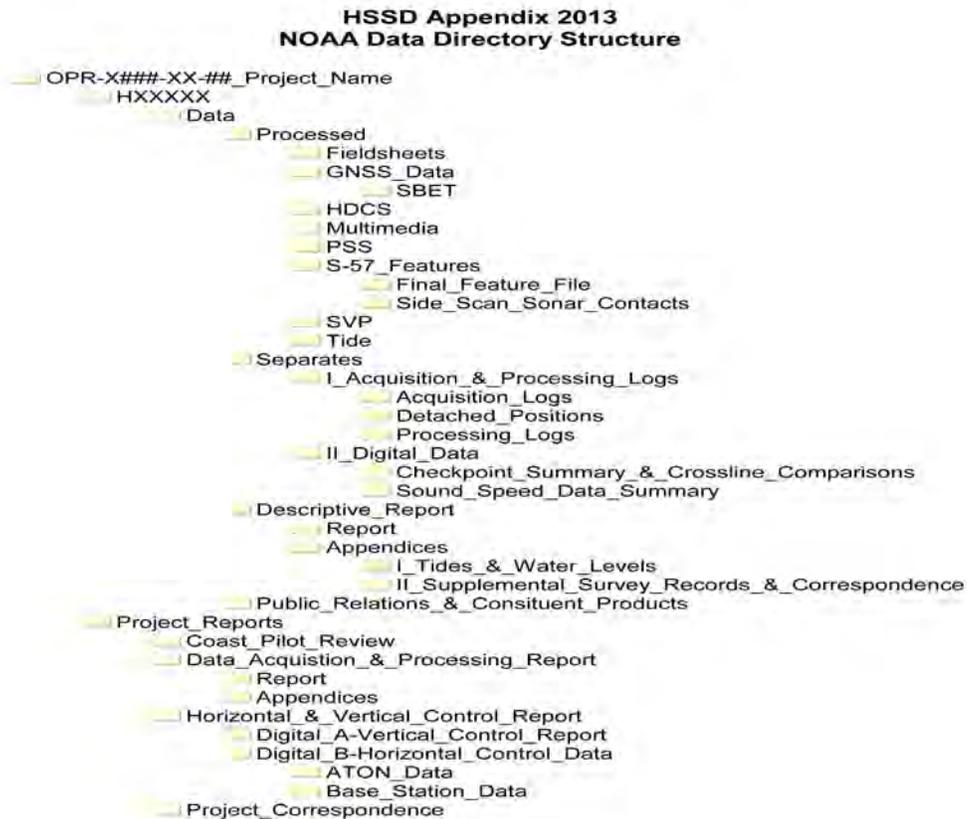
### **5.1.2.3 Project Reports**

This folder shall be named to identify the project number under which the submitted survey is assigned. It should contain subfolders for documents and reports that apply to all surveys completed for a given project over the course of the year specified. At a minimum, the following subfolders shall be included:

**Data Acquisition and Processing Report (DAPR)** - Include the Data Acquisition and Processing Report for the project (in \*.pdf format) and any supporting information as defined by the HSSD. The DAPR file should be named according to the project number (e.g., OPR-A###-AA-YY\_DAPR.pdf.)

**Horizontal and Vertical Control Report (HVCR)** - Include the Horizontal and Vertical Control report for the project (OPR-A###-AA-YY\_HVCR.pdf) and any supporting information as defined by the HSSD and section 5.2.2.2.3 of this manual. No report is necessary if no HorCon and/or VerCon were conducted; however, a text document stating that no HorCon and/or VerCon operations were conducted shall be placed in this folder in lieu of an HVCR.

**Project Correspondence** - Include all project correspondence such as documented telephone conversations and email correspondence that pertain to the survey being submitted.



**Figure 2: Data Directory Structure for NOAA Data**

Figure 5.4: Submission Directory Structure

#### **5.1.2.4 Naming Conventions**

It is critical that file naming conventions be standardized to quickly communicate what information a file contains. (See section 8.1 of the HSSD for specific file names). As a standard practice, use the survey registry number (H12345) rather than survey priority designations when naming survey files. Any files submitted that will be unfamiliar to the receiving hydrographic branch and/or do not follow standard naming conventions shall be accompanied by a separate digital text document fully describing the file(s). This text file shall be named “read me”, with an appropriate extension, and should be located at the top level of the directory structure containing the unfamiliar or non-standard files.

### **5.2 Survey Deliverables**

Survey deliverables refer to all data, reports, and products associated with an OCS hydrographic survey that will be approved and submitted by a NOAA field unit. When submitting a survey to AHB or PHB, the data deliverables shall include all data and information necessary for office verification, including the ability to manipulate data if necessary, thorough documentation of the field unit’s survey procedures, and results and recommendations for the survey. Some survey deliverables, such as DTON Reports, the Request for Tides, Coast Pilot Review, and NODC files, have additional and/or unique submission requirements. All required OCS hydrographic survey deliverables and any specific submission requirements are briefly described in the following sections.

#### **5.2.1 Digital Data**

If possible, all data shall be submitted to AHB or PHB in digital format. This requirement includes documents that can be easily scanned into \*.pdf files, such as memos, system calibration reports, and DP reports. Digital data shall be submitted using the directory structure described in section 5.1.2.2 and illustrated in Figure 5.4, see section 8.1 and L Appendix 12 of HSSD for further details. Only data that pertains to the survey being submitted should be included in the digital data deliverables. All preliminary, temporary, or working data files shall be removed prior to submission.

Prior to submitting digital data, the field unit shall verify that all files are present and none have become corrupt during transfer to a portable media.

The field unit shall generate a UNIX formatted MD-5 hash of the content of the entire directory structure and include it in the digital data submission. This shall be done using FileVerifier++ following the FileVerifier++ SOP in Appendix 5.

Additionally, a digital directory listing of data on the transfer media should be created and compared to the original file structure. The field unit shall include this directory listing, as a text file named to reference the transmittal letter number, in the data submission package. This directory listing can be generated and automatically sent to a text file by typing “dir /s submission directory name > transmittal reference number.txt” (e.g., dir /s H12345 > RU-2-06.txt) at the Windows Command Prompt.

To ensure that a complete data recovery is possible in case of lost mailings or media problems, the procedures below shall be followed by each field unit when submitting final digital survey data to AHB or PHB:

- Verify that backups of all data being submitted have been made and are securely stored. Backups must be in a format that can be readily restored at the receiving Hydrographic Branch.

- Review the content of all backups and deliverable digital media to ensure they are complete, accurate, and structured in accordance with OCS specifications.
- Retain the backup for a survey until notified by AHB or PHB that the data have been successfully archived and the Survey Acceptance Review has been completed (Survey Acceptance Review is only required for processed data).

### 5.2.1.1 POSPac Deliverables

NOAA field units using POSPac MMS processing may satisfy the ERS based deliverables defined in section 8.4.5 of the HSSD with the following items:

#### Raw Files

- Raw POSPac Files with naming convention YYYY\_DDD\_VSSL.000 (ex. 2010\_123\_S220.000)
- Files shall be Unlimited in size but not more than 24 hours long.
- Base Station Files in native format, if native format is other than RINEX
- Base Station Files in RINEX version 2.11+
  - Including navigation (.yyN) as well as observation files (.yyO).
  - RINEX files must include all types of dual-frequency observations, including manufacturers SNRs: C1, L1, L2, P2, P1, S1, and S2
  - RINEX header shall include at a minimum: station / marker name, receiver type / S/N, antenna type / S/N and antenna height
  - May use Compact RINEX (Hatanaka)
- Final Ephemerides
- user\_basestation\_db.xml file containing Project wide base station positions overridden in POSPac Coordinate Manager (C:\Program Files\Applanix\User Base Stations\user\_basestation\_db.xml)
- APPA\_RSDB5.out file, if it has been modified from the Applanix default: C:\Program Files \Applanix\ POSPac MMS 5.3\APPA\_RSDB5.out

## Processed Files

- 50 Hz SBET (0.02 seconds) and SMRMSG output files with naming convention YYYY\_DDD\_VSSL.sbet and YYYY\_DDD\_VSSL.smrmsg
- All .log files from the Extract and Proc POSPac Project folders
- Plots2
  - Smoothed Performance Metrics, Reference Frame (One graph per bullet)
    - North, East and Down Position Error RMS (m)
    - \* • North, East and Down Velocity Error RMS (m/sec)
    - Roll, Pitch and Heading Error RMS (arc-min)
  - Calibrated Installation Parameters (One graph per bullet)
    - X Reference-Primary GPS Lever Arm (m)
    - Y Reference-Primary GPS Lever Arm (m)
    - Z Reference-Primary GPS Lever Arm (m)
    - Reference – Primary GPS Lever Arm Figure of Merit
  - Solution Status (One graph per bullet)
    - Number of SVs
    - PDOP
    - Baseline Length (m)
    - Processing mode
  - Separation model file
    - Current acceptable model file formats: ASCII XYZ,NGS BIN.

Note: Substitutes for POSPac plots may be acceptable if they provide all the information needed in a format acceptable to HSD and are agreed upon ahead of time by the field unit, receiving branch, and OPS.

### 5.2.2 Reports and Field Products

Various reports and field products will be generated in conjunction with an OCS hydrographic survey. Survey reports can be divided into three tiered categories. Field Unit Reports refer to those providing information that encompasses the entire field unit and its operations. Project Reports are those containing information that applies to all surveys completed (or to be completed) within a project for a specific year. Project Reports may reference information contained in Field Unit Reports, provided the referenced document is clearly identified and readily available for review. Survey Reports contain information specific to only one survey and may reference information contained in both Field Unit Reports and Project Reports, provided the referenced documents are clearly identified and readily available for review.

This section of the FPM provides an overview of reports and products to be submitted in conjunction with every OCS hydrographic survey completed by a NOAA field unit. Each of these reports shall be delivered to the hydrographic branch that supports that field unit unless a different recipient is explicitly identified either in this manual or the Project Instructions.

## 5.2.2.1 Field Unit Reports

### 5.2.2.1.1 Hydrographic Systems Readiness Review (HSRR) Memo

The only OCS-mandated Field Unit Report is the annual Hydrographic Systems Readiness Review (HSRR) Memo (see Appendix 1). The HSRR Memo is to be submitted on an annual basis within 10 working days of commencing survey operations at the start of the field season. Details on the submission of the HSRR Memo are in 1.1.1.1 .

## 5.2.2.2 Project Reports

### 5.2.2.2.1 Survey Progress and Vessel Utilization Reports

Monthly Survey Progress Estimates (formerly Progress Sketch), Project Statistics and Vessel Utilization worksheets shall be submitted as one workbook to [progress.sketches@noaa.gov](mailto:progress.sketches@noaa.gov), along with a courtesy copy to either the AHB or PHB Chief ([AHB.Chief@noaa.gov](mailto:AHB.Chief@noaa.gov) or [PHB.Chief@noaa.gov](mailto:PHB.Chief@noaa.gov), in accordance with the guidance below by the fifth day of the month following survey operations. To assist in the submission of this information, at the beginning of the field season, HSD Operations Branch will provide each ship with a Monthly Report Excel file with three separate worksheets as indicated below.

**Survey Progress Estimate** – This will be used to track estimated monthly survey progress by area within a given month. It will be a spreadsheet that consists of rows showing the vessel’s current project and all associated survey sheets. Column titles are self-explanatory. For each month that data is acquired on a survey sheet (as well as sheets that are still incomplete) the cumulative percentage completed through the end of that month should be entered in the spreadsheet. Any modifications to the initial survey sheet layout must be reported.

**Project Statistics** – This will be used to track monthly statistics other than square nautical miles. Since each row of the spreadsheet represents a specific project within a given month, the field is advised to maintain one sheet for the entire fiscal year and submit the updated version every month. The following provides clarification of the columns within the spreadsheet:

- The “LNM VBES” (vertical beam echo sounder), “LNM MB” (multibeam), and “LNM SSS” (side scan sonar) are for the purpose of reporting operations using only one sonar sensor.
- The “LNM Combo” is for reporting LNM if a combination of sensors is used., such as side scan and single beam or multibeam and side scan.
- The LNM above are to be subdivided between ship and launch platforms as appropriate.
- “Items Investigated” includes the number of AWOIS items or newly discovered items that require extra survey time.

- “Tide Gauges Installed/Removed” and “Bottom Samples” are the only other stats needed from NOAA survey vessels. Contractors are still required to report Days at Sea (on site working on the project) and days (or fraction of days) lost due to weather or equipment malfunction.

Vessel Utilization Report – The purpose of this form is to collect data that will highlight the areas that are having the greatest effect on productivity and may be in need of additional resources. A brief description of the various columns is below:

- Comment – short description of survey activities and lost productivity.
- Days at Sea (DAS) – as defined by the Office of Marine and Aviation Operations (Any day in which a vessel is at sea for at least 1 hour during a 24-hour period in support of an assigned project. DAS include days of arrival and departure, times anchored (except during port calls) or hove-to drifting on the working grounds, and occasions when a survey ship (even though moored) deploys 25 percent or more of its total complement including officers and crew in field survey activities.)
- Transit (hours) – ship travel time from port to the project area or within the project area (i.e from one anchorage to another – does not include launch transit time between ship and survey area). Transit hours are in support of surveys but should not be counted as planned/actual survey hours.
- Ship/launch planned and actual survey hours - number of hours planned at the beginning of each day for each platform if all equipment is operating properly and if the authorized number of skilled personnel are available; hours planned may be increased during the day due to reflect a change in plans (e.g. late launches) but should rarely, if ever, be decreased; the number of actual hours worked for each platform. Note: actual hours can never be greater than planned hours.
- Vessel Utilization - percentage (rounded to the nearest decimal) of planned hours that were actually worked; this number should not be affected by time lost due to routine mechanical/electrical maintenance or safety stand down days.
- Weather/Safety Stand down (hours) - hours of production lost due to weather or safety stand down (divided between ship and launches)
- Unscheduled Maintenance or Equipment Issues (hours) - hours of production lost due to unscheduled repairs to non-survey equipment.
- Downtime due to Survey Equipment Issues (hours) - hours of production lost due to problems related to survey equipment.
- Downtime due to Personnel Shortage (hours) - hours of production lost due to shortage of personnel or shortage of personnel with requisite skill level.

It is understood that the determination of planned survey hours is very subjective and dependent upon numerous factors including the requirement to process acquired data in a timely fashion and the availability of vessels and personnel.

#### **5.2.2.2.2 Data Acquisition & Processing Report (DAPR)**

A Data Acquisition and Processing Report shall be created to describe the data acquisition and processing procedures, quality control procedures, and any major deviations from OCS standard survey practices implemented throughout a project. The DAPR shall be completed in accordance with section 8.1.5.1 of the HSSD and submitted to the Chief of HSTP and the hydrographic branch that will be receiving data for the project. The DAPR should be submitted simultaneously with, or before, the first survey of the project completed that year. Note: For projects that span multiple years, a new DAPR shall be generated each calendar year. Information contained in the HSRR memo may be referenced in the DAPR to meet reporting requirements set forth in the HSSD.

#### **5.2.2.2.3 Horizontal & Vertical Control Report (HVCR)**

The Horizontal and Vertical Control Report shall be completed in accordance with section 8.1.5.2 of the HSSD and submitted to the appropriate hydrographic branch before or not later than the submission of the last survey of a project. For projects that span multiple years, a new HVCR shall be generated each calendar year. No report is necessary if no HorCon and/or VerCon were conducted; however, a text document stating that no HorCon and/or VerCon operations were conducted shall be placed in this folder in lieu of an HVCR.

#### **5.2.2.2.4 Tide & Water Level Data Package**

Field units that have installed and serviced water level stations in support of an OCS survey project shall provide the following Tide and Water Level Data Package to CO-OPS in accordance with section 4 of the HSSD.

1. Transmittal letter (PDF format).
2. Field Tide Note (PDF format), if applicable.
3. Calibration test documentation from an independent source other than the manufacturer for each sensor used to collect water level or ancillary data. (PDF format).
4. E-Site Report, Water Level Station Xpert Site Report, or Tide Station Report (NOAA Form 77-12), or equivalent.
5. (E-Site report application is in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format). Contractor created Site Reports are acceptable as long as the reports provide same required information.
6. U.S. Geological Survey quadrangle map (7.5 minutes map) indicating the exact location of the station, with map name and scale shown (JPEG and PDF format).
7. Sensor test worksheet (JPEG and PDF format) (applicable for acoustic gauges).
8. Sensor elevation drawing (JPEG and PDF format) showing sea floor, pier elevation and sensor elevation if sensor is mounted vertically. For stations with Aquatrak sensors, provide the Aquatrak Sounding Well Diagram.

9. Water level transfer form (applicable for Great Lakes stations only, in JPEG and PDF format).
10. Large-scale bench mark location diagram of the station site showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The bench mark sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (derived from the handheld GPS) of the gauge, NOAA chart number or Quad map name (JPEG and PDF format).
11. New or updated description of how to reach the station from a major geographical landmark (in Microsoft Word and PDF format). (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).
12. Bench mark descriptions with handheld GPS coordinates (in Microsoft Word and JPEG format) (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003).
13. Digital photographs of bench mark disk faces, setting, bench mark locations from two different (perpendicular cardinal directions, station, DCP, equipment, underwater components, and vicinity (JPEG and PDF format). As a minimum, photographs shall show a view of the water level measurement system as installed, including sensors and DCP; a front view of the staff (if any); multiple views of the surroundings and other views necessary to document the location; and photographs of each bench mark, including a location view and a close-up view showing the bench mark disk (face) stamping. Bench mark photo file names start with mark designation followed by either "face" or "location" and direction of view, with jpg extension (e.g. 8661070 B location south. jpg). All other station component photo file names start with station number and view name (e.g. 8661070 tide station view south).
14. Level records (raw levels) including level equipment information (electronic files) and field notes of precise leveling, if applicable.
15. Level abstract (electronic file for optical and barcode levels).
16. Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor "zero" measurement point is referenced to the bench marks.
17. Calibration certificates for Invar leveling rods, if applicable (in PDF format).
18. Staff-to-gauge observations, if applicable (in Microsoft Excel and PDF format).
19. Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (in PDF format).
20. Other information as appropriate, or as specified in the contract (in PDF format).
21. Water level data download.
22. All required GPS deliverables (OPUS published data sheet and bench mark photos) as specified in CO-OPS "User's Guide for GPS Observations at Tide and Water Level Station Bench Marks"

Completed CO-OPS Evaluation Criteria for Water Level Station Documentation Check-Off List Standing Project Instructions for Coastal and Great Lakes Water Level Stations (included in Appendix 3).

### **5.2.2.2.5 Coast Pilot Review**

A Coast Pilot Review shall be completed for each project in accordance with section 7.4 of the HSSD and section 3.5.7 of this manual. The products shall be and submitted to NSD's Coast Pilot Branch via email to OCS.NDB@NOAA.GOV and Coast.Pilot@NOAA.GOV with a courtesy copy to the appropriate hydrographic branch and the HSD OPS project planner.”

Coast Pilot Reviews shall be submitted following the completion of operations within a project area, and no later than at the time of submission of the first Descriptive Report for that project. If a survey project spans multiple years, a Coast Pilot Review shall be submitted at the conclusion of operations within the affected area each field season so that edits can be reviewed and applied to the Coast Pilot prior to compilation of source data for the following field season.

### **5.2.2.3 Survey Reports**

#### **5.2.2.3.1 Descriptive Report (DR)**

For each survey, a Descriptive Report shall be completed in accordance with section 8.1.4 of the HSSD and Chapter 5 of this manual. Information contained in the DAPR may be referenced in the DR to meet reporting requirements set forth in the HSSD.

#### **5.2.2.3.1.1 Pydro Chartlets**

Pydro supports creation of automated “cookie cut” chartlets for features using OpenGL-based “HSTP Control” ChartWindow. From the ChartWindow context menu, select “Screen Capture” -> “Auto Chartlets”. A subsequent dialog allows you to specify a feature tree template filter to control which items/features have chartlets generated (empty template implies use all features). Chartlets are saved in a user-specified directory in PNG format. The visible data content within each chartlet is as per the plot configuration as seen in the Pydro ChartWindow. The Auto Chartlets command can be executed multiple times to generate more than one chartlet view for any feature(s). Pydro automatically generates unique chartlet names, so the same output directory can be used each time—no existing files will be overwritten. The Chartlets get a default caption in the Pydro PSS, listing the center position in decimal degrees and the width and height in meters of each chartlet image. PSS chartlet output is supported in all Pydro reporting options. The Pydro DTON report includes a Zip archive containing the .xml and .pdf files, as well as a DTONImages folder containing all of relevant chartlets (always included) and report images (user selectable).

#### **5.2.2.3.1.2 Pydro Line Classification**

Pydro supports classification of HIPS/SIPS survey lines in compliance with HSSD. Lines can be classified in Pydro according to “mode” and “type”. Line mode includes “Interferometric”, “Multibeam”, “Shoreline”, “SideScanSonar”, “SingleBeam”, and “UnclassifiedMode”; multiple modes can be selected per line (not to include “UnclassifiedMode”). Line type includes “Crossline”, “Development”, “Mainscheme”, “Other”, and “UnclassifiedType”; only one type can be selected per line. Pydro line classification is accessible in the Data -> Stats -> “PVDL / In Bathy Info” and “Survey Line Info” dialogs. Any HIPS/SIPS survey lines can be brought into Pydro via Data -> Insert -> “HIPS/SIPS Survey Lines”, without the added expense of inserting any associated feature or bathymetry data into the PSS. Survey line data read in this way does include the survey track and swath-bathymetry coverage limits (if any), and can therefore be used in Pydro to compute linear nautical miles

(LNM) and to index full-density PVDL depth data. The Pydro information dialogs include a versatile HIPS/SIPS PVDL-filtering engine that can be used to compute LNM for any particular line mode/type classification, for any subset of project(s), vessel(s), day(s), and line(s). Each filtering category includes a choice of the use of inclusive or exclusive logic.

#### **5.2.2.3.1.3 Pydro Surface-Points Comparisons**

Point and surface data comparison statistics can be compiled and reported in Pydro via Reports -> “Points/Surface Stats”: - Items for localized comparison points can be those as filtered using any feature tree template, not just “Checkpoints” - Reference surface data choices include HIPS BASE/weighted grid data, in addition to PVDL binned depth data - Reference surfaces can be filtered according to precision - Comparison point data choices include HIPS BASE/weighted grids, PVDL depths, and the localized comparison item depth data - Greater control over PDF report output: grouped summary or localized details of cumulative and/or by beam or depth bin - Option for graphs and/or tabular output; graphing options for by-beam or by-depth bin and a “IHOness” pie chart of surface-minus-depth pass/fail percentages - Reference surface image output options: (filtered) bathy and (filtered) precision, as well as item/feature report images and chartlets.

#### **5.2.2.3.2 Survey Outline**

Upon completion of data acquisition for a survey, submit a final survey outline to [survey.outlines@noaa.gov](mailto:survey.outlines@noaa.gov) in accordance with the Project Instructions and section 8.1.2 of the HSSD.

#### **5.2.2.3.3 Request for Tides**

Within 24-hours of completion of data acquisition for a survey, a request for final discrete zoning (often referred to as a “final tides request”) shall be submitted to CO-OPS. Pydro should be used to automatically generate a zipped digital “Request for Tides” package that contains all of the survey information needed by CO-OPS. The package includes a formal memorandum requesting approved water level data, an Abstract of Times of Hydrography, and digital \*.MID and \*.MIF files of survey track lines. Submit the Request for Tides package via email to [final.tides@noaa.gov](mailto:final.tides@noaa.gov), with the project number referenced in the email subject line. Once this request has been received, CO-OPS has agreed to provide field units with final water level correctors relative to the appropriate chart datum and final tidal zoning, as close to “near real-time” as possible. Final approved water levels shall be applied to all applicable survey data before data submission to HSD. If the lack of final approved water levels delays submission of a survey, please contact the appropriate HSD Operations Branch Chief or NSD Navigation Response Branch Chief. The type of tide/water level file (predicted, preliminary, or verified) applied to submitted data shall be noted in the Corrections to Echo Soundings section of the Descriptive Report. Include a copy of the digital Request for Tides package, as well as the \*CORP.tab, \*STNP.tab, and \*LABP.tab files applied to survey data, in Appendix I(Tides and Water Levels) of the Descriptive Report.

#### **5.2.2.3.4 ATON Report**

Information for each USB assigned ATON and any additional ATONs which should be reported based on the criteria defined in section 3.5.3.3 of this manual shall be submitted to MCD at the completion of a survey. Refer Appendix 5 of the FPM for an example of the (Fixed Aton Report.pdf), created by MCD to facilitate a standardized submission.

Field units shall submit an ATON Report of all ATONs investigated directly to MCD via email to [aton.reports@noaa.gov](mailto:aton.reports@noaa.gov). Courtesy copies shall be provided to the Chief of the appropriate hydrographic branch and either Chief of OPS or Chief of NRB. A copy of the ATON Report and processed data record shall also be included in Appendix II (Supplemental Survey Records and Correspondence) of the Descriptive Report.

#### **5.2.2.3.5 Data Directory Size Report**

After data acquisition is complete for each survey, send an e-mail indicating the survey/project number, survey platform, raw MBES and/or VBES directory size, and raw SSS directory size to NGDC at [hydro.info@noaa.gov](mailto:hydro.info@noaa.gov) with a copy to the chief of the appropriate processing branch.

#### **5.2.2.4 Public Relations and Constituent Products**

Any preliminary survey products, including public relation documents (chartlets, sounding plots, images, mosaics, DTMs, etc.) created by the field unit at the request of any parties outside of OCS (pilots, harbor masters, port authorities, other NOAA offices, etc.), that detail any surveyed information or significant discoveries made during a project are important documents that often support NOAA public relations and presence in an area. These documents can and will be used in various ways that are often unknown to the field unit that provided that product. Therefore, it is essential that each document contain a minimum amount of metadata to inform both the recipient of the document and NOAA offices of the origin and particulars of the data. A digital copy (preferably PDF) of any preliminary product delivered to a local constituent should be included with the survey deliverables.

The minimum elements suggested in each document are:

1. Title bar or block (include the name of the local area in title)
2. Date and registry number of the survey
3. Field unit acquiring the data
4. Type of equipment used to acquire the data (EM3002, Klein 5000, Klein 3000, Reson 7125, etc.)
5. If a sounding plot, a statement stating: Soundings in (feet, fathoms or meters) at (MLLW, ITRF 00, etc.) corrected using (predicted tides, preliminary observed tides, verified observed tides, Vdatum, ellipsoidally referenced)
6. A scale bar with units
7. Legend (i.e. red=0-10 feet/fathoms, yellow=10-20 feet/fathoms, etc.)
8. A north arrow (if applicable)
9. Graticules (labeled Lat/Long grid)
10. A disclaimer stating: “Data reflect the state of the sea floor in existence on the day and at the time the survey was conducted. The survey and the chart have not been updated for inclusion of the latest Local Notice to Mariners. Preliminary data subject to office review. Not for use in navigation.”
11. Optional: Contact information and/or NOAA website

Prior to releasing any preliminary survey data to parties outside of OCS, personnel shall first obtain approval from the Chief-of-Party and notify the Chief of HSD OPS or Chief of NRB. In addition to the local constituent, the product shall be digitally submitted to the regional Navigation Manager and the Chief of HSD OPS or Chief of NRB in a timely fashion.

All supplemental correspondence, including these preliminary data products, are to be included in Appendix II of the DR. In addition to a digital copy of the product, it is prudent for the field unit to provide a copy of any correspondence referring to the product, and any of the files and workspaces used to create the product (if applicable).

### **5.2.3 NODC Files**

Each time a sound speed profile is processed using Velocipy, an archive file will be automatically generated in the proper format for submission to the National Oceanographic Data Center (NODC). At the conclusion of a project, these archive files shall be submitted to HSTP. All NODC files associated with the project should be zipped into a single file and transmitted as an email attachment to [NODC.Submissions@noaa.gov](mailto:NODC.Submissions@noaa.gov) with a courtesy copy to the Chief of HSTP. The files will be checked by HSTP and forwarded to the NODC for inclusion in the World Ocean Database.

Be certain to submit the archive files created by Velocipy, and not the historical NODC files used by Velocipy as a quality control tool. The NODC files to be submitted can be identified by their naming convention. The file names will indicate the cast date and time and have an extension ending in “a” for CTD casts and “d” for sound speed versus depth profilers, as shown below.

- Filename examples - YYDDDHHMM.ssa or YYDDDHHMM.ssd, where:
- YY = 2-digit year
- DDD = day-of-year
- HH = hour of day (UTC)
- MM= minutes of the hour
- ss = ship code

Note: NODC files should not be included in the survey data submitted to either AHB or PHB.

### **5.2.4 Transmittal Procedures**

Final survey data submitted to either AHB or PHB should be complete and not require supplemental data from other surveys in the project. All survey data submitted shall be packaged to safeguard against loss or damage and be accompanied by a hard copy transmittal letter (NOAA Form 61-29, Letter Transmitting Data). Additionally, a digital copy of the transmittal letter(s) should be submitted via e-mail to the cognizant hydrographic branch at the time the data is transferred using either [LTDSUBMISSION.AHB@NOAA.GOV](mailto:LTDSUBMISSION.AHB@NOAA.GOV) or [LTDSUBMISSION.PHB@NOAA.GOV](mailto:LTDSUBMISSION.PHB@NOAA.GOV) as appropriate. If shipping more than one package, a separate transmittal should be used for each package. The transmittal letter shall indicate the contents of the package and list all digital media being submitted (e.g., tapes, portable hard drives, CD, DVD) with a detailed catalog of the data contained on each and the file name of the digital directory listing created in accordance with section 5.2.1 of this manual. If additional pages are needed for the transmittal letter, the project number and survey registry number shall be included on each page. Transmittal letters can be created in Pydro through the Reports > NOAA Forms menu, and should be signed digitally.

Raw data can be shipped to NGDC at the following address:

NOAA, National Geophysical Data Center  
NOAA/NESDIS/NGDC/MGG  
325 Broadway E/GC3  
Boulder, CO 80305-6429  
Attn: Manager, Hydro Database

All other data shall be shipped to the appropriate hydrographic branch at one of the following addresses:

NOAA, National Ocean Service  
Atlantic Hydrographic Branch, N/CS33  
439 West York Street  
Norfolk, Virginia 23510-1114

NOAA, National Ocean Service  
Pacific Hydrographic Branch, N/CS34  
BIN C15700, Bldg. 3  
7600 Sand Point Way N.E.  
Seattle, Washington 98115-0700

# Chapter 6

## Acronyms

ACSM	American Congress on Surveying and Mapping
AHB	Atlantic Hydrographic Branch
ARP	Antenna Reference Point
AWOIS	Automated Wreck and Obstruction Information System
BASE	Bathymetry Associated with Statistical Error
BS	Bottom Sample
CEF	Chart Evaluation File
CFF	Cartographic Feature File. Now referred to as a GC.
CSF	Composite Source File
CGTP	Cartographic and Geospatial Technology Programs
CM	Center of Motion
CO	Commanding Officer
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continually Operating Reference Station
CM	Center of Motion
CSDL	Coast Survey Development Laboratory
CTD	Conductivity Temperature Depth
DAPR	Data Acquisition and Processing Report
DGPS	Differential Global Positioning System
DIG	Digilink data file format
DPAS	Data Processing and Analysis System
DTM	Digital Terrain Model
DXF	Drawing eXchange File format, a text representation of the binary format
DWG	DraWinG format, a CAD format used to store 2-D and 3-D data and metadata
EED	Electronic Engineering Division
ENC	Electronic Navigational Chart
ERS	Ellipsoidally Referenced Survey
ERZT	Ellipsoidally Referenced Zoned Tides
FOD	Field Operations Division
FOO	Field Operations Officer
FPM	Field Procedures Manual
FTP	File Transfer Protocol
GAMS	GPS Azimuth Measurement Subsystem
GEODAS	Geophysical Data System
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
HDCS	Hydrographic Data Cleaning System
HDOP	Horizontal Dilution of Precision
HorCon	Horizontal Control
HPT	Hydro Planning Team
HSD	Hydrographic Surveys Division
HSRR	Hydrographic Systems Readiness Review
HSSD	NOS Hydrographic Surveys Specifications and Deliverables
HSTP	Hydrographic Systems and Technology Program

HTD	Hydrographic Technical Directive
HVF	Hydrographic Vessel File
IAPPK	Inertially Aided Post-Processed Kinematic
IHO	International Hydrographic Organization
IMU	Inertial Measurement Unit
INS	Inertial Navigation Systems
ITRF	International Terrestrial Exchange Format
KGPS	Kinematic Global Positioning System
MBES	Multibeam Echosounder
MCD	Marine Charting Division
MLLW	Mean Lower-Low Water
MOC-A	Marine Operations Center - Atlantic
MOC-P	Marine Operations Center - Pacific
NAD83	North American Datum of 1983
NALL	Navigable Area Limit Line
NESDIS	National Environmental Satellite, Data, and Information
NGA	National Geospatial Intelligence Agency, formerly NIMA & DMA
NGDC	National Geophysical Data Center
NGS	National Geodetic Survey
NMEA	National Marine Electronics Association
NIMA	National Imagery and Mapping Agency
NMAO	NOAA Marine and Aviation Operations
NODC	National Oceanographic Data Center
NOS	National Ocean Service
NRB	Navigation Response Branch
NRT	Navigation Response Team
NSD	Navigation Services Division
OCS	Office of Coast Survey
OPUS DB	Online Positioning User's Service Database
OS	Operating System
OWTT	One Way Travel Time
PDOP	Positional Dilution of Precision
PHB	Pacific Hydrographic Branch
PI	Project Instructions
POD	Plan of the Day
POS/MV	Position and Orientation System, Motor Vessel
PPK	Post Processed Kinematic
PPP P	precise Point Position
PRF	Project Reference File
PVDL	Project Vessel Day Line
RDT	Rotating Directional Transmission
RINEX	Receiver Independent Exchange Format
RMS	Root Mean Square
RTCM	Radio Technical Commission for Maritime Services
SBET	Smoothed Best Estimate of Trajectory
SDF	Sonar Data File
SHPO	State Historic Preservation Officer
SOP	Standard Operating Procedure
SSS	Side Scan Sonar
SWMB	Shallow Water Multibeam

TCARI	Tidal Constituent and Residual Interpolation
TPU	Total Propagated Uncertainty
TVG	Time-Variied Gain
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
UTM	Universal Transverse Mercator
VBES	Vertical Beam Echosounder
VerCon	Vertical Control
WAAS	Wide Area Augmentation System
XTF	Extended Triton Format

# Chapter 7

## Glossary

### 7.1 A

#### ABANDONED

An adjective referring to a man-made facility no longer being used for its original purpose. The term may be used with a symbol, e.g., beside an airport symbol, or with a place name, e.g., Elma (Abandoned).

#### ABSOLUTE ERROR

Absolute deviation (the value taken without regard to its sign) from the corresponding true value.

#### ACCRETION

The gradual building up of land over a long period of time, solely by the action of the forces of nature, on a beach by deposition of water or airborne material. Artificial accretion is a similar build-up of land by reason of an act of man. Also called aggradations.

#### ACCURACY

Closeness of a measured or estimated value to a standard or accepted value of a particular quantity.

#### ACROSS TRACK

The dimension of the seabed or data record in a direction lateral to the track of the survey vessel or towfish. This is the opposite of the along-track dimension. These two terms are used to describe sonar phenomena and dimensional corrections.

#### ADJUSTED POSITION

An adjusted geographic position of a point on the earth in which discrepancies arising from errors in the observational data are removed; a fixed position.

#### ADR GAUGE

Analog to Digital Recording tide gauge. A float or pressure actuated tide gauge that records the heights at regular time intervals in digital format.

#### ADRIFT

Afloat or unattached to shore or bottom.

#### AERIAL SURVEY

A survey using aerial photographs as part of the surveying operation; also, the taking of aerial photographs for surveying purposes.

#### AEROTRIANGULATION

Triangulation for the extension of horizontal and (or) vertical control accomplished by means of aerial photographs.

#### AFLOAT

Floating, as opposed to being aground.

## AGROUND

Touching, resting, or lodged on the seafloor in shallow water. The opposite is afloat.

## AID TO NAVIGATION

A device external to a craft, designed to assist in determination of position of the craft, a safe course, or to warn of dangers or obstructions. The expression "Aid to Navigation" should not be confused with "Navigational Aid", a broad expression covering any instrument, device, chart, method, etc., intended to assist in the navigation of a craft. See Navigational Aid.

## ALMANAC

The almanac is a set of parameters used by a Global Positioning System (GPS) receiver to predict the approximate location of a navigation satellite and the expected offset of the satellite's clock. Each GPS satellite contains and transmits the almanac data for the entire satellite network. See Ephemeris.

## ALONG TRACK

The dimension of the seabed or data record in a direction parallel to the track of the towfish (transverse). This is the opposite of the across track dimension. These two terms are used to describe sonar phenomena and dimensional corrections.

## ALTITUDE

The height of a towfish above the seabed, typically measured in feet or meters. Proper towfish altitude is important for acceptable seabed backscattering and to avoid seabed collisions. An excessively low altitude will reduce the range at which effective backscattering is produced. Excessively high altitudes can leave unsonified seabed as well as prevent accurate slant range correction.

## AMBIENT NOISE

Acoustic signals, sensed by the sonar system, emanating from a variety of sources in the underwater environment. Ambient noise visible in sonar data can result from propeller cavitation, engine noise, and biological sources. Other sources are environmental, such as wind, waves, and rain.

## ANCHORAGE

An area where a ship anchors or may anchor, either because of suitability or designation. A suitable place for anchoring is sheltered from wind and sea, does not interfere with harbor traffic, and has a sea bottom that gives good holding to anchors. The anchorage space allotted to a vessel should include a circle with a radius equal to the combined length of anchor chain and ship.

## ANCHORAGE CHART

A nautical chart showing prescribed or recommended anchorages. Such a chart may be a harbor chart overprinted with a series of circles, each indicating an individual anchorage.

## ANGLE OF INCIDENCE

The angle that a straight line acoustic pulse meeting a surface makes with a normal to the surface. The angle of incidence is important in sonar backscattering. For instance, if the sonar altitude is too low, at long ranges the angle of incidence with the seabed becomes high. Much of the incident energy is not returned to the transducer. Further, if the seabed angles up at the outer ranges, the angle of incidence becomes lower and more energy will be returned, making a notable anomaly in the data.

## APPARENT SHORELINE

The seaward limits of marine vegetation, such as mangrove, marsh grass, or trees in water that would reasonably appear to the mariner from a distance to be the fast shoreline. The seaward limits of kelp, low grass in water, and

other low-lying vegetation normally do not constitute an apparent shoreline. A line drawn on the chart in lieu of the mean high water line or the mean water level line in areas where either may be obscured by marsh, mangrove, cypress, or other type of marine vegetation. This line represents the intersection of the appropriate vertical datum with the outer limits of vegetation and appears to the navigator as shoreline.

#### APPROXIMATE CONTOUR

A contour substituted for a normal contour whenever there is a question as to its reliability (reliability is defined as being accurate within one-half the contour interval).

#### APPROXIMATE POSITION

A charting term meaning a position that is considered to be within 100 ft of its correct geographic location but less than third order or equivalent specification. Usually shown by the abbreviation "P.A." Alternative form: Position Approximate.

#### ARCHIVE MEDIA

Either magnetic media or compact discs. Magnetic media includes DAT DDS 4 mm tapes, DLT (digital linear tape), 8 mm Exabyte tape, and Ultrium LTO (linear optical tape). Compact discs include both CDs and DVDs.

#### ARTIFACT

Bias-related error. See Bias, Systematic Error.

#### AREA AND DEPTH SHEETS

A plotted representation of information acquired during a wire-drag survey. The results of the survey are depicted as polygons representing the areas of coverage by the wire drag apparatus. Only the deepest of these is shown. Each area is annotated with the corrected depth of the wire at the time of operations. The sheets may also include information identifying specific depths at locations of hangs or groundings.

#### AREA CHARTS

NOS charts which are versions of conventional nautical charts overprinted with additional small-craft information, and published in the pocket-fold format.

#### AREA FEATURE

An area feature is an item such as a fish haven, a disposal area, or a prohibited or quarantine area which consists of a region with defined boundaries.

#### ARGO

A medium-range electronic positioning system once used for horizontal control purposes during hydrographic surveys.

#### ATOLL

A coral island or islands, consisting of a belt of coral reef surrounding a central lagoon. A ring-shaped coral reef which has closely spaced islands or islets on it enclosing a deeper central area or lagoon. The diameter may vary from less than a mile to 80 miles or more.

#### ATTENUATION

The process of weakening or reducing the amplitude of a sonar signal. It is caused by numerous factors, including material dispersion, beam spreading, and absorption. The attenuation of a sonar signal makes its detection more difficult. Reflected signals from far ranges are sometimes attenuated to such a degree that system noise in the sonar receiver electronics can be a problem.

## AUTOMATED WRECK AND OBSTRUCTION INFORMATION SYSTEM (AWOIS)

A database containing information about wrecks and obstructions located in areas charted by NOAA. The primary purpose of this system is to support operational hydrography, although it is available online to the general public.

## AUV

Acronym for Autonomous Underwater Vehicle, an unmanned underwater vehicle that conducts operations from pre-programmed instructions without being tethered or otherwise attached to a support vessel. See ROV.

## AWASH

Situated so that the top is intermittently washed by waves or tidal action. The term applies both to fixed objects such as rocks, and to floating objects with their tops flush with or slightly above the surface of the water.

## AWOIS

See Automated Wreck and Obstruction Information System.

## AZIMUTH

A horizontal angle reckoned clockwise from the meridian. In the basic control surveys of the U. S., azimuths have been historically reckoned from south. In 1986, when the NGS began publishing geodetic data on the North American Datum of 1983 (NAD83), the measurement of azimuths was referenced from the north for basic control surveys.

## 7.2 B

### BACKSCATTER

The deflection of acoustic energy in a scattering process, commonly used to describe the return of energy from the seabed to the receiver of a sonar. See Scattering.

### BACKSHORE

That part of a beach which is usually dry, being reached only by the highest tides and, by extension, a narrow strip of relatively flat coast bordering the sea.

### BANK

1. An elevation of the sea floor located on a continental or an island shelf and over which the depth of water is relatively shallow but sufficient for safe surface navigation. Reefs or shoals, dangerous to surface navigation, may rise above the general depths of a bank. 2. A shallow area consisting of shifting forms of silt, sand, mud, and gravel; in this case it is only used with a qualifying word, such as "sandbank" or "gravelbank." 3. The edge of a cut or fill. The edge of a waterway or channel.

### BAR

A ridge or mound of sand, gravel, or other unconsolidated material below the high water level, especially at the mouth of a river or estuary, or lying a short distance from and usually parallel to the beach, and which may obstruct navigation.

### BAR CHECK

A method of field-calibrating sounding equipment used in a hydrographic survey by suspending a bar or disc beneath the echosounder transducer at various depths. Echoes from this surface are compared to the actual known depth of the bar.

## BARE

Extending above the datum of mean high water. In nautical charting, used to qualify rocks which extend more than one foot above mean high water on the Atlantic and Gulf Coasts, and extending more than two feet above mean high water on the Pacific coast.

## BARRIER REEF

A coral reef fronting, but at some distance from, the shore and separated from the shore by a lagoon.

## BAR SCALE

A line or series of lines on a chart or map subdivided and labeled with the distances represented on the chart or map. Also called Graphic Scale.

## BASE LINE

A surveyed line established with more than usual care to which surveys are referred for coordination and correlation. Base lines are established for specific purposes; the pertinent ones are defined below: 1. The side of one of a series of connected triangles, the length of which is measured to a prescribed standard of accuracy and from which the lengths of the sides of the other triangles were obtained by computation. Base lines in triangulation are classified according to the character of the work they were intended to control; the instruments and methods used in their measurement assure that the prescribed standards of accuracy were met. 2. The reference used to position limits of the territorial sea and the contiguous zone. The U. S. base line is determined from the mean lower low water line. The United Nations Conference on the Law of the Sea defined the low water line along a coast, as shown on large-scale charts of the coastal State (country), to be the base line for determining the limit of the territorial sea.

## BASE (BATHYMETRY ASSOCIATED WITH STATISTICAL ERROR) SURFACE

A CARIS software generated seafloor model, created by one or more different algorithms, that contains depth and uncertainty at each model node. It can also contain one or more auxiliary information layers, including standard deviation of soundings, sounding density, shoal depth, source identification, hypothesis count, hypothesis strength, and others, in addition to the basic bathymetric layer. Content of the auxiliary layers depends on the algorithm used to construct the BASE surface.

## BASIC SURVEY (Hydrographic)

A comprehensive and complete hydrographic survey adequate to supersede all prior hydrographic surveys covering the common area, and to verify or discredit/disprove the existence of all charted or reported features.

## BATHYMETRIC MAP

A topographic map of the ocean floor, or the bed of a lake. Generally, bathymetric maps show depths by contour lines and gradient tints. Sometimes referred to as a bathymetric chart.

## BATHYMETRY

The measurement of depths of water in oceans, seas and lakes. Also the information derived from such measurements.

## BAUD

A unit of speed for the transfer of data. The speed in baud is the number of discrete conditions or events per second.

## BAY

An indentation of the coast; an embayment; a subordinate adjunct to a larger body of water; a body of water between and inside of two headlands. According to the Geneva Convention, a well-marked indentation whose penetration is in such proportion to the width of its mouth as to contain landlocked waters and constitute more than a mere curvature of the coast. The area of such an indentation must be as large as, or larger than, the semicircle whose diameter is a line drawn across the mouth of the indentation. (The specifications are contained in Article 7

of the Convention on the Territorial Sea and the Contiguous Zone.)

#### BAYOU

A small sluggish stream or estuarine creek, with a slow or imperceptible current in coastal swamps or river deltas. Sometimes called Slough.

#### BEACH

1. The area between the extreme high-water and extreme low-water lines extending from such water lines inland to a marked change in physiographic form or material or to the line of permanent vegetation. 2. That area of the shore upon which the waves break and over which shore debris accumulates. A beach includes backshore and foreshore. 3. To intentionally run a craft ashore, as a landing ship.

BEACON 1. A fixed aid to navigation. 2. Anything serving as a signal or conspicuous indication, either for guidance or warning.

BEAM COMPASS A drafting instrument for drawing circles with a long radius. The point and the pen, or pencil tip, are separate units, mounted to slide and clamp on a long bar or "beam" so that the distance between them is equal to the desired radius.

#### BEAM FORMING

The process of shaping an acoustic beam through the control of the geometry of the transducer array. As the shape of the acoustic beam is crucial in imaging sonar systems, careful beam forming is important. The size, shape, and arrangement of groups of transducer elements help form the beam.

#### BEAM SPREADING

The divergence of a sonar beam as a direct function of angle and range. Beam spreading causes a loss of resolution in the far ranges; however, where the beam is wider the system ensonifies more of the environment per ping. Beam spreading also causes adjacent beams in the far ranges to overlap, which may be advantageous in some side scan sonar operations.

#### BEAM WIDTH

The angular measure of the transverse section of a beam (usually in the main lobe) lying within directions corresponding to specified values of field strength (usually -3 db) relative to the maximum.

#### BEARING

The horizontal direction of a line of sight between two objects on the surface of the earth.

#### BED

The ground upon which a body of water rests. The term is usually used with a modifier to indicate the type of water body, as river bed or sea bed.

#### BELL BUOY

A steel float surmounted by a short skeleton tower in which the bell is fixed. Most bell buoys are sounded by the motion of the buoy in the sea. In a few buoys, the bells are struck by compressed gas or electrically operated hammers.

#### BENCH MARK

A fixed physical object containing a marked point of known elevation with respect to a datum used as a reference level for tidal observations or as a control point for leveling. With the advent of GPS an increasing number of bench marks are also used for spatial reference with regard to horizontal control.

### BENCH MARK (Tidal)

A fixed physical object or mark used as reference for a horizontal or vertical datum. A tidal bench mark is one near a tide station to which the tide staff and tidal datums are referred. A primary bench mark is the principal mark of a group of tidal bench marks to which the tide staff and tidal datums are referred. The standard tidal bench mark of the National Ocean Service is a brass, bronze, or aluminum alloy disk 3-1/2 inches in diameter containing the inscription NATIONAL OCEAN SERVICE, together with other individual identifying information. A geodetic bench mark identifies a surveyed point in the National Spatial Reference System. Bench mark disks of either type may, on occasion, serve simultaneously to reference both tidal and geodetic datums.

### BERTH

A place in which a ship is, or can be, moored.

### BIAS

The distortion of a result through negligence of a factor usually introducing a systematic error of unchanging magnitude and sign throughout a given series of observations.

### BIFURCATION BUOY

A buoy which, when viewed from a vessel approaching from the open sea or in the same direction as the main stream of flood current, or in the direction established by appropriate authority, indicates the place at which a channel divides in two. See also Junction Buoy.

### BIGHT

A bend or curve; a bend in a coast forming an open bay; a small open bay formed by an indentation in the coast; a minor feature which affords little protection for vessels.

### BIN (BIN, BINNED, BINNING)

One process used to thin dense hydrographic data where the shoalest sounding is selected in an N-by-N m box, called a bin. Another method of data decimation is called “gridding” which considers points in proximity to a grid node – usually a radial distance.

### BLUE TINT CURVE

A nautical charting term describing the use of a blue tint in the water areas associated with a depth curve or contour. The blue tint curve is considered the danger curve for vessels expected to use that particular chart.

### BLUNDER

A mistake. A blunder is not an error, although a small blunder may remain undetected in a series of observations and have the effect of an error in determining the result. Examples of blunders are: reading a horizontal circle incorrectly by an even degree; neglecting to record the tape length in a measured traverse; and reversing numerals in recording an observation.

### BOAT HOUSE

A building at or near a shore for the storage of boats.

### BOAT SHEET

The work sheet used by a hydrographer in the field for plotting the details of a hydrographic survey as it progresses. It may include projection lines, control stations, shoreline, and proposed sounding lines, and corresponds to what was termed a “diagram,” “sounding sheet,” or a “working sheet” in early project instructions.

## BOOM

A floating barrier used to protect a river or harbor mouth or to create a harbored area for storage purposes. See also log boom.

## BORE

A very rapid rise of the tide in which the advancing water presents an abrupt front of considerable height. Bores generally occur in shallow estuaries where the range of tide is large.

## BOTTOM CHARACTERISTICS

Designations used on smooth sheets and nautical/navigational charts to indicate the size, consistency, color, and classification of bottom sediments. Thus, "soft gray sand, shells, pebbles" is designated "sft gy S Sh P." The expressions "bottom characteristics" and "bottom sample" are not to be used interchangeably.

## BOTTOM SAMPLE

Samples of the ocean bottom obtained by means of a mechanical device designed to collect relatively small-sized material. The actual bottom materials/sediments obtained in the "sampling" procedure.

## BOULDER

A more or less rounded rock, larger than a cobblestone and as much as 10 ft or more in diameter.

## BOUNDING MERIDIAN

A meridian which is coincident with a part of the neat line of a map or chart.

## BOWDITCH

See Publication No. 9.

## BREAKER

A wave that has become so steep that the crest of the wave topples forward, moving faster than the main body of the wave.

## BREAKWATER

A structure protecting a shore area, harbor, anchorage, or basin from waves. A floating breakwater is a contrivance consisting of floating materials connected by mooring chains or cables attached to anchors or stone blocks in such a manner as to form a basin within which vessels may be protected from the violence of waves. A breakwater may be attached to or separated from the shore. Part of the coast line from which maritime zones are measured.

## BRIDGE

A structure designed to carry traffic over a depression or other obstruction. The term refers to a lawful bridge over navigable waters of the United States, including approaches, fenders, and appurtenances thereto, which is used and operated for the purpose of carrying railroad traffic, or both railroad and highway traffic, or if a State, county or municipality, or other political subdivision is the owner or joint owner thereof, which is used and operated for the purpose of carrying highway traffic.

## BRIDGE CLEARANCE

Minimum vertical or horizontal space available for passage. Vertical clearances are referenced to the plane of high water adopted for charting.

## BROADCAST NOTICE TO MARINERS

A radio transmission by the U. S. Coast Guard to provide important marine information.

## BROOK

A stream of less length and volume than a creek, as used locally in the Northeast. Generally, one of the smallest branches or ultimate ramifications of a drainage system.

## BSB

Digital format of navigation charts (RNC). The BSB format was developed by Maptech under license by NOAA to produce digital images of paper charts. File extensions are \*.bsb and \*.kap.

## BULKHEAD

1. A structure built to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action. Bulkheads are frequently filled behind, thereby increasing the utility of the adjacent land.
2. A nautical term used aboard ship. It is analogous to a “wall” in a building.

## BUOY

A floating object, other than a lightship, moored or anchored to the bottom to serve as an aid to navigation. Buoys may be classified according to shape, color, or special purpose.

## BUOYAGE

A system of buoys. One in which the buoys are assigned shape, color, and number distinction in accordance with location relative to the nearest obstruction is called a cardinal system. One in which buoys are assigned shape, color, and number distinction as a means of indicating navigable waters is called a lateral system.

## 7.3 C

## CABLE

A unit of distance originally equal to the length of a ship’s anchor cable, but now generally considered to be about 600 feet. In the British Navy it is 608 feet, or exactly one-tenth of a nautical mile. In the U.S. Navy it is 720 feet but is infrequently used.

## CADASTRAL SURVEY

A cadastral survey is a land survey that defines boundaries, property lines, and other measurements pertaining to an official register of ownership, known as a cadastre. A cadastral survey helps determine the expanse and value of real property for resale and taxation.

## CAIRN

A mound of rough stones or concrete, usually conical or pyramidal, raised as a landmark or to designate a point of importance in surveying.

## CAISSON

A steel structure used for closing the entrance of locks and wet and dry docks. Also a type of steel cylindrical foundation used for some lighthouses.

## CANAL

An artificial waterway for navigation. A long narrow arm of the sea extending inland between islands or between islands and the mainland. A sluggish coastal stream, as used locally on the Atlantic coast of the U.S.

## CANOE CHARTS

Nautical charts of the Minnesota-Ontario Border Lakes. Most Canoe Charts do not show hydrography. They are intended to portray the general shape and size of these lakes and to provide information of interest to campers and boaters.

## CANYON

On the sea floor, a relatively narrow, deep depression with steep sides, the bottom of which generally has a continuous slope.

## CAPE

A relatively extensive land area jutting seaward from a continent or large island, which prominently marks a change in or interrupts notably the coastal trend.

## CARDINAL POINT

Any of the four principal directions: north, east, south, or west. Directions midway between cardinal points are called inter-cardinal points.

## CARDINAL SYSTEM

A buoyage system generally used to indicate dangers where the coast is flanked by numerous islands, rocks, and shoals, as well as to indicate dangers in the open sea. In this system the bearing (true) of the mark from the danger is indicated to the nearest cardinal point. The buoys are assigned shape, color, and number distinction in accordance with location relative to the nearest obstruction. The cardinal points delineate the sectors for buoy location.

## CARIS FIELD SHEET

See field sheet.

## CARRIER PHASE

The fraction of a cycle often expressed in degrees, where 360 degrees equals a complete cycle. Carrier phase can also mean the number of complete cycles plus a fractional cycle. A survey-grade GPS receiver can lock-on to a satellite and count the number of whole cycles of the carrier frequency, measuring the cumulative phase of the signal. This is often referred to as integrated Doppler.

## CARTESIAN COORDINATES

Named after René Descartes, a French philosopher and mathematician. A pair of numbers (x, y), defining the position of a point in a two-dimensional space by its perpendicular projection onto two axes which are at right angle to each other.

## CARTOGRAPHER

One who practices Cartography, particularly a member of a profession regularly concerned with any stage in the evaluation, compilation, design, or drafting of a map or chart.

## CARTOGRAPHIC CODE

A proprietary system of numeric identifiers used to index a variety of cartographic symbols used in the compilation of smooth sheets. The codes may also appear embedded in various digital records containing information on sounding and features observed during a hydrographic survey.

## CARTOGRAPHIC FEATURE

A term applied to the natural or cultural items shown on a map or chart. The three main categories are point feature, line feature, and area feature.

## CARTOGRAPHIC INTERPRETATION

The process of interpreting data for a particular purpose, such as nautical charting. Selected features are retained and highlighted in the data, and other features may be neglected or shifted, depending on the purpose of the product.

## CARTOGRAPHY

The art, science, and technology of making maps, together with their study as scientific documents and works of art. In this context maps may be regarded as including all types of maps, plans, charts, and sections, three-dimensional models, and globes representing the Earth or any celestial body at any scale.

## CASCADE

A fall of water over steeply sloping rocks, usually comparatively small or one of a series.

## CATENARY

The curve(s) assumed by a tow cable moving through the water, typically induced by the forces of water drag on the cable. The catenary is a significant factor in computing the horizontal distance to a towfish from the towing block. Towfish drag coefficients, cable weight, and drag and length-of-cable-out determine the shape of cable catenaries. The sweep wire as part of a wire-drag rig also assumes the catenary shape when being towed.

## CATARACT

A waterfall, usually larger than a cascade, over a precipice.

## CAUSEWAY

A raised way, as for a road across wet ground or water.

## CAY

A low, flat island of sand, coral, etc., awash or drying at low water; a term originally applied to the coral islets around the coast and islands of the Caribbean Sea. When spelled key, refers to a low, insular bank of sand, coral, etc., (e.g., one of the islets off the southern coast of Florida).

## C-COAST

(Coastal Cartographic Object Attribute Source Table) The NGS's attribution scheme which was developed to conform the attribution of various sources of shoreline data into one attribution catalog. C-COAST is not a recognized standard but was influenced by the IHO's S-57 Object-Attribute standard so that the data would be more accurately translated into S-57. C-COAST is used to attribute GC's which are provided to field units conducting hydrography.

## CENTERLINE CONTROLLING DEPTH

The controlling depth of a waterway which applies only to the center of the waterway; it is usually the result of a reconnaissance-type survey consisting of only a few lines of soundings which do not provide adequate coverage to determine the controlling depth of the entire waterway.

## CENTRAL MERIDIAN

1. The line of longitude at the center of a projection. Generally, the basis for constructing the projection. 2. The longitude of origin at the center of each 6-degree zone of the Universal Transverse Mercator (UTM) grid. The central meridian is arbitrarily numbered 500,000 and called a false easting. 3. In the State Plane Coordinate System, the meridian is used as the y-axis for computing projection tables for a state coordinate system. The central meridian of the system usually passes close to the center of the figure of the area or zone for which the tables are computed.

## CHAIN

1. A group of associated stations of a radio navigation system. A LORAN-C chain consists of a master station and 2 - 4 secondary stations. 2. The unit of length prescribed by law for the survey of the public lands of the United States. The chain is equivalent to 66 ft or 4 rods, poles, or perches. Ten square chains equal one acre.

## CHANNEL

1. A natural or artificial waterway of perceptible extent which either periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. 2. The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation. 3. The deepest portion of a stream, bay, or strait through which the main volume or current of water flows. 4. A band of radio frequencies with which a radio station must maintain its modulated carrier frequency to prevent interference with stations on adjacent channels. 5. One of two or more signals in a multi-signal sonar system; the area on the display or sonar record where data from this signal is shown. Modern instrumented sonar systems may utilize separate channels for many kinds of data such as: port and starboard side scan, sub bottom, towbody heading, depth, conductivity, temperature, and magnetometry.

## CHAPP

Chart History And Plotting Parameter file containing identifying information concerning each KAPP in the database.

## CHART (Nautical)

A special purpose map specifically designed to meet the requirements of, and to promote, safe navigation. Included on most nautical/navigational charts are: depths of water, characteristics of the bottom, elevations of selected topographic features, general configuration of the coast or shoreline, dangers, obstructions and aids to navigation, limited water level data, and information about magnetic variation in the charted area.

## CHART (Navigational)

Similar to a Nautical Chart but different in that it consists of a database of chart features and their attributes which is used in an ECDIS to construct and query a chart-like display. The ENC data is written in an exchange standard of the IHO designated S-57. See ECDIS and ENC .

## CHART AGENT

Business establishments that are under contract with NOAA and receive discounts for resale of nautical and aeronautical navigational charts and related publications to the general public at retail prices stipulated by the agency.

## CHART DATUM

The datum to which soundings on a chart are referred. It is usually taken to correspond to a low-water elevation. Since 1989, chart datum has been Mean Lower Low Water (MLLW) for all marine waters of the United States, its territories, the Commonwealth of Puerto Rico, and the Trust Territory of the Pacific Islands. Depths on charts of inland waters may be referenced to a local datum. CHARTED DEPTH The vertical distance from the chart datum to the seafloor, lake or river bottom.

## CHART EVALUATION FILE (CEF)

An ESRI Shapefile containing 2-D polygons intended for overlay on an included NOAA nautical chart (or set of charts) within a Geographic Information System. The CEF is created in association with a photogrammetric shoreline mapping or change analysis project, in order to document navigational hazards, landmarks, fixed aids, and coastline features portrayed on NOAA nautical chart products whose existence or geographic position can not be confirmed photogrammetrically, or whose size, shape, orientation or position appear to have changed significantly from the current chart portrayal.

### CHART EVALUATION SURVEY (CES)

A product of NOAA's Chart Evaluations Surveys (CES) program intended to: • Resolve all deficiencies reported or discovered. A deficiency is defined as charted information that can be made more complete through field examination, or information which should be charted but is not. • Evaluate the adequacy/accuracy of hydrographic information on existing charts. • Verify or revise information published in the appropriate Coast Pilot. Conduct user evaluation and public relations efforts to provide an awareness of agency products and obtain user input.

### CHART HISTORY

A record of the original compilation and subsequent corrections of every chart published by NOAA. The chart history preserves, in compact form, every detail and authority used on the chart, together with the date when a correction was applied. Also called History Sheet.

### CHART LETTER

A designation applied to source documents received by the agency for use in revising nautical/navigational charts. They may originate from within or outside the agency. The physical size of the document determines whether it is registered as a chart letter or a blueprint. Each document is registered within the source data system with a unique identifier number.

### CHART MAINTENANCE PRINT

An annotated copy of a shoreline map, a revision print, a revised topographic map, a photogrammetrically revised chart, or other graphic generated photogrammetrically, showing the differences between that document and the latest edition of the largest-scale nautical chart of the area.

### CHART PROJECTION

See Map Projection, Projection .

### CHARTLET

1. A small chart or portion of a chart scaled and used to display survey data. 2. A corrected reproduction of a small area of a nautical chart which is pasted to the chart for which it is issued. These chartlets are disseminated in Notices to Mariners when the corrections are too numerous, and such detail is not feasible in printed form.

### CHIEF-OF-PARTY

The Commanding Officer of a NOAA ship or the Officer-in-Charge or Team Leader of a NOAA field party.

### CHIMNEY

A relatively small, upright structure projecting above a building for the conveyance of smoke. Sometimes denoted on charts as a landmark.

### CHIRP

A type of sonar technology utilizing a separate projector and hydrophone, in which the projector transmits digitally produced, linear, swept FM pulses resulting in an increased system bandwidth. Because these systems are multi-frequency, greater bandwidth, rather than the pulse length, results in higher theoretical range resolution. Chirp technology has been successfully used in sub bottom profilers, and is being developed for long-range side scan applications.

### CLIFF

Land arising abruptly for a considerable distance above water or surrounding land, characterized by a high, extremely steep rock face, approaching a vertical incline.

## CLOSING LINE

The line dividing inland waters and the marginal sea across the entrance of a true bay. **COAST** The zone of land of indefinite width (may be several miles) that extends inland from the shore to the first major change in terrain features.

## COAST CHARTS

Nautical charts published at scales from 1:50,001 to 1:150,000 intended for nearshore navigation inside outlying reefs and shoals, in entering or leaving bays and harbors of considerable size, and in navigating the larger inland waterways.

## COAST LINE (two words)

The line of contact between land and sea. The low water datum for purposes of the Submerged Lands Act (Public Law 31). According to Public Law 31, the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters. Coast line has significance for both domestic and international law (in which it is termed the “baseline”), and is subject to precise definitions. Special problems arise when offshore rocks, islands, or other bodies exist, and the line may have to be drawn to seaward of such bodies. See also Coastline (one word).

## COAST PILOT

A descriptive book for the use of mariners, containing detailed information on the coastal waters, harbor facilities, etc., of an area. Such books are prepared by NOAA for waters of the United States and its possessions and are intended to supplement the nautical chart.

## COASTAL CONFLUENCE ZONE

A coastal area of the U.S. which has an outer boundary of 50 nautical miles from shore or the 100 fathom curve, whichever is farther, and an inner boundary of the shore line or the outer boundary of the harbor entrance, whichever is farther.

## COASTAL WATERS

1. The U.S. waters of the Great Lakes 2. The territorial seas of the U.S. 3. Those waters directly connected to the Great Lakes and territorial seas (i.e., bays, sounds, harbors, rivers, inlets, etc.) where any entrance exceeds 2 nautical miles between opposite shorelines to the first point where the largest distance between shorelines narrows to 2 miles as shown on the current edition of the appropriate agency chart used for navigation.

## COASTLINE

(one word) The line of contact between land and sea. In OCS, the term is considered synonymous with shoreline. The use of this term is discouraged. See also Coast Line (two words).

## COBBLE

Rounded rocks ranging in diameter from approximately 64 - 256 mm.

## COLREGS

Acronym for International Regulations for Preventing Collisions at Sea. Lines of demarcation delineating those waters upon which mariners must comply with the International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS) and those waters upon which mariners must comply with the Navigation Rules for Harbors, Rivers, and Inland Waters (Inland Rules). The waters outside the lines are COLREG waters. For specifics concerning COLREGS Demarcation Lines, see U.S. Code of Federal Regulations, Title 33, Navigation and Navigable Waters; Part 82, COLREGS Demarcation Lines. See Inland Rules of the Road.

## COMBINED UNCERTAINTY

In the context of the uncertainty of a finalized bathymetry grid, the greater of the standard deviation (scaled to 95%) and the grid uncertainty, which is derived from the total propagated error of the soundings that contributed to that node. COMPASS MAGNETIC ERROR The angle by which a compass direction differs from the true direction; the algebraic sum of the variation and deviation.

## COMPASS POINTS

The 32 divisions of a compass, at intervals of  $11 \frac{1}{4}^\circ$ . Each division is further divided into quarter points.

## COMPASS ROSE

A circle graduated in degrees, clockwise from  $0^\circ$  at the reference direction to  $360^\circ$ , and sometimes also in compass points. Compass roses are placed at convenient locations on the nautical chart or plotting sheet to facilitate measurement of direction.

## COMPILATION

The production of a new or revised map or chart, or portions thereof, from existing maps, aerial photographs, survey and other data, and other sources. The process requires the selection, evaluation, assembly, and graphic presentation of all relevant information.

## CONCUR/DO NOT CONCUR

Agree or do not agree. Cartographic review comments used to indicate the agreement or non-agreement with regard to the field's charting recommendation concerning specific features.

## CONCUR WITH CLARIFICATION

Cartographic agreement, requiring better description without confusion as to the data verification and charting recommendation. In general, this means the cartographic verifier agrees or concurs with the field hydrographer, providing additional comments are added. The note will usually indicate where the additional cartographic comments should be placed, along with additional descriptions that are needed for clarification.

## CONE OF SILENCE

In three dimensions, the Cone of Silence is the area that begins at the intersection of two overlapping swaths of multibeam coverage and continues upward to the water's surface. Any object or part of an object that falls within this 'cone' will not be ensonified. The size of this area will be affected by vessel roll.

## CONSTANT ERROR

A systematic error which is the same in both magnitude and sign through a given series of observations.

## CONTACT IMAGE

A snippet or small graphic image file generated during side scan processing in CARIS HIPS and SIPS. The image file is written as a \*.tif format and resides within the line directory of the side scan data directory (PVDL).

## CONTERMINOUS UNITED STATES

Comprises the 48 States of the United States and the District of Columbia; all of the states exclusive of Alaska and Hawaii. They have common boundaries and are not separated by foreign territory or the high seas.

## CONTIGUOUS ZONE

1. A zone seaward of the territorial sea in which coastal states may assert jurisdiction short of complete sovereignty. Article 24 of the Convention on the Territorial Sea and the Contiguous Zone authorizes such a zone "to prevent

infringement of its customs, fiscal, immigration or sanitary regulations in territory or territorial sea... ” Under the Convention, the contiguous area may extend no more than 12 miles from the coast line. 2. The belt of high seas, 9 nautical miles wide, that is adjacent to and seaward of the territorial seas of the United States and that was declared to exist in Department of State Public Notice 358 of June 1, 1972, FR 11906.

#### CONTINENTAL MARGIN

The zone, generally consisting of shelf, slope, and rise, separating the continent from the abyssal plain or deep sea bottom.

#### CONTINENTAL RISE

A gentle slope rising from the oceanic depths toward the foot of a continental slope.

#### CONTINENTAL SHELF

The submerged portion of a continent which slopes gently (average slope of less than 1:100) seaward from the low-water line to a point where a substantial break in grade occurs, at which point the bottom slopes seaward at a considerable increase in slope (typically exceeding 1:40) until the great ocean depths are reached. The point of break defines the “edge” of the shelf, and the steeper sloping bottom the continental slope. Conventionally, the edge is taken at 100 fm (or 200 m), but instances are known where the increase in slope occurs at more than 200 fm or less than 65 fm. Alternate juridical (legal) definition: Under the UN Conference on Law of the Sea, Article 76, the continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance.

Under certain circumstances a coastal State may submit a claim for an extension of its continental shelf beyond 200 nautical miles.

#### CONTINENTAL SLOPE

The relatively steep descent from the edge of the continental shelf to the deep-sea floor, usually a very irregular area.

#### CONTINUOUSLY OPERATING REFERENCE STATIONS (CORS)

A network of continuously operating stations operated by the National Geodetic Survey that provide Global Positioning System (GPS) carrier phase and code range measurements in support of 3-dimensional positioning activities throughout the United States and its territories.

#### CONTOUR

A line joining points of equal vertical distance above or below a datum. Such a line on a map is a type of isoline.

#### CONTROL

1. The coordinated and correlated dimensional data used in geodesy and cartography to determine the positions and elevations of points on the land, sea, lake, river, air, etc., or on a cartographic representation of the surface.
2. A collective term for a system of marks or objects on the earth or on a map or photograph, whose positions or elevations (or both) have been or will be determined.

#### CONTROLLING DEPTH

1. The least depth in the approach or channel to an area, such as a port or anchorage, governing the maximum draft of vessels that can enter. See Federal Project Depth.
2. The least depth within the limits of a channel; it restricts the

safe use of the channel to drafts of less than that depth. The centerline controlling depth of a channel applies only to the channel centerline; lesser depths may exist in the remainder of the channel. The mid-channel controlling depth of a channel is the controlling depth only for the middle half of the channel.

#### CONTROL STATION

A point on the ground whose horizontal or vertical location is used as a basis for obtaining locations of other points.

#### CONVENTIONAL CHARTS

Flat, printed reproductions published by NOAA of some portion of the navigational part of the Earth's surface. Depending on their scale, these charts show the nature and shape of the coast, depth of the water, general configuration and character of the bottom, prominent landmarks, port facilities, cultural details, dredged channels, aids to navigation, marine hazards, magnetic variations, and seaward boundaries. Changes brought about by people and nature require that nautical charts be constantly maintained to aid safe navigation. NOAA's area of responsibility includes the national and territorial coastal waters of the United States, including the Great Lakes, Puerto Rico, U.S. Virgin Islands, U.S. Trust Territories, and other islands in the Atlantic and Pacific Oceans.

#### CONVENTION ON THE TERRITORIAL SEA AND THE CONTIGUOUS ZONE

One of the four Conventions on the law of the sea adopted at Geneva in 1958 which, among other things, sets out principles for establishing the baseline from which maritime zones of jurisdiction will be measured. 15 U.S.T 1606. Those principles were later adopted by the United States Supreme Court for purposes of implementing the Submerged Lands Act, 43 U.S.C 1301 et seq. Sometimes referred to herein simply as "the Convention."

#### COORDINATED UNIVERSAL TIME (UTC)

A "time" referencing term which supersedes, but is generally equivalent to, Greenwich Mean Time (GMT). The new UTC time scale is almost perfectly constant, since it is based on stable atomic clocks. GMT is based upon a form of solar time-keeping and is approximately the same as UTC. See Greenwich Mean Time (GMT). UTC is a time scale that is based on the second (SI), as defined and recommended by the CCIR (International Radio Consultative Committee, of the International Telecommunications Union), and maintained by the Bureau International des Poids et Mesures (BIPM). For most practical purposes associated with the Radio Regulations, UTC is equivalent to mean solar time at the prime meridian (0° longitude), formerly expressed in GMT. The maintenance by BIPM includes cooperation among various national laboratories around the world. Adjustments to the atomic, i.e., the UTC, time scale consist of an occasional addition or deletion of 1 full second, which is called a leap second. Twice yearly, during the last minute of the day of June 30 and of December 31, Universal Time, adjustments may be made. Historically, adjustments, when necessary, have usually consisted of adding an extra second to the UTC time scale in order to allow the rotation of the Earth to "catch up." Therefore, the last minute of the UTC time scale, on the day when an adjustment is made, will have 59 or 61 seconds. UTC is also called World Time, Z Time, Zulu Time.

#### COORDINATES

Linear or angular quantities which designate the position of a point in relation to a given reference system.

#### CORAL

Hard calcareous skeletons of many tribes of marine polyps. In the strict sense, a bottom-dwelling marine organism which secretes an external skeleton of calcium carbonate and which frequently forms large, irregularly shaped colonies with numerous coral heads and pinnacles. Coral formations usually consist of a mixture of coral and other marine organisms, along with other debris and chemically precipitated rock. For shoreline mapping purposes, a coral formation is a naturally occurring, consolidated mass of hard calcareous matter which is too large to be adequately represented on the shoreline map by a single rock (coral) symbol. These formations include masses of irregular shape, as well as those relatively flat, ledge type features that may fringe a shore.

## CORAL HEAD

A massive mushroom- or pillar-shaped coral growth.

## CORAL REEF

A reef consisting of coral, fragments of coral, and other marine organisms consolidated together so as to form a massive structure.

## CORS

See Continuously Operating Reference Stations.

## COVE

A small, sheltered recess in a coast, often inside a larger embayment.

## COVERS/UNCOVERS

An expression used to indicate an area of a reef or other projection from the bottom of a body of water which periodically extends above and is submerged below the surface. See also Awash.

## CRIB

A permanent marine structure usually designed to support or elevate pipelines; especially a structure enclosing a screening device at the offshore end of a potable water intake pipe. The structure is commonly a heavy timber enclosure that has been sunken with rocks or other debris.

## CRIT

Informal name for the critical corrections database that is used in the Update Service Branch. The CRIT database was started in 1991 and includes all corrections from the LNM and NM and Canadian Notice. It is used by all cartographers and is a major research tool as well as application history.

## CRITICAL SURVEY AREA

Per the NOAA Hydrographic Survey Priorities document, critical survey areas are defined as waterways with high commercial traffic volumes (cargo, fishing vessels, cruise ships, ferries, etc., extensive petroleum or hazardous material transport, compelling requests from users, and/or transiting vessels with low under-keel clearance over the seafloor. Approximately 43,000 square nautical miles of critical survey areas were identified in 1994 by NOAA and given the highest priority for hydrographic survey. New areas are continuously being identified as critical based on changing usage and are designated as emerging critical areas.

## CROSSLINES

Sounding lines that cross the main system of survey lines at either right angles or at an oblique angle. Cross line data is acquired, processed, and evaluated as a system check. Crosslines are not an accuracy test or assessment, but a system check comparing data from different times and different line azimuths or directions.

## CULTURAL FEATURE

A feature delineated on a survey, map, or chart which represent objects either constructed by, or resulting from the actions of man, e.g., shipwrecks, roads, buildings, canals, piers, etc.

## CUPOLA

A small dome-shaped tower or turret rising from a building.

## CUPPING/FROWNING (SVP)

A sound speed profile artifact exhibited in MBES data either as a concave or smiling swath (cupping) and convex or frowning swath

## 7.4 D

### DANGER LINE

1. A line drawn on a chart to indicate the limits of safe navigation for a vessel of specific draft. 2. A line of small dots used to draw the navigator's attention to a danger which would not stand out clearly enough if it were represented on the chart solely by the specific symbols. The line of small dots is also used to delimit areas containing numerous dangers, through which it is unsafe to navigate.

**DANGEROUS WRECK** A wreck either visible or submerged at such a depth as to be considered a danger to navigation with respect to local vessel traffic. See derelict and wreck.

### DANGER TO NAVIGATION (DTON)

Any feature, e.g., a wreck, obstruction, depth, or condition deemed to constitute a potential risk to mariners. Advisory information is published by the U. S. Coast Guard in the Local Notice to Mariners and by National Geospatial-Intelligence Agency (NGA) in the Notice to Mariners.

### DAPR

See Data Acquisition and Processing Report. **DATA** General term used to denote facts, numbers, letters, and symbols. The basic elements of information; usually but not always expressed in numerical form.

### DATA ACQUISITION AND PROCESSING REPORT

A project-wide survey report that is separated into three sections: Equipment, Quality Control, and Corrections to Echo Soundings. Refer to NOS Specifications and Deliverables, June 2006 Edition.

### DATA FLIERS

Erroneous data points that could be the result of noise interference within the water column, operational parameters or settings such as TVG (time varied gain), pulse widths, pulse lengths, power and/or gain levels.

### DATAGRAM

A discrete package of data and headers which contain addresses (which is the basic unit of transmission across an IP network). Also called a 'packet'.

### DATUM

Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities. In geodesy a datum is defined by a set of parameters specifying the reference surface or the reference coordinate system. Therefore, two types of datums are required: a horizontal datum which forms the basis for computations of horizontal control surveys and a vertical datum to which elevations or depths are referred.

### DATUM CORRECTION

The correction (in latitude and longitude) that must be applied to the projection lines on a survey sheet or chart to transform it to a different datum.

### DATUM PLANE

A vertical control datum. Although a level surface is not a plane, the vertical control datum is frequently referred to as the datum plane.

### DAYBEACON

An unlighted structure which serves as a daytime aid to navigation by virtue of its distinctive appearance which makes it recognizable and identifiable.

## DAY OF YEAR

A sequential numbering system starting with 001 on January 1 of each year and ending with 365, or 366 in leap years, on December 31 of that year. DOY is often incorrectly referred to as Julian Day.

## DAYMARK

The identifying characteristics of an aid to navigation, unique and distinctive to facilitate its daytime recognition. Also, a conspicuous target added to a daybeacon or light.

## DEADHEAD

A submerged or barely awash log or tree trunk freely floating at varying attitudes, in contrast to the plane formed by the still undisturbed surface of the water. At times, one end of a deadhead may become temporarily attached to the bottom with the opposite (unattached) end floating in a pivotal or vertical manner due to the action of waves and/or currents.

## DEAD RECKONING

A method of navigation that has been historically used in hydrographic surveying to control the position of the survey ship beyond the range of control stations, and to supplement astronomic observations. The position is determined by applying the ship's run to the last well-determined position, using the course steered and the distance traveled by the log.

## DEADWEIGHT DEPRESSOR

A heavy, inert weight used to increase towfish depth when attached to the tow cable. When using long lengths of in-water cable, such as when towing lightweight towfish in depths greater than 100 m, drag forces on the cable often prevent the towbody from descending to the required depth. Slower tow speeds or greater downward pull at the towbody are required. Although deadweight depressors are more straightforward in application than hydrodynamic depressors, they should be streamlined and rigged as to be tangle-free during and after deployment. The use of deadweights also requires greater overside lifting capacity than with hydrodynamic depressors.

## DECIBEL

A logarithmic measurement unit that describes a sound's relative loudness, though it can also be used to describe the relative difference between two power levels. A decibel (dB) is one tenth of a Bel. In sound, decibels generally measure a scale from 0 (the threshold of hearing) to 120-140 dB (the threshold of pain). A 3dB difference equates to a doubling of power. A dB is a unit of measure of signal strength, usually the relation between a transmitted signal and a standard signal source. Every 3 dB = 50% of signal strength.

## DECONFLICT

The process of reconciling conflicting information based on the age of the information, reliability of the source, etc.

## DELTA

The low alluvial land, deposited in a more or less triangular form at the mouth of a river, which is often cut by several tributaries of the main stream.

## DEMARICATION LINE

A line through the high seas marking the allocation of territory between two countries, rather than a boundary line; for example, the line through the Bering Strait and Bering Sea between Russia and Alaska.

## DENSITY OF SOUNDINGS

Intervals between lines of soundings and soundings within the same line. Density of soundings depends heavily on the scale and nature of the survey and type of sounding equipment used.

## DENSITY OF WATER

Mass per unit volume. The reciprocal of specific volume. In oceanography, the density of sea water is numerically equivalent to specific gravity and is a function of salinity, temperature, and pressure.

## DEPRESSION CONTOUR

A closed contour delimiting an area of lower elevation than the surrounding terrain. Directional ticks extend from the contour in a downhill direction.

## DEPRESSOR

An attachment to a sonar tow cable or towed body that assists in increasing the depths of the towed body; commonly of two types, deadweight and hydrodynamic. The depressor allows the user to bring a sonar towbody within an optimum altitude above the seabed. Although lower tow speeds also assist in lowering a towfish, speeds below 1 - 1.5 knots may produce towbody instability such as kiting and yaw, resulting in data distortions.

## DEPTH

The vertical distance from a given water level to the seafloor, lake or river bottom.

## DEPTH CONTOUR NAVIGATION

A method of position determination by utilizing the depth curves on the nautical chart. Consists in fitting a series of observed echo soundings to the depth curves. The line of soundings is fitted to the depth contours by moving it so that it remains parallel to the true course steered.

## DEPTH CURVES

A line on a map, smooth sheet, or nautical chart drawn in accordance with prescribed conventions and generally connecting points of equal depth at or below a specified datum. The line is sometimes significantly displaced outside of soundings, symbols, and other chart detail for clarity as well as generalization. Depth curves therefore often represent an approximate location of the line of equal depth as related to the surveyed line delineated on the source.

## DEPTH UNITS

The units (fathoms, feet, meters) in which the soundings are plotted on the smooth sheet or on the nautical chart. On early surveys, two depth units were generally used on one survey, but with no uniform dividing line (see Registry Nos. H-1 (1837) and H-336 (1852)).

## DERELICT

A vessel or any property abandoned and afloat within navigable waters and thereby constituting a real or potential danger to navigation.

## DESCRIPTIVE REPORT (DR)

A written report that accompanies every topographic and hydrographic survey for the purpose of supplementing it with information that cannot be shown graphically thereon, and to direct attention to important results.

## DETACHED POSITION (DP)

A discrete geographic position observed and recorded at a specific location. The position is "detached" from the main scheme of hydrographic sounding lines. Rocks, wrecks, obstructions, aids to navigation, etc., are typically the sort of features subject to this type of positioning.

## DETECTABILITY

The size, shape and makeup of a seabed anomaly, as related to a sonar's ability to discern its existence. Detection occurs when excess energy is returned to the sonar transducer from a target or discontinuity. When a target

returns this excess energy from only one of many pings, the system will detect the target but the operator may not recognize it in the data. Some modern sonar data processors are assisting the user in narrowing the gap between detection and recognition with separate graphic displays of the amplitude of individual return signals. See Recognition.

#### DEVIATION

The angle between the magnetic meridian and the axis of a compass card, expressed in degrees east or west to indicate the direction in which the northern end of the compass card is offset from magnetic north. Deviation is caused by disturbing magnetic influences in the immediate vicinity of the compass, as within the craft.

#### DEVIATION OF COMPASS

The deflection of the needle of a magnetic compass due to masses of magnetic metal within a ship on which the compass is located. This deflection varies with different headings of the ship. The deviation is called easterly and marked plus (+) if the deflection is to the right of magnetic north, and is called westerly and marked minus (-) if it is to the left of magnetic north. A deviation table is a tabular arrangement showing the amount of deviation for different headings of the ship. Each compass requires a separate deviation table.

#### DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS)

Differential Global Positioning System (DGPS) is an enhancement Global Positioning System that uses a network of fixed ground based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions. These stations broadcast the difference between the measured satellite pseudoranges and actual (internally computed) pseudoranges, and receiver stations may correct their pseudoranges by the same amount. Differential corrections can be applied in either real time or post-processing.

#### DIFFERENTIATION

The process of using separate but identical navigational instruments where one is fixed at a known location and provides, via radio link, a second mobile instrument with offset calculations. This process is used to increase the accuracy of certain navigational instruments that may be affected by diurnal or atmospheric variations, such as LORAN, and those with inherent errors, such as GPS.

#### DIGITAL CARTOGRAPHIC FEATURE FILE (DCFF or CFF)

National Geodetic Survey's deliverable file that stores geometry and attribute information for spatial features in a vector data set. The previous file formats included Standard Digital Data Exchange Format and ArcInfo Interchange file (E00). The current format is the ESRI Shapefile using the Coastal Cartographic Object Attribute Source Table (C-COAST) attribution schema.

#### DIGITAL MAP (DM)

The National Geodetic Survey's Coastal Mapping Program's series identifier for shoreline data contained within the Digital Cartographic Feature File (DCFF) used from 1990 to 1999. The file identifiers consisted of two alpha and five numeric characters. The alpha characters were DM, which reflect Digital Map while the numbers ranged from DM10000 to DM10404.

#### DIGITAL TERRAIN MODEL

A surface, typically land or seafloor, represented in digital form by an elevation grid or lists of three-dimensional coordinates.

**DIKE** A bank of earth or stone used to form a barrier, frequently and confusingly interchanged with levee. A dike restrains water within an area that is normally flooded.

## DILUTION OF POSITION (DOP)

A measure of the geometry of the satellites seen by the receiver. DOP relates the statistical accuracy of the satellite measurements to the statistical accuracy of the computed solution. Position Dilution of Precision (PDOP) is a common measure, composed of Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP). Geometric Dilution of Precision (GDOP) is composed of Time Dilution of Precision (TDOP) and PDOP. The larger the DOP, the less accurate the measurement.

## DIPFILE

An automated Discrete Independent Point File once maintained within NOAA's nautical chart program which listed charting sources and geographic positions of cartographic features, such as navigational aids, landmarks, wrecks, and obstructions. Elements of the DIPFILE were/are being used in the initial encoding of Electronic Navigational Charts.

## DIRECTION

In surveying and mapping, the angle between a line or plane and an arbitrarily chosen reference line or plane.

## DIRECTION LIGHT

A light illuminating a sector of very narrow angle and intended to mark a direction to be followed. A direction light bounded by other sectors of different characteristics which define its margins with small angles of uncertainty is called a single station range light.

## DISCOLORED WATER

Unnatural colored areas in the sea due to the existence of shoals. Sea water having a color other than the blues and greens normally seen. Variations of the colors red, yellow, green, and brown, as well as black and white, have been reported. Discolorations may appear in patches, streaks, or large areas, and may be caused by concentrations of inorganic or organic particles or plankton.

## DISCONTINUITY

In NOAA hydrography, a change in the make-up of a body of water that causes a change in the speed and/or direction of sound propagation, of an incident sonar pulse. In contrast to an anomaly, which is usually distinct and separate within the environment, discontinuities are often widespread and difficult to discern as distinct. These include haline changes in the water, aerated or cavitated bodies of water, and thermoclines.

## DISPOSAL AREA

Area designated by the Corps of Engineers for depositing dredged material, where existing depths indicate that the intent is not to cause sufficient shoaling to create a danger to surface navigation. Disposal areas are shown on nautical charts. See also dumping grounds, dump site, spoil area.

## DIURNAL TIDE

A tide in which the tidal cycle consists of one high water and one low water each tidal day. In British terminology also called a single day tide.

## DOCK

The slip or waterway between two piers, or cut into the land for the berthing of ships. A pier is sometimes erroneously called a dock.

## DOLPHIN

A mooring post or buffer placed at the entrance of a dock, alongside a wharf, or in the middle of a stream. In the first and second instances it is used as a buffer. In the third, it is used as a mooring post by vessels which discharge their cargoes without going alongside a dock or wharf. Each dolphin is generally composed of a series of heavy

piles contiguous to one another. They are arranged in a circle, brought together, and capped over the top.

#### DOME

A large rounded hemispherical structure rising from a building or a roof of the same shape.

#### DOP

See Dilution of Position.

#### DOPPLER POSITION SYSTEM

A positioning system consisting of a radio receiver at the point whose coordinates are to be determined, one or more beacons in orbit about the Earth, and a computing system for determining the orbits of the beacons. The difference between the frequency of a radio wave as received and its frequency as transmitted from the beacon is a function of the radial velocity of the source with respect to the receiver. Given the ephemeris of the beacon, the coordinates of the receiver can be calculated from measurements of the difference in frequency.

#### DOUBTFUL SOUNDING

A depth shown on a chart over a shoal, a rock, etc., that may be less than that indicated, the position not being in doubt.

#### DOWNSAMPLING

The process of reducing the number of data points in a data set, generally by keeping shoaler soundings when they are near deeper soundings. DP See Detached Position. DR See Descriptive Report.

#### DRAFT

The vertical distance, at any section of a vessel from the surface of the water to the bottom of the keel. When measured at or near the stem, it is referred to as draft forward and when measured at or near the stern as draft aft. For a hydrographers, draft refers to the vertical distance from the surface of the water to the transducer face.

#### DRAG

The hydrodynamic forces exerted on the components of a body in contact with a moving fluid. In the case of a towed assembly, drag tends to reduce its forward motion.

#### DREDGED CHANNEL

An artificially maintained sea lane extending from an inland water body into the marginal sea to accommodate vessel traffic through coastal shallows.

#### DRY DOCK

An artificial basin fitted with gate or caisson into which a vessel may be floated and from which the water may be pumped out to expose the bottom of the vessel.

#### DRYING HEIGHTS

Heights above chart sounding datum of those features which are periodically covered and exposed by the rise and fall of the tide.

#### DTM

See Digital Terrain Model.

#### DTON

See Danger to Navigation.

## DUCK BLIND

For agency charting purposes, a duck blind is a non-floating structure, used for concealing waterfowl hunters, usually consisting of a wooden framework covered with brush. They pose a special problem for the cartographer. They are essentially unreported to any charting authority when built. They are unlighted and often constructed in navigable water without regard to the possible hazard they pose, especially to the small craft operator. Many are substantial structures built on piles. Even after they are eventually reduced to ruins the pilings may persist for years.

## DUMPING GROUNDS

Although shown on nautical charts as dumping grounds in U.S. waters, the federal regulations for these areas have been revoked and their use for dumping discontinued. These areas will continue to be shown on nautical charts until such time as they are no longer considered to be a danger to navigation.

## DUMP SITE

Area established by federal regulation in which dumping of dredged and fill material and other non-buoyant objects is allowed with the issuance of a permit. Dump sites are shown on nautical charts.

## 7.5 E

### EARTH CENTERED, EARTH FIXED (ECEF)

A Cartesian coordinate system beginning at the Earth's center of mass. The Z-axis is aligned with the Earth's mean spin axis. The X-axis is aligned with the zero meridian. The Y-axis is 90 degrees west of the X-axis, forming a right-handed coordinate system.

### EBB CURRENT

The movement of a tidal current away from shore or down a tidal river or estuary.

### ECDIS

See Electronic Chart Display and Information System.

### ECHOGRAM

The graphic representation of echosoundings recorded as a continuous profile of the bottom. Often erroneously called a fathogram when not recorded by a Fathometer.

### ECHO SOUNDER

An instrument for determining the depth of a body of water or of an object below the surface by measuring the travel time of an acoustical signal.

### ECHOSOUNDING

A method for determining the depth of water by measuring the time interval between the emission of an acoustic pulse at or near the water surface and its echo from the bottom.

### EDITION DATE

The date of first publication of a chart, or the date when a new edition is printed.

### EELGRASS

A submerged marine plant with very long narrow leaves.

### ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM (ECDIS)

The navigation information system which is considered the legal equivalent of the nautical chart, displaying selected information from an electronic navigational chart (ENC) integrated with data from positional and, optionally, other sensors.

### ELECTRONIC CHART SYSTEM (ECS)

A navigation information system that electronically displays vessel position and relevant nautical chart data and information from the ECS database on a display screen, but does not meet all the IMO requirements for ECDIS and is not intended to satisfy the SOLAS chapter V requirement to carry a navigational chart.

### ELECTRONIC NAVIGATIONAL CHART (ENC)

A vector representation of a nautical chart, intended to be used in conjunction with ECDIS (Electronic Chart Display and Information Systems). ENC's are standardized as to content, structure and format and may contain supplementary nautical information useful for safe navigation.

### ELECTRONIC POSITIONING SYSTEM

A positioning system in which the travel time or phase shift of radio waves from fixed points on land was measured. Short range systems measured travel time of a direct wave using an ultra high frequency (UHF) signal. Medium range systems measured phase shift of a ground wave that utilized a much lower frequency. These systems were essentially made obsolete by the advent of GPS in the 1990's.

### ELEVATION MASK

An adjustable feature of GPS receivers that specifies a satellite must be a certain number of degrees above the horizon before its signals are used for positioning. Satellites at low elevation angles (five degrees or less) have lower signal strengths and are more prone to loss of lock, thus causing noisy solutions.

### ELEVATION

The vertical distance of natural and artificial objects above an adopted reference plane. On nautical/navigational charts the elevations of bare rocks, bridges, landmarks, and lights are referenced to the plane of mean high water; contour and summit elevations are referenced to mean sea level, if the source for such information is referenced to this plane.

### ELLIPSOID (or Reference Spheroid)

A mathematical figure generated by the revolution of an ellipse about one of its axes. The ellipsoid that approximates the geoid is an ellipse rotated about its minor axis. An ellipsoid serves as the mathematical model from which maps and charts are produced. However, numerous ellipsoids have been developed to support local datums. The use of the WGS 84 ellipsoid provides a single standard of reference within the Department of Defense. Also called spheroid of reference, or ellipsoid of reference. See Geoid, Oblate Spheroid, Reference Spheroid.

### ELLIPTICITY OF THE SPHEROID

The ratio of the difference between the equatorial (a) and polar (b) radii of the earth (major and minor semi-axes of the spheroid) and its equatorial radius, or  $(a-b)/a$ . Also called flattening of the earth.

### EMBANKMENT

An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, to support roads or railways, or for other similar purposes.

### EMBAYMENT

Any indentation of a coast, regardless of width, at the entrance or depth of penetration into the land.

## ENC VIEWER

Software capable of viewing S-57 format ENC files, i.e., CARIS Easy ENC, Seven C's, etc.

## ENSONIFY

To expose an area, or portion of seabed, to acoustic energy. Seabed that has been covered by sonar, is said to have been ensonified. Ping rates (numbers of output pulses per second) are often referred to as "ensonification rates."

## EPHEMERIS

The set of parameters used by a global navigation satellite receiver to predict the location of a satellite and its clock behavior. Each satellite contains and transmits ephemeris data about its own orbit and clock. Ephemeris data is more accurate than the almanac data, but is applicable over a short time frame from 4 - 6 hr.

## EQUIDISTANT MULTIBEAM SONAR SCANNING MODE

The equidistant mode electronically forms the center of each footprint at a uniform distance from each other across the swath width. This even sampling of across the swath width reduces the amount of overlapping coverage and intensity of returns in the inner half of the swath in effort to improve resolution in the outer beams. This is not recommended for hazard investigation surveys because the weak, lower resolution inner beams. Another disadvantage of this mode is that it reduces the received signal aperture of the outer beams thus reducing the possibility of detecting distant returns.

## EQUIANGULAR MULTIBEAM SONAR SCANNING MODE

The equiangular mode electronically forms the receiving beams in equal angles. This means in the outer beams the beam footprint increases in length across-track providing bottom coverage across the entire swath width. The advantage of this mode is the overlapping coverage of the inner half of the swath, excellent for hazard investigation surveys where precise measurements of small targets are necessary. The primary disadvantage is the lower resolution in the outer beams. To maintain equal resolution across an entire survey area survey lines must be planned for at 100% overlap (outer beam matching the nadir of the adjacent lines).

## ESTIMATED POSITION

The most probable position of a craft determined by incomplete data or data of questionable accuracy. Such a position might be determined by applying a correction to the dead reckoning position.

## ESTUARY

An embayment of the coast in which fresh river water entering at its head mixes with the relatively saline ocean water. When tidal action is the dominant mixing agent it is usually termed a tidal estuary. Also, the lower reaches and mouth of a river emptying directly into the sea where tidal mixing takes place. The latter is sometimes called a river estuary.

## EVALUATION REPORT

The successor to the Verifier's Report, with format and content essentially unchanged. See also Review and Review Report.

## EVENT MARK

A mark or notation put on a sonar record, or embedded in stored data, representing the moment of a navigational fix or other critical occurrence during a survey. Event marks are important in assessing progress of a survey and in tying navigation logs to sonar data. Modern computer data processors which geo-code every sonar ping have simplified the practice of manual log keeping, but event marks are still important as progress references and data-related geodetic markers.

## EXCLUSIVE ECONOMIC ZONE (EEZ)

An area, not exceeding 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, subject to a specific legal regime established in the United Nations Convention on the Law of the Sea under which the coastal state has certain rights and jurisdictions.

## EXISTENCE DOUBTFUL

Of uncertain existence. The expression is used principally on charts to indicate the possible existence of a rock, shoal, etc., the actual existence of which has not been verified. Usually shown by the abbreviation "E.D."

## 7.6 F

### F SURVEY

See Field Examination.

### FAIRWAY

That part of a river, harbor, etc., where the main navigable channel for vessels of larger size is located. The usual course followed by vessels entering or leaving harbor. Also called ship channel. The word "fairway" has been generally interpreted to include any navigable water on which vessels of commerce habitually move, and therefore, embraces the water inside channel buoys where light-draft vessels frequently navigate and not merely the ship channel itself.

### FALSE ORIGIN

A fixed point to the south and west of a grid zone from which grid distances are measured eastward and northward. Also called a grid origin.

### FAST LAND

Land inshore of the inner edge of a marsh; usually at or above the plane of mean high water.

### FAST SHORELINE

The line appearing on a shoreline map that separates water from fast, natural uplands. This line should not be confused with the approximate back limits of marsh or marine vegetation which is normally compiled shoreward from an apparent shoreline and in lieu of the fast shoreline.

### FATHOGRAM

A graphic record of depth measurements obtained by a Fathometer. Frequently, the term is improperly used to refer to an echogram.

### FATHOM

A unit of length equal to 6 ft (1.82880 m), and used principally as a measure of depth of water.

### FATHOMETER

Copyrighted trade name for a type of single beam echo sounder. Often incorrectly used to identify any echosounder.

### FE

See Field Examination.

### FEATURE

Any single-source item that is significant enough to warrant cartographic and/or hydrographic representation. See Cartographic Feature.

## FEDERAL PROJECT

A navigation channel or maintenance dredging activity of any nature and for any purpose that is to be performed by or for the United States Army Corps of Engineers (USACE).

## FEDERAL PROJECT DEPTH

The design dredging depth of a channel constructed by the U.S. Army Corps of Engineers (USACE); the project depth may or may not be the goal of maintenance dredging after completion of the channel. For this reason federal project depth must not be confused with controlling depth.

## FETCH

The distance along open water or land over which the wind blows; the distance traversed by waves without obstruction.

## FIELD EDIT

The process of on-site examinations and measurements designed to ensure that detail and nomenclature, as portrayed or described on a previously compiled document, is current, reliable, and adequate for its intended purpose. The purpose of these documents, which may have been in graphic or tabulated form, was to provide data for the nautical charting program.

## FIELD EXAMINATION (FE)

Hydrographic surveys intended to cover only limited areas. Each survey is assigned a unique registry number the format of which has varied over time. The original form was F.E. No. (consecutive number by year) (year), for example, F.E. No. 5 1945. This format was revised in 1980 to FE-(consecutive number), for example, FE-112. The format was later revised to its present form, F(consecutive number), for example, F0025.

## FIELD POSITION

An unadjusted, geographic position of a point on the earth, computed while field work is in progress to determine the acceptability of the observations or to provide a preliminary position for other purposes.

## FIELD SHEET

The system CARIS HIPS and SIPS uses for organizing data products created from cleaned and processed bathymetry and side scan data. The field sheet consists of a data directory with a field sheet definition file and a CARIS file for storing vector products. The definition file contains information about the geographic boundary of the field sheet and the coordinate system to be used for the data products. (Former use: The hydrographer's or topographer's work sheet; the fieldsheet presents a graphic display of all surface and subsurface features in the area.)

## FIGURE OF THE EARTH

The defining elements of the mathematical surface which approximates the surface of the geoid. The figure of the earth has been proved to be approximately an oblate spheroid. See also Geoid and Spheroid.

## FILE TRANSFER PROTOCOL (FTP)

Method of transferring usually large files across network connections.

## FINAL WATER LEVEL CORRECTORS

Verified 6-minute water levels (see Verified Water Levels) for which CO-OPS has provided final discrete zoning. These data are often referred to as "Final Tides".

## FINGER PIERS

Small piers which extend from a larger main pier.

## FIRMWARE

Coded instructions related to processor function, and sometimes data processing algorithms, embedded as integral portions of the internal circuitry of an electronic system.

## FIRST BOTTOM RETURN

The component of a side scan sonar record representing the shortest acoustic path between the towfish and the seabed directly below the towfish. The first bottom return is utilized by many sonar systems to determine fish height (altitude), which is important in the algorithms used for range compression correction. In uncorrected data, the operator will use the first bottom return as a measure of fish height for winch in/out commands to maintain proper towing altitudes. This feature of the sonar display will be very strong in hard bottom or over a rocky substrate, but may be difficult to discern over a mud or silt seabed.

## FIRST SURFACE RETURN

The component of a side scan sonar record representing the shortest acoustic path between the towfish and the surface directly above the towfish. Because the vertical beamwidth is very wide in side scan sonar, some of the acoustic energy propagates upwards from the transducer. Although this energy is very low level, the sea surface can be a good reflector and return enough of the incident pulse to be noticeable in data. As the fish is lowered, the first surface return moves, in the water column portion of the record, away from the centerline. In shallow water operations, as the fish is lowered past the half-depth point, this return becomes lost in the near range data. Beyond this it may not be discernible because of its low signal strength. In shallow water, when the first surface return crosses the first bottom return, the towfish is halfway between the surface and the seabed.

## FISH HAVEN

An area established by private interests, usually sport fishermen, to simulate natural reefs and wrecks that attract fish. The reefs are constructed by dumping assorted material in areas which may be of very small extent or may stretch a considerable distance along a depth contour. Fish havens have defined authorized boundaries and minimum clearances, both of which are shown on nautical charts.

## FISH HEIGHT

The distance between a side scan sonar towfish and the seabed, usually measured in feet or meters.

## FISH TRAP

A device for catching fish. It usually consists of stakes and nets arranged such that fish entering are prevented from exiting.

## FISH TRAP AREA

An area established by the Corps of Engineers in which traps may be built and maintained according to established regulations. The fish stakes which may exist in these areas are obstructions to navigation and may be dangerous. The limits of fish trap areas and a cautionary note are usually charted.

## FIX

A position determined without reference to any former position. In concept, a fix is the common intersection of two or more lines of position obtained from simultaneous observations not dependent upon any former position. In normal practice, a fix is the most probable position derived from 2 or more intersecting lines of position obtained from observations made at nearly the same time.

## FJORD

A long narrow arm of the sea, usually formed by the entrance of the sea into a deep glacial trough.

## FLASHING LIGHT

A light in which the total duration of light in a period is shorter than the total duration of darkness and appearances of light (flashes) are usually of equal duration.

## FLATS

A place covered with water too shallow for navigation with vessels ordinarily used for commercial purposes; the space between high- and low-water marks along the edge of an arm of the sea, a bay, tidal river, etc.

## FLIERS

Outliers. Soundings which are not associated with the seafloor. See Data Fliers.

## FLOAT

A floating structure, usually rectangular in shape, which generally serves as a landing or pier head.

## FLOATING BREAKWATER

A breakwater consisting of a series of logs or timbers chained or lashed together and secured by chains or cables attached to anchors or large blocks of stone, so as to form a protected basin for the mooring or anchoring of vessels.

## FLOATING DOCK

1. A floating dock is a platform or ramp supported by pontoons. These are usually joined to the shore with a ramp that rests upon the dock on rollers, to adjust for the vertical movement of the dock. The dock is usually held in place by vertical poles embedded in the soil under the water or by anchored cables. 2. A form of dry dock consisting of a floating structure of one or more sections which can be partly submerged by controlled flooding to receive a vessel, then raised by pumping out the water so that the vessel's bottom can be exposed.

## FLOOD

The movement of a tidal current toward the shore or up a tidal river or estuary.

## FOLIO CHARTS

NOS charts consisting of two to four sheets printed front and back, folded, and bound in a protective cardboard jacket.

## FOOTPRINT

The area of seabed ensonified by an outgoing sonar beam during, or after, a specific period of time. A smaller footprint of sonar on the seabed will result in a higher resolution image in the data.

## FORELAND

A cape or peninsula.

## FORESHORE

That part of the shore lying between the crest of the seaward berm (or the upper limit of wave wash at high tide) and the ordinary low-water mark. According to riparian law, the strip of land between the high- and low-water marks that is alternatively covered and uncovered by the flow of the tide.

## FORMLINE

Broken lines resembling contour lines but representing no actual elevations, which have been sketched from visual observation or from inadequate or unreliable map sources, to show collectively the shape of the terrain rather than the elevation.

## FOUL AREA

1. An area where numerous hazards to navigation may cause damage to vessels entering or transiting the area.
2. An area in which hazardous rocks or other obstructions are too numerous to be located individually during a hydrographic survey or cartographically depicted individually. Such areas shall be delimited by a surveyed dashed line. Unless annotated otherwise, a note “foul” within such a delimited area will be construed as foul with rocks. The term “foul” should not be applied to a soft continuum with indefinite boundaries such as mud or sand; to areas congested with marine vegetation such as kelp or grass in water; or to materials not likely to cause damage to a vessel.

## FOUL BERTH

A berth in which a vessel cannot swing to her anchor or moorings without fouling another vessel or striking an obstruction.

## FOUL BOTTOM

A hard, uneven, rocky, or obstructed bottom having poor holding qualities for anchors, or one having rocks or wreckage that would endanger an anchored or transiting vessel.

## FOUL GROUND

An area where the holding qualities for an anchor are poor, or where danger of striking or fouling the ground or other obstructions exist. Examples would be areas strewn with rocks, boulders, coral or obstructions.

## FRINGING ISLANDS

A series of islands that fringe, or mask, a mainland coast. Often known as barrier islands.

## FRINGING REEF

A reef attached to and paralleling a shore.

## 7.7 G

### GAIN

A measure of the increase in signal amplitude produced by an amplifier. In sonar applications, gains are most often applied in two ways. One is time-varied-gain (TVG), where signal amplification increases as a function of time. This methodology can be applied because there is a constant speed of sound underwater for most sonar applications and the returning signal level from the seabed decreases as the pulse travels across the seabed and away from the transducer. Closer returns have a far higher intensity than distant ones. The other method of increasing gains in sonar is to apply them to the display only. In hard copy recorders, printer gain will darken the record, and with computerized sonar processors, increasing video intensity has a similar effect.

### GAUSSIAN ERROR

Deviation of a magnetic compass due to transient magnetism which remains in a vessel's structure for short periods after the inducing force has been removed. This error usually appears after the vessel has been on the same heading for a considerable time.

### GENERAL CHARTS

Nautical charts which are published at scales from 1:150,001 to 1:600,000 and are intended for coastal navigation when a course is well offshore but can be fixed by landmarks, lights, buoys, and characteristic soundings.

## GENERALIZATION

The process of reducing the complexity of a presentation of map information to make it appropriate for a particular scale of product. For example, shoreline which shows detailed information about a cove at a large scale may only show a small indentation on a small-scale chart.

## GEO-CODED

Geographically referenced, usually when associated with an image file registered using a GIS system.

## GEODESY

The science related to the determination of the size and shape of the earth (geoid) by such direct measurements as triangulation, leveling, and gravimetric observations. Geodetic observations document and explain the external gravitational field of the earth and, to a limited degree, its internal structure.

## GEODETTIC CONTROL

A system of horizontal and/or vertical control stations that have been established and adjusted by geodetic methods and in which the shape and size of the Earth (geoid) have been considered in position computations.

## GEODETTIC COORDINATES

The quantities of latitude, longitude, and height (ellipsoid), which define the position of a point on the surface of the earth with respect to the reference spheroid. Also imprecisely called geographic coordinates.

## GEODETTIC DATUM

The adopted position in latitude and longitude of a single point to which the charted features of a vast region are referred. It consists of five quantities; the latitude and longitude of the point; the azimuth of a line from this point to another point to which it is tied by the triangulation; and two constants necessary to define the terrestrial spheroid.

## ELLIPSOID HEIGHT

The distance from a point to the reference ellipsoid along a line normal to the ellipsoid. The difference between a point's ellipsoid height and its orthometric height equals the geoidal height.

## GEODETTIC POSITION

A position of a point on the surface of the earth expressed in terms of geodetic latitude and geodetic longitude. A geodetic position implies an adopted geodetic datum.

## GEODETTIC SURVEY

A survey in which the figure and size of the Earth is considered. It is applicable for large areas and long lines and is used for the precise location of basic points suitable for controlling other surveys.

## GEOGRAPHIC CELL (GC)

The current National Geodetic Survey's Coastal Mapping Program's series identifier for shoreline data contained within the Digital Cartographic Feature File (DCFF). Geographic Cells replaced the DM series of DCFFs which superseded the registry numbers (e.g. T and TP) used to identify topographic survey manuscripts. The GC series identifier consists of two alpha and five numeric characters. The alpha characters are "GC" for Geographic Cells while the five numeric characters are a continuation of the DM series numbers (GC10405 being the first GC).

## GEOGRAPHIC COORDINATES

The world-wide system of latitude and longitude used to define the location of any point on the earth's surface.

### GEOGRAPHIC INFORMATION SYSTEM (GIS)

A system of spatially referenced information, including computer programs that acquire, store, manipulate, analyze, and display spatial data.

### GEOGRAPHIC NUMBER

The number assigned to an aid to navigation for identification purposes in accordance with the lateral system of numbering.

### GEOGRAPHIC POSITION

The position of a point on the surface of the Earth expressed in terms of latitude and longitude, either geodetic or astronomic. NOAA uses the term for positions on a geodetic datum.

### GEOID

The figure of the earth, which approximates a mean sea level surface extended continuously through the continents. The actual geoid is an equipotential surface to which, at every point, the plumb line (direction in which gravity acts) is perpendicular. Geoids currently in use are GEOID84 and GEOID90.

### GLOBAL POSITIONING SYSTEM (GPS)

A constellation of 24 satellites operated by the U.S. Department of Defense which orbit the earth at a very high altitude. GPS satellites transmit signals that allow one to determine, with great accuracy, the locations of GPS receivers. The receivers can be fixed on the Earth, in moving vehicles, aircraft, or in low-Earth orbiting satellites. GPS is used in air, land and sea navigation, mapping, surveying and other applications where precise positioning is necessary. GPS can provide highly accurate position and velocity information in three dimensions and precise time and time interval on a global basis continuously.

### GRAPHIC SCALE

A line or bar on a map or chart subdivided to represent distances on the earth in various units, to wit: nautical miles, statute miles, yards, feet, kilometers, etc. Also called bar scale or linear scale.

### GRASSY SHOAL

Marsh in the early stages of development often found contiguous to a well-defined marsh or outside the high-water line.

### GRATICULE

The network of lines representing meridians and parallels on a map, chart, plotting sheet, etc.

### GRAVEL

1. Loose, rounded fragments of rock, larger than sand, but smaller than cobbles. 2. Small stones and pebbles, or a mixture of these with sand.

### GRAZING ANGLE

The angle at which a sonar pulse strikes, and propagates across, the seafloor. The grazing angle of the sonar pulse has an effect on the reverberation or backscatter of the ensonified seabed. Grazing angle algorithms in side scan sonar systems attempt to compensate for these changes and produce a uniform image in the sonar data.

### GREENWICH MEAN TIME (GMT)

Mean solar time at the meridian of Greenwich, England. It has been used as a basis for standard time throughout the world. Also called Coordinated Universal Time (UTC).

## GREENWICH MERIDIAN

The meridian of the Royal Observatory, Greenwich, England. Adopted in 1884 by a conference of nations as the initial or zero of longitudes for all nations.

## GRID

A series of lines, usually straight and parallel, or two sets of mutually perpendicular lines, dividing a map, chart, or other representation of the earth's surface into squares or rectangles to permit the location of any point by a system of rectangular coordinates or to serve as a directional reference for navigation. A grid is not necessarily a graticule, and the terms should not be used interchangeably.

## GRIDDING

A process used to thin dense hydrographic data by determining a depth at a "grid node" (intersection point of perpendicular grid lines) by considering points in proximity to that grid node – usually a radial distance.

## GROIN

A low artificial wall-like structure of durable material extending from the land to seaward for a particular purpose, such as to protect the coast or to force a current to scour a channel. Groins may be classified as permeable or impermeable: impermeable groins have solid or nearly solid structure, permeable groins have openings through them of sufficient size to permit passage of appreciable quantities of littoral drift.

## GROSS ERROR

The result of carelessness or a mistake; may be detected through the repeating of the measurement. Also called blunder.

## GROUNDING

The touching of the seafloor by a vessel or by the wire sweep during a wire-drag survey.

## GROUND SURVEY

A survey made by ground methods, as distinguished from an aerial survey. A ground survey may or may not include the use of photographs.

## GROUP REPETITION INTERVAL (GRI)

Of a particular LORAN-C chain, the specified time interval for all stations of the chain to transmit their pulse groups. For each chain a minimum group repetition interval (GRI) is selected of sufficient duration to provide time for each station to transmit its pulse group and additional time between each pulse group so that signals from two or more stations cannot overlap in time anywhere within the coverage area. The GRI is normally stated in terms of tens of microseconds, i.e., the GRI having a duration of 79,900 microseconds is stated as 7990. In providing means for identifying a chain within a system all stations of which transmit on the same frequency (100 kHz), the GRI is the chain signature.

## GULF

A tract of water within an indentation or curve of the coastline, in size between a bay and a sea – the Gulf of California, for example.

## GULF COAST LOW WATER DATUM (GCLWD)

A tidal datum used as chart datum for the coastal waters of the Gulf coast of the United States from November 14, 1977 to November 27, 1980. GCLWD is defined as mean lower low water (MLLW) when the type of tide is 28, 1980 by the National Tidal Datum Convention of 1980.

## GYROSCOPE (GYRO)

A rapidly rotating mass free to move about one or both axes perpendicular to the axes of rotation and to each other. It is characterized by gyroscopic inertia and precession. This term refers colloquially to the gyrocompass.

## 7.8 H

### HCell

The S-57 map in CARIS HOM containing all of the new survey and chart information necessary for updating or creating a new ENC and chart product. The CARIS map is referred to as an HCell at any stage in CARIS HOM processing.

### HCell DELIVERABLE

The S-57 Base Cell File (\*.000) exported and converted to charting units in HOM.

### H DRAWING

Compiled drawing of the nautical chart reflecting revisions based upon source data, such as hydrographic surveys or other sources.

### H SURVEY

Refers to a Basic Hydrographic Survey because registry numbers for Basic Hydrographic Surveys begin with the letter "H". A basic survey is one that is so complete and thorough it does not need to be supplemented by other surveys.

### HACHURES

Short lines or wedge shaped marks on topographic maps or nautical charts to indicate the slope of the ground or the submarine bottom. They usually follow the direction of the slope. Hachures may be used to identify a steep coast, but unlike contours they do not show degree of slope or actual elevation of ground above chart datum. They may also be used to accentuate a spot elevation on very small-scale charts without contours.

### HAND LEAD

A light sounding lead (7 to 14 pounds), usually having a line of not more than 25 fm.

### HARBOR

A place where ships may find shelter. A harbor may be natural or artificially constructed. In either case its waters are inland. The limits of its inland waters are determined, at least in part, by their use as a harbor rather than the mere application of delimitation principles to geography, as is the case with bays and rivers.

### HARBOR CHARTS

Nautical charts published at scales of 1:50,000 and larger, and intended for navigating in harbors and smaller waterways and for anchorage.

### HARBOR LINE

Lines prescribed by the Corps of Engineers (USACE), which limit the length of piers and other structures projecting into navigable channels; the construction of structures channelward of this line is not permitted unless the harbor lines are modified. Navigation improvements and surveys by the (USACE) do not extend inside (shoreward of) the harbor lines. Harbor lines are of two types, pierhead lines and bulkhead lines. Bulkhead lines are prescribed where the waterfront construction is of a solid nature, such as marginal wharves, backfilled seawalls and bulkhead wharves; the water areas inside bulkhead lines normally may be filled in by private concerns upon proper application to the USACE. Pierhead lines are associated with open-type construction, such as open pile piers, and no such structure may extend channelward of these lines. For waterfronts where both types of construction occur, both

lines will be prescribed. Harbor lines are usually straight line-segments crossing the outermost pierheads and/or bulkhead facilities, and are marked with accurately located, permanent monuments so that local surveyors may easily locate them.

#### HARBOR OF REFUGE

A harbor provided as a temporary refuge on a stormy coast for the convenience of passing shipping. It may or may not be part of a shipping port. Also called port of refuge. HDAPS Stands for Hydrographic Data Acquisition and Processing System. Antiquated hydrographic acquisition and processing software used during the late 1980s and obsolete by the mid-1990s.

#### HDOP (HORIZONTAL DILUTION OF PRECISION)

The horizontal dilution of precision (HDOP) allows one to more precisely estimate the accuracy of GPS horizontal (latitude/longitude) position fixes by adjusting the error estimates according to the geometry of the satellites used. In probability terminology, HDOP is an additional variable that allows one to replace the overall accuracy estimates with conditional accuracy for the given HDOP value.

#### HEAD

A steep cape or peninsula.

#### HEADING

The horizontal direction in which a ship actually points or heads at any instant, expressed in angular units from a reference direction, usually from 000° at the reference direction clockwise through 360°. Heading is often designated as true, magnetic, compass, or grid, as the reference direction is true, magnetic, compass, or grid north, respectively. Heading should not be confused with course, which is the intended direction of movement through the water. At a specific instant the heading may or may not coincide with the course, depending upon such factors as steering errors, actions of the seas upon the ship, etc. The heading of a ship is also called Ship's Head.

#### HEADLAND

1. In common usage, a land mass having a considerable elevation. In the context of the Law of the Sea, elevation is not an important attribute and a headland may be the apex of a salient of the coast, the point of maximum extension of a portion of the land into the water, or a point on the shore at which there is an appreciable change in direction of the general trend of the coast. 2. A geographic feature that serves to give an inland water body its landlocked nature. A headland may be natural or man-made. It must be above mean low water but not by any significant extent. It will usually provide an appreciable change in the direction of the coast.

#### HEAVE

The oscillatory rise and fall of a ship due to the entire hull being lifted by the force of the sea. The disjointed, jagged images on a sonar record produced by heave. Heave is a major cause of data distortion. Heave compensators are used on vessels to remove the effect of this motion from the recorded seabed profile. Also applies to the rhythmic up and down movement of a towfish in moderate to heavy seas. Under some conditions, longer tow cables will dampen the effect of heave affecting towfish but can also result in a harmonic effect, increasing the heave.

#### HIGH SEAS

The open sea beyond the Exclusive Economic Zone, the territorial sea or the archipelagic waters of an archipelagic country.

#### HIGH WATER

The maximum height reached by a rising tide. The high water is caused by the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions. For tidal datum computational purposes, the maximum height is not considered a high water unless it contains a tidal high water.

## HIGH WATER LINE

1. The intersection of the land with the water surface at an elevation of high water. 2. A generalized term associated with the tidal plane of high water, but not with a specific phase of high water, such as higher high water or lower high water.

## HIGH WATER MARK

A line or mark left upon tide flats, beach, or alongshore objects indicating the elevation of the intrusion of high water. The mark may be a line of oil or scum on alongshore objects, or a more or less continuous deposit of fine shell or debris on the foreshore or berm. This mark is physical evidence of the general height reached by wave runup at recent high waters. It should not be confused with the mean high water line or mean higher high water line.

## HIPS VESSEL FILE (HVF)

A file generated in CARIS software used to set the parameters for sensors and other equipment for data processing. Previously referred to as a Vessel Configuration File (VCF).

## HISTORY SHEET

See Chart History.

## HOLDING GROUND

An expression usually used with a modifying adjective to indicate the quality of the holding power of the material constituting the bottom of an anchorage; e.g., of good (or poor) holding power.

## HOLIDAY

An unintentionally unsurveyed area within a given hydrographic survey project, where the spacing between soundings, sounding lines, or surveys exceeds the maximum allowable limits.

## HOOK

Something resembling a hook in shape, particularly (a) a spit or narrow cape of sand or gravel which turns landward at the outer end, or (b) a sharp bend or curve, as in a stream.

## HORIZONTAL BEAM WIDTH

The angle of the transmitted (and/or received) sonar beam in the along-track (transverse) dimension. Narrow horizontal beamwidths increase transverse resolution. Because beamwidth is related to transducer length and frequency, beamwidth decreases with increasing frequency for a given transducer length.

## HORIZONTAL CONTROL

Historically, a network of stations of known geographic or grid positions referred to a common horizontal datum, which control the horizontal position of mapped features with respect to parallel and meridians, or northing and easting grid lines shown on the map. Horizontal control includes basic (marked) and supplementary (unmarked) stations.

## HORIZONTAL CONTROL STATION

A station whose position has been accurately determined in x and y grid coordinates, or latitude and longitude. Also called horizontal control point.

## HORIZONTAL DATUM

1. At its most basic level of definition, the horizontal datum is a collection of specific points on the Earth that have been identified according to their precise northerly or southerly location (latitude), and their easterly or westerly location (longitude).

2. A reference system for specifying positions on the Earth's surface. Each datum is associated with a particular reference spheroid that can be different in size, orientation, and relative position from the spheroids associated with other horizontal datums. Positions referred to different datums can differ by several hundred meters.

**HPS**  
Stands for Hydrographic Processing System. Outdated proprietary NOAA hydrographic data processing software.

**HULK**  
The hull or portion of the hull of a derelict vessel, usually without superstructure or other appurtenance. A major portion of the hulk is usually visible at some stage of tide.

**HYDRO HOT LIST**  
A list, maintained by CO-OPS, of water level stations which are currently providing data for NOAA hydrographic surveys. If a station is on the Hydro Hot List, the gauge's data is carefully monitored and its processing is given priority over other gauges.

**HYDRODYNAMIC DEPRESSOR**  
A tow assembly depressor designed with vanes or a wing oriented in such a way as to increase negative lift when exposed to an increased water flow. Hydrodynamic depressors work by increasing the downward pull on the towbody end of the cable during towing. The advantage of this kind of depressor is that they are lightweight and relatively easy to deploy. Some types can be rigged to invert and increase drag if they come in contact with the seabed, thus rapidly bringing the towfish to altitude and out of collision danger. They must be rigged carefully so as to be tangle-free during and after deployment. A disadvantage to the hydrodynamic depressor is that an increase in towspeed will not raise the towfish to avoid an obstruction. It may, instead, bring it deeper. Another disadvantage to this type of depressor is that it typically requires significant towspeeds to develop effectiveness.

**HYDROGRAPHER**  
One who studies and practices the science of hydrography. The term is capitalized when referring to the person in charge of a hydrographic department or office of a country.

**HYDROGRAPHIC DATA CLEANING SYSTEM (HDACS)**  
CARIS's acronym for their Hydrographic Data Cleaning System. The HDACS data format uses the Project/Vessel/Day/Line (PVDL) hierarchical structure to store the information.

**HYDROGRAPHIC MANUALS**  
The form of publication used by NOAA since 1928 for providing instructions for hydrographic work. Four such manuals have been issued to date – in 1928, 1942, 1960, and 1976.

**HYDROGRAPHIC SURVEY**  
A survey having for its principal purpose the acquisition of data relating to a body of water for the purpose of promoting safe navigation. A hydrographic survey may consist of or require one or several of the following classes of data: depth of water; configuration and nature of the bottom; velocity of currents; heights and times of tides and water levels; location of aids and dangers to navigation; configuration of marginal land areas; and determination of magnetic declination and anomalies for navigating by magnetic compass. Information on geographic names and harbor facilities may also be documented.

**HYDROGRAPHIC SURVEY EXAMINATION**  
Consequent to a formal policy transferring responsibility for hydrographic survey quality and final approval to the then Office of Marine Operations, the quality control of all hydrographic survey products was discontinued in October, 1982. Instead, procedures and policies were established to conduct quality control examinations on a

statistically representative sample consisting of not more than 10% of products. This examination was identified as a Hydrographic Survey Examination and was approximately equivalent to the preparation of a Quality Control Report. However, it differed from the quality control examination in that the effort was directed toward evaluating compliance with, and the adequacy of, standards, rather than a careful examination of the data and their quality. Each survey selected was carefully examined by a cartographer for adequacy with respect to data acquisition and conformance with applicable standards and project instructions. In addition, the overall condition of the records and the descriptive report were reviewed. The digital data representing the survey was plotted and subjected to a cursory examination to determine the degree of compliance with digital data standards. The examination was limited to only that necessary to evaluate the acquisition and processing procedures.

#### HYDROGRAPHIC SURVEY GUIDELINES

A discontinued series of guidelines initiated in 1979 to emphasize, interpret, and supplement material contained in the NOAA Hydrographic Manual, Fourth Edition, and various other publications and memorandums. The Guidelines were intended primarily for communication of processing techniques between the Hydrographic Surveys Division and the Marine Centers.

#### HYDROGRAPHIC SURVEY SHEET

An inclusive term used to designate boat sheets, field sheets, and smooth sheets.

#### HYDROGRAPHY

The branch of applied science which deals with the measurement and description of the physical features of the navigable portion of the Earth's surface and adjoining coastal areas, with special reference to their use for the purpose of navigation.

#### HYDROPHONE

A sonar receiver functioning by transforming underwater sound signals (pressure waves) into electrical signals. Often a hydrophone is a passive device doing no transmitting on its own.

#### HYPERBOLIC POSITIONING SYSTEM

A positioning system in which the observer measures the difference in time of reception of signals from two stations whose coordinates are known. The difference in time is converted to a difference in distance. The locus of all points lying at a fixed difference in distance from two points are the two branches of a hyperbola. There is usually a third station operating in conjunction with one of the two to provide the observer with another difference in distance and another pair of hyperbola branches. The observer is at one of the intersections of the branches. LORAN is the oldest known positioning system using this technique.

## 7.9 I

#### IDENTIFICATION LETTERS AND NUMBERS

Letters and numbers (in color) once used to identify sounding lines on a hydrographic survey sheet and which correspond to those used in the sounding records.

#### IHB

See International Hydrographic Bureau.

#### IHO

See International Hydrographic Organization.

## IKONOS

The Ikonos-2 satellite was launched in September, 1999, and has been delivering commercial data since early 2000. Ikonos is the first of the next generation of high spatial resolution satellites. Ikonos data records 4 channels of multi-spectral data at 4 m resolution, and 1 panchromatic channel with 1 m resolution. This means that Ikonos was the first private-sector satellite to deliver near-photographic high-resolution satellite imagery of objects or specified locations anywhere in the world, e.g., shorelines. Ikonos-2 is equipped with a Kodak digital camera. This payload will enable the satellite to collect 1-m resolution panchromatic (gray-scale) resolution and 4-m resolution, 4-band multi-spectral (red, green, blue, near infrared) imagery of the Earth. The camera is comprised of a Kodak-designed and -manufactured focal plane array and a lightweight telescope using a state-of-the-art mirror fabricated with Kodak's advanced ion-figuring technology. To speed the downloading of data to Space Imaging EOSAT's ground receiving stations, the original 11-bit data will be compressed using Kodak's proprietary bandwidth compression technology.

## IMPROVED CHANNELS

Dredged channels under the jurisdiction of the U.S. Army Corps of Engineers, and maintained to provide an assigned controlling depth. Symbolized on the nautical/navigational charts by black, dashed lines to represent the side limits, with the controlling depth and date of ascertainment; sometimes accompanied by a tabulation for more detailed information.

## INERTIAL POSITIONING SYSTEM

A positioning system consisting of a computer and an assemblage of three accelerometers and two or three gyroscopes. The gyroscopes are fastened together in such a way that they define the orientation of the accelerometers with respect to non-rotating coordinates and the accelerometers measure the components of acceleration of the positioning system along the directions defined by the gyroscopes. The computer and associated equipment integrate the components of acceleration to give the 3 components of displacement of the positioning system.

## INFORMATION AWOIS ITEM

An AWOIS item for which no search radius has been assigned. If the item is detected in the course of hydrography, develop to fullest extent.

## INLAND RULES OF THE ROAD

Rules to be followed by all vessels while navigating upon certain inland waters of the U.S. See also Colregs.

## INLAND WATER LINE

A series of straight lines developed by the Coast Guard to separate areas that are subject to its Inland Rules of the Road from those to which the International Rules apply. The lines have no bearing on inland water determinations for Convention of Submerged Lands Act purposes.

## INLAND WATERS

Waters landward of the baseline from which the marginal seas are measured and over which complete sovereignty is exercised. Specific information is contained within 33 U.S.C. Chapter 3. Also known as "internal waters."

## INLET

1. A narrow strip of water running into the land or between islands. 2. An arm of the sea (or other body of water) that is long compared to its width, and that may extend a considerable distance inland.

## INNER HARBOR

The part of a harbor more remote from the sea, as contrasted with the outer harbor. These expressions are usually used only in a harbor that is clearly divided into two parts, as by a narrow passageway or man-made structures. The inner harbor generally has additional protection and is often the principal berthing area.

## INS

See Integrated Navigation System.

## INSET

In cartography: (a) a small area outside the neat lines of a map or chart included within the neat lines or borders to avoid publishing a separate graphic of the small area alone; (b) a representation of a small area on a larger scale (e.g., town-plan inset), or of a large area at a smaller scale (e.g., orientation inset); (c) any information, not normally appearing within the geographic limits of a map, which has been enclosed by border lines and included within the map neat lines. Insets are always placed in areas where important features will not be covered. See Subplan.

## INSHORE

1. In beach terminology, the zone of varying width extending from the low water line through the breaker zone.
2. In NOAA operational hydrography terminology, the zone extending shoreward from depths of 8 m.

## INTEGRATED NAVIGATION SYSTEM

Most commonly, a computer-based navigation system deployed on large vessels. INS systems have one or more displays and take input from a navigational device such as a GPS receiver and display the ship's track, course, and heading on a screen. Modern units allow the user to log targets, filter errant position fixes, log the ship's position history, display user-defined lines the ship is to follow, and display shorelines.

## INTERFERENCE

The display of erroneous signals from acoustic or electrical sources that conflict with the display of the primary sonar data. Interference can be internal to the sonar system, but is most commonly from other sources. Causes of external interference include generator noise, electromagnetic radiation from other electronics, ship's engines and propellers, flow noise, and noise from biological sources. See Noise.

## INTERFEROMETRIC SONAR

A system based on the process by which two or more sonar waves of the same frequency combine to reinforce or cancel each other, the amplitude of the resulting wave being equal to the sum of the amplitudes of each of the combining waves. Because the angle of interference can be determined, these sonar systems provide bathymetric information over a wide swath.

## INTERNATIONAL CHART

One of a coordinated series of small-scale charts for planning and long range navigation. The charts are prepared and published by different Member States of the International Hydrographic Organization (IHO) using the same specifications.

## INTERNATIONAL GREAT LAKES DATUM 1985 (IGLD)

A vertical control datum having its zero horizontal plane at mean sea level at Rimouski, Quebec, as determined from measurements at Rimouski/Pointe-au-Pere over the period 1982-1988. It is used primarily for the definition of the chart datum, Low Water Datum, in each of the Great Lakes, their connecting waterways, and the St. Lawrence River, and for hydraulic studies of the same. IGLD (1985) was implemented, effective January 1992, replacing the old International Great Lakes Datum (1955).

## INTERNATIONAL HYDROGRAPHIC BUREAU (IHB)

An organization founded in 1921 for the purpose of establishing a close and permanent association among hydrographic offices of its 19 Member States. The Bureau was provided with headquarters in the Principality of Monaco by H.S.H. Prince Albert I of Monaco, a noted marine scientist. In 1970, an intergovernmental Convention entered into force which changed the organization's name and legal status, creating the International Hydrographic Organization (IHO), with its headquarters (the IHB) permanently established in Monaco.

## INTERNATIONAL HYDROGRAPHIC ORGANIZATION (IHO)

An intergovernmental consultative and technical organization that traces its origin to 1921 and was established to support safety in marine navigation and the protection of the marine environment. The main objectives of the IHO is to bring about the coordination of the activities of national hydrographic offices, the greatest possible uniformity in nautical charts and documents, the adoption of reliable and efficient methods of carrying out and exploiting hydrographic surveys, the development of the sciences in the field of hydrography and the techniques employed in descriptive oceanography.

## INTERNATIONAL NAUTICAL MILE

In 1929, the International Hydrographic Conference in Monaco defined the international nautical mile as exactly 1,852 m, about 6,076.11549 ft.

## INTRACOASTAL WATERWAY

An approximately 3,000 mile-long, partly natural, partly artificial, waterway, providing sheltered passage for commercial and leisure boats along the U.S. Atlantic coast from Boston, MA to Key West, in southern FL, and along the Gulf of Mexico coast from Apalachee Bay, in NW FL, to Brownsville, TX, on the Rio Grande. The toll-free waterway, authorized by Congress in 1919, is maintained by the U.S. Army Corps of Engineers at a minimum depth of 12 ft (4 m) for most of its length; some parts have 7-ft (2.1-m) and 9-ft (2.7-m) minimum depths. The Intracoastal Waterway has a good deal of commercial activity; barges haul petroleum, petroleum products, foodstuffs, building materials, and manufactured goods. [From: The Columbia Encyclopedia, Sixth Edition. Copyright © 2003, Columbia University Press., NY, NY]

## ISLAND

mean high water; an area of dry land entirely surrounded by water or a swamp; an area of swamp entirely surrounded by open water.

## ISLET

A small island.

## ISTHMUS

A narrow strip of land connecting two larger bodies of land.

## 7.10 J

### JETTY

A substantial, artificial structure erected on the coast for the purpose of extending the flow of a river or protecting a harbor or beach.

### JULIAN DAY

The consecutive number of each day commencing January 1, 4713 B.C. The Julian day begins at noon, 12 hours later than the corresponding civil day. For example, the day beginning at noon January 1, 1968 was Julian day 2,439,857. This term is often incorrectly used when referring to the sequential 3-digit day number of the year. The sequential 3-digit day number of the year should be referred to as the “day of year” or “day number” rather than as the “Julian Day.”

### JUNCTION

A place of meeting or joining. In hydrographic surveying, the joining of two or more adjacent/adjoining survey sheets.

## JUNCTION BUOY

A buoy which, when viewed from a vessel approaching from the open sea or in the same direction as the main stream of flood current, or in the direction established by appropriate authority, indicates the place at which two channels meet. Also referred to as a Bifurcation Buoy.

## 7.11 K

### KAPP

A unique number assigned to each chart panel, inset, or extension of all agency nautical charts. See Chapp.

### KELP

An order of usually large blade-shaped or vine-like brown algae that grows on rocky bottoms and is therefore associated with possible dangers to navigation.

### KEY

See Cay.

## KINEMATIC SURVEYING

Kinematic surveying is a method of surveying with GPS that initially solves wavelength ambiguities and retains the resulting measurements by maintaining a lock on a specific number of satellites throughout an entire surveying period. Observations are made while a receiver is in motion. In surveying applications, kinematic refers to uninterrupted carrier-phase measurements following successful solution of the integer ambiguities. This can be accomplished in a continuous mode where the receiver remains in motion for precise positioning of a vehicle, or in an intermittent mode where data is recorded only after a receiver is brought to a stationary point, and the observations while in motion are tracked as a way to maintain the integer ambiguities.

## KITING

A rhythmic, lateral movement experienced by tow bodies on long cables and in deep water; most often induced by poor hydrodynamics of a depressor. The proper application of depressors is important to maintain reliable fish stability. One depressor shape and form may work well at only certain speeds, while creating instabilities at others. Kiting is one of a variety of instabilities that can be recognized in sonar data.

## KNOT

A unit of speed defined (1978) as 1 international nautical mile per hour. It was previously defined as 1 nautical mile per hour, but this led to confusion because the American and British nautical miles differ by 1.184 m. The knot is equal to 1.852 km/hr.

## 7.12 L

### LAGOON

A shallow body of water which usually has a shallow restricted inlet from the sea.

### LAKE

Any standing body of inland water, generally of considerable size. There are exceptions, such as the lakes in Louisiana which are open to or connect with the Gulf of Mexico. Occasionally, a lake is called a sea, especially if very large and composed of salt water.

## LAMBERT CONFORMAL CONIC PROJECTION

A conformal map projection of the conical type, on which the meridians are straight lines meeting in a common point outside the limits of the map, and the parallels are concentric arcs of circles having the common point as center.

## LAND

The solid part of the surface of the earth, as opposed to water as constituting a part of such surface.

## LANDING

A place where boats receive or discharge passengers, freight, etc.

## LANDMARK

A conspicuous object, natural or man-made, located near or on land, which aids in fixing the position of an observer.

## LARGE NAVIGATIONAL BUOY (LNB)

A large buoy designed to take the place of a lightship, where construction of an offshore light station is not feasible. These 40-ft diameter buoys may show secondary lights from heights of about 36 ft above the water. In addition to the light, such buoys may mount a radiobeacon and provide sound signals. A station buoy may be moored nearby.

## LARGE SCALE SURVEY (CHART)

A scale involving a relatively small reduction in size. A large scale chart is one covering a small area. The opposite is small scale. In agency usage, a scale of 1:80,000 would be the upper limit of classification.

## LATERAL OFFSET

The position of the towfish off to the side of the surface vessel's track. This occurs when the surface vessel track is not aligned with a surface or subsea current. It can also be caused by poor hydrodynamics. The effect of the current will pull the towfish away from the vessel trackline. In extreme cases, the towfish can also crab into such a current and result in a loss of data.

## LATERAL SYSTEM

A system of aids to navigation in which buoys, daybeacons, and minor lights are assigned colors and shapes in accordance with their respective location in relation to safe water.

## LATTICE

A pattern formed by two or more families of intersecting lines, such as the pattern formed by two or more families of hyperbolas representing curves of equal time difference associated with a hyperbolic radio navigation system. Sometimes the term "pattern" is used to indicate curves of equal time difference, with the term "lattice" being used to indicate its representation on the chart.

## LATITUDE

Angular distance from a Primary Great Circle or plane, usually the Equator. One of the coordinates used to describe a position, the other being longitude.

## LAW OF THE SEA CONVENTION

The United Nations' 1982 Convention that, for most purposes, supersedes the four Geneva Conventions of 1958. The "baseline" provisions of the Law of the Sea Convention do not deviate significantly from those of the Convention on the Territorial Sea and the Contiguous Zone. The Supreme Court's adoption of the 1958 principles for purposes of the Submerged Lands Act is not affected by the new Convention. Entered into force on November

16, 1994. The United States has recognized most provisions of the 1982 Convention as customary international law (including the baseline provisions).

#### LAYBACK

The horizontal distance between the survey vessel, or the navigation antenna, and the towfish. In deep water towing, this distance is important for positioning features on the seabed and geo-coding sonar data for mosaics. Because most navigation instruments provide the position of their antenna mounted on the vessel and the “x, y” origin of the sonar image is at the towfish, this difference in position can be significant. Many methods of subtracting this distance have been tested using acoustics and algorithms. Acoustic fish positioning methods rarely work well and often cause more problems than they solve. Algorithms, while not calculating such parameters as lateral offset, are very accurate in eliminating layback errors.

#### LEAD

A weight attached to a line. A sounding lead is used for determining depth of water. A hand lead is a light sounding lead (7 - 14 lbs), usually having a line of not more than 25 fm. A deep sea lead is a heavy sounding lead (about 30 - 100 lbs), usually having a line 100 fm or more in length. A light deep sea lead (30 - 50 lbs), used for sounding depths of 20 - 60 fm, is called a coasting lead. A type of sounding lead used without removal from the water between soundings is called a fish lead. A drift lead is one placed on the bottom to indicate movement of a vessel. To heave the lead is to take a sounding with a lead.

#### LEAD LINE

A line, graduated with attached marks and fastened to a sounding lead, used for determining the depth of water when taking soundings by hand. The lead line is usually used in depths of less than 25 fm. Also called a sounding line.

#### LEAGUE

A measure of distance, varying for different times and for different countries, from 2.4 - 4.6 miles. In the U.S. it is considered to be about three miles.

#### LEAST DEPTH

The minimum depth of a submerged feature. The term is only used when the quality of the sounding meets existing hydrographic accuracy standards. It is never considered to be an approximate depth.

#### LEDGE

A rocky formation connected with and fringing the shore, and generally uncovered at the sounding datum. Where such features exist, the seaward limit of the area that uncovers is usually symbolized on smooth sheets and serves as a substitute for the zero depth curve.

#### LEEWARD

The direction toward which the prevailing wind is blowing; the direction toward which waves are traveling.

#### LEFT BANK

The river bank on the left-hand side as one proceeds downstream.

#### LEGEND

A description, explanation, table of symbols, and other information, printed on a map or chart to provide a better understanding and interpretation of it. The title of a map or chart formerly was considered part of the legend, but this usage is obsolete.

## LEVEE

1. An artificial or naturally formed low ridge of material built or deposited along a stream channel or limit areas subject to flooding. 2. An embankment bordering on one or both sides of a submarine canyon or sea channel, usually occurring along the outer edge of a curve or meander. See Dike, often incorrectly used interchangeably with levee.

## LEVELING

The process of determining differences of elevation between points on the surface of the earth; the determination of the elevation of points relative to a vertical datum. Also called differential leveling.

## LIDAR (LIght Detection and Ranging)

An airborne instrument that measures distance to an object by emitting timed pulses of light and measuring the time between emission and reception of the reflected pulses. The measured time interval is converted into distance. Topographic LIDAR measures elevations on land. Bathymetric LIDAR uses two different laser frequencies to measure water depths (one reflects off the water surface and the other off the seafloor). The ability of bathymetric

LIDAR to obtain such depth information is totally dependent on water turbidity but can measure depths of 60 meters in very clear water.

## LIGHT

A luminous or lighted aid to navigation.

## LIGHTHOUSE

A building on some conspicuous point of the coast, a pier or jetty, an island or rock, from which a light is exhibited at night as an aid to navigation. All maritime nations have government departments responsible for the establishment and maintenance of lighthouses.

## LIGHT LIST

A publication that lists and describes all marine aids to navigation maintained by or under authority of the U.S. Coast Guard.

## LIGHT LIST NUMBER

The number used to identify a navigational light in the Light List.

## LIGHT SECTOR

As defined by bearings from seaward, the sector in which a navigational light is visible or in which it has a distinctive color different from that of adjoining sectors, or in which it is obscured.

## LINE

A course or track, down the center of which a survey vessel travels during a survey. A line is delineated on either side by half the distance between the current and adjacent tracks. A common method of using sonar to perform search or survey operations is to set up a series of parallel lines. Represented as imaginary lines on the sea surface, they may be depicted on a computer screen from an Integrated Navigation System.

## LINEAR SCALE

Known in the U.S. as a bar scale. A sub-divided line which shows distances at a given scale. See also Graphic Scale.

## LINE FEATURE

A cartographic feature with the geometry of a line, i.e., defined by a sequence of connected points. Represented on a map by a line of a certain width or type, e.g., dashed, dotted, double, a sequence of symbols. Contrast with point

feature and area feature.

#### LINE SMOOTHING

The numerical manipulation of data points (pairs of coordinates) in order to reduce the number or amount of undulations along a line. May be used to remove irregularities introduced during digitizing, e.g., in case of line segments which do not join exactly or smoothly enough.

#### LINE SPACING

The distance between successive parallel vessel tracks in a multi-line survey that are traversed to build a grid to cover an intended survey area. Line spacing will vary depending upon survey equipment and operational goals.

#### LITTORAL

Of, or pertaining to, a shore, especially a seashore. Specifically, the various parts of a region bordering the sea, including the coast, foreshore, backshore, beach, etc.

#### LOCAL NOTICE TO MARINERS (LNM)

A notification issued at frequent intervals by U.S. Coast Guard districts giving changes and deficiencies in aids to navigation and other information of navigational importance within the particular district. LNM was historically a printed document, but is now available only on the U.S. Coast Guard website. Information of a continuing nature is included in the weekly Notice to Mariners which is issued by NGA.

#### LOCK

A basin in a waterway with caissons or gates at each end by means of which vessels are passed from one water level to another without materially affecting the higher level. To lock a vessel means to pass a vessel through a lock.

#### LOG BOOM

A floating barrier of timber used to protect a river or harbor mouth or to create an enclosed area for storage purposes.

#### LONGITUDE

Angular distance, along a Primary Great Circle, from the adopted reference point, usually the Greenwich or prime meridian. One of the coordinates used to describe a position, the other being latitude.

#### LORAN

A navigation system developed in the 1950s based on the time displacement between signals from two or more fixed shore based antennas. Two types of LORAN (an acronym for LONG RANGE Navigation) were developed. A low resolution LORAN-A was first. Cumbersome and difficult to use, LORAN-A required the user to tune a receiver and align signal peaks on a scope. A more efficient system, LORAN-C, was developed for use in the 1960s and provided the user with a readout of numbers representing time differences in microseconds. American charts were produced with these "TD" lines overprinted on them. Although LORAN-C was very repeatable (often to within 20 m), the system was not accurately tied to any datum. Further, since the radio transmissions propagated over land, conversion to latitude and longitude was only approximate, at best. For several decades since the late 1950s, LORAN was the major worldwide land-based navigation system. Offshore beyond the 600-mile range of these systems, dead reckoning with occasional fixes from transit satellites was a large part of ocean navigation. The Global Positioning System is expected to completely replace the need for LORAN transmitting stations worldwide.

#### LOW ORDER STATIONS

A category of control established by ground survey methods that do not meet established Third-Order criteria. Included are stations positioned through the use of a sextant or planetable, and any station positioned from, or sighting on, a moving object such that repeat measurements cannot be made.

#### LOWER LOW WATER (LLW)

The lowest of the low waters (or single low water) of any specified tidal day due to the declinational effects of the Moon and Sun.

#### LOW-TIDE ELEVATION

A naturally formed area of land surrounded by and above water at low tide but submerged at high tide. Lowtide elevations serve as part of the coast line when they are within the breadth of the territorial sea of the mainland or an island.

#### LOW WATER

The minimum height reached by a falling tide. The low water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions.

#### LOW WATER DATUM (LWD)

An approximation of mean low water that has been adopted as a standard reference for a limited area and is retained for an indefinite period regardless of the fact that it may differ slightly from a better determination of mean low water from a subsequent series of observations. Used primarily for river and harbor engineering purposes.

#### LOW WATER LINE

The intersection of the land with the water surface at an elevation of low water.

### **7.13 M**

#### MAGNETIC ANOMALY

The difference between the intensity of the magnetic field at a particular place and the intensity predicted for that place by a standard formula, such as that for a magnetic dipole.

#### MAGNETIC BEARING

Bearing determined with a magnetic compass and related to the magnetic meridian.

#### MAGNETIC NORTH

The direction indicated by the north-seeking pole of a freely suspended magnetic needle, influenced only by the earth's magnetic field.

#### MAGNETIC POLE

Either of the two places on the surface of the Earth where the magnetic dip is 90 degrees, that in the northern hemisphere being designated north magnetic pole, and that in the southern hemisphere being designated south magnetic pole. The magnetic poles are not fixed and do not coincide with the geographical poles.

#### MAGNETIC VARIATION

The angle between the magnetic and geographical meridians at any place, expressed in degrees east or west to indicate the direction of magnetic north from true north. Also called magnetic declination.

#### MAINLAND

The principal portion of a large land area. The term is used loosely to contrast a principal land mass from outlying islands and sometimes peninsulas.

#### MAINScheme

A term used to describe the primary set of sounding lines in a hydrographic survey.

## MAJOR AID TO NAVIGATION

An aid of considerable intensity, reliability, and range exhibited from fixed structures or marine sites. Major aids are classified as primary or secondary and are usually manned or remotely monitored.

## MANGROVE

For charting purposes, includes the mangroves and stands of tree-like plants that are predominately mangrove. These plants are perennials that frequently create an apparent shoreline. Much of this vegetation grows in the vicinity of the high waterline with overhanging and tangled growth that obscures the shoreline. Mangrove is found in saltwater throughout the tropics.

## MAN-MADE SHORELINE

The line of contact between the surface of a body of water and man-made land or features provided the man-made waterline is continuous with the natural shoreline. This is intended to include as man-made shoreline the water line along breakwaters, bulkheads, fill areas, jetties, and other features built out from the land.

## MANUSCRIPT

The original hand drawing of a map as compiled or constructed from various data, such as ground surveys, photographs, etc.

## MAP

A graphic representation of the physical features of the earth's surface observed during one or more surveys and depicted on a definite projection.

## MAP LOCATION

The location of a point or line on a map, rather than its demarcation on the ground.

## MAP PROJECTION

The process by which a portion or all of the curved surface of the earth can be represented on a plane with the least amount of distortion; a systematic drawing of lines representing meridians and parallels on a plane surface, either for the whole earth or some portion of it. See Projection.

## MARGINAL SEA

See Territorial Sea.

## MARIGRAM

Agraphic record of the rise and fall of the tide. The record is in the form of a curve in which time is generally represented on the abscissa and the height of the tide on the ordinate.

## MARINA

A harbor facility for small boats, yachts, etc., where supplies, repairs, and various services are available.

## MARINE RAILWAY

A track, cradle, and winching mechanism for hauling vessels out of the water so that the bottom can be exposed, as in a dry dock.

## MARK

1. A charted conspicuous object, structure, or light serving as an indicator for guidance or warning of a water craft.  
2. A definite object (such as an imprinted metal disk) used to designate a survey point and usually used with a qualifying term such as "Reference Mark" or "Bench Mark".  
3. A call used by hydrographers to signal an event such as the instant a survey position is recorded.

## MARKER

That which marks something for a specific purpose, e.g., a measured mile marker, or a dredging range marker. This term is generally used to refer to certain aids to navigation, often privately maintained, which are erected to mark channels.

## MARKER BUOY

A buoy used to temporarily mark a location of particular interest, such as a shoal, reef, obstruction, or diving operation.

## MARSH

A tract of soft, wet land, usually vegetated by reeds, grasses and occasionally small shrubs.

## MEADES RANCH

A triangulation station established in 1891 in central Kansas which was adopted as the basis for the United States Standard Datum. The selection was based on the fact that it was near the center of area of the United States and was common to 2 great arcs of triangulation extending across the country – one along the 39th parallel and the other along the 98th meridian. The origin or initial point for the North American Datum of 1927 (NAD 27) which was the regional horizontal coordinate system used throughout the U.S. until 1986.

## MEAN HIGHER HIGH WATER (MHHW)

A tidal datum which is the average of the higher high water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch.

## MEAN HIGH WATER (MHW)

A tidal datum which is the average of all the high water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch

## MEAN LOWER LOW WATER (MLLW)

A tidal datum which is the average of the lower low water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch

## MEAN LOW WATER (MLW)

A tidal datum which is the average of all the low water heights of each tidal day observed over a 19-year National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch

## MEAN SEA LEVEL (MSL)

A tidal datum that is the arithmetic mean of hourly water elevations observed over a 19-year National Tidal Datum Epoch. Shorter series are specified in the name; e.g., monthly mean sea level and yearly mean sea level.

## MEAN WATER LEVEL

A tidal datum which is the mean surface elevation as determined by averaging the heights of the water at equal intervals of time, usually hourly, over a 19-year National Tidal Datum Epoch. Mean water level used in areas of little or no range in tide.

## MEASURED MILE

An cartographically displayed length of 1 nautical mile, the limits of which have been accurately measured and are

indicated by ranges ashore. It is used by vessels to calibrate logs and engine revolution counters, and to determine speed.

#### MERCATOR CHART

A chart on the Mercator Projection. This is the chart commonly used for marine navigation. On a Mercator chart, a rhumb line is a straight line.

#### MERCATOR PROJECTION

A Conformal Projection of the cylindrical type. The Equator is represented by a straight line true to scale; the geographic meridians are represented by parallel straight lines perpendicular to the line representing the Equator; they are spaced according to their distance apart at the Equator. The geographic parallels are represented by a second system of straight lines perpendicular to the family of lines representing the meridians, and therefore parallel with the Equator. Conformality is achieved by mathematical analysis, the spacing of the parallels being increased with the increasing distance from the Equator to conform with the expanding scale along the parallels resulting from the meridians being represented by parallel lines. Since Rhumb Lines appear as straight lines and directions can be measured directly, this projection is widely used in navigation.

#### MERIDIAN LINE

A north-south line from which longitudes or azimuths are reckoned.

#### MERIDIANS

A north-south reference line, particularly a great circle through the geographical poles of the earth. Meridians are measured in degrees east or west of the prime meridian and pass through longitude 0°. See Longitude.

#### MERIDIONAL PARTS

The length of the arc, expressed in units of 1 min of longitude at the equator, of a meridian between the Equator and any parallel of latitude on the graticule of the Mercator map projection. See Tables for a Polyconic Projection of Maps.

#### METES AND BOUNDS

The boundary lines or limits of a tract of land. One of the oldest methods of describing land and was used to transfer lands in the Thirteen Original Colonies. Defined variously in law dictionaries as: the boundary lines of land, with their terminal points and angles; the boundary lines and corners of a piece of land; and the boundary lines of lands with their terminating points of angles.

#### MILE

A unit of distance. The nautical mile, or sea mile, is used primarily in navigation. Nearly all maritime nations have adopted the International Nautical Mile of 1,852 m proposed in 1929 by the International Hydrographic Bureau. The International Nautical Mile is equivalent to 6076.11549 ft, approximately. The geographical mile is the length of 1 minute of arc of the equator, considered to be 6,087.08 ft. The statute mile or land mile (5,280 ft in the U.S.) is commonly used for navigation on rivers and lakes, notably the Great Lakes of North America.

#### MILEAGE NUMBER

Assigned to aids and gives the distance in sailing miles along the river from a reference point to the aid. Principally used in the Mississippi River System.

#### MINIMUM OBSERVED DEPTH

The shallowest depth over a submerged feature obtained during the course of a non-specific investigation. It may not be the Least Depth but could be reclassified as such following a careful review of the data to determine if it meets or exceeds current specifications for a basic hydrographic survey.

## MICRO WAVE POSITIONING SYSTEM

A compact, light, and mobile distance measuring system that operates on the basic principle of pulse radar. A transmitter aboard the survey vessel interrogates transponders at known locations. Elapsed time between transmitted interrogations and the reply from each transponder is used as the basis for determining range to each transponder. This range information, together with the known location of each transponder, can be trilaterated to provide the position of the survey vessel. A widely used type of survey positioning system in the 1970's through early 1990's which was made obsolete by GPS.

## MINOR AID TO NAVIGATION

An unmanned, unmonitored light on a fixed structure showing usually low to moderate intensity; generally fitted with light characteristics and day boards in accordance with its lateral significance in the waterway.

## MINUS SOUNDINGS

Soundings that reduce to height above the sounding datum (plane of reference) when corrected for water level. Minus soundings are shown on the smooth sheet preceded by a minus sign unless they are used to denote the least depth on a wreck or obstruction. In that case, the sounding is portrayed as an underlined value in parentheses. A minus sounding has a value above chart datum. For example, chart datum of MLLW would be the 0 contour; a value of -1 would be 1 ft above MLLW chart datum water line.

## MISCELLANEOUS SOURCES

Source information provided by other organizations. Such sources would include the U.S. Army Corps of Engineers, U.S. Coast Guard, National Geospatial-Intelligence Agency (formerly known as the National Imagery and Mapping Agency or NIMA), U.S. Geological Survey, Environmental Protection Agency, U.S. National Park Service, and state, local, and foreign government sources.

## MIXED TIDES

Tides characterized by a conspicuous diurnal inequality in the higher high and lower high waters and/or the higher low and lower low waters. Quantitatively, a tide is mixed if the ratio of diurnal tidal constituents  $K1+O1$  to the semidiurnal constituents  $M2+S2$  is between 0.25 and 3.0.

## MODIFIED ROUTE CHARTS

NOS charts that are versions of Intracoastal Waterway charts that were originally issued in a conventional chart format. They are identical in construction and format to area charts, and are used for some areas not adaptable to route chart style for long, narrow waterways. See Route Charts.

## MOLE

A form of breakwater alongside which vessels may lie on the sheltered side only; in some cases it may lie entirely within an artificial harbor, permitting vessels to lie along both sides.

## MONUMENT

In surveying, a structure used or erected to mark the position of a station; permanence is implied.

## MOORING

1. A place where a vessel may be secured. 2. The process of securing a vessel, other than anchoring with a single anchor.

## MOORING BUOY

A buoy secured to the sea floor by permanent moorings and provided with means for mooring a vessel by use of its anchor chain or mooring lines.

## MORAINES

An accumulation of earth, stones, etc., deposited by a glacier, usually in the form of a mount, ridge, or other prominence on the terrain. In charting, these features often exist at the entrance to or within fjord-like waterways and, frequently, contain hazardous shoal depths or rocky obstructions.

## MOSAIC

An assembly of side scan sonar records matched in such a way as to show a continuous, two-dimensional representation of an area of seabed.

## MOTION REFERENCE UNIT (MRU)

Measures the motion of the vessel or platform, usually Heave, Pitch, and Roll. Yaw is also measured by some MRUs.

## MUD FLAT

A muddy, low-lying strip of ground by the shore, or an island, usually submerged more or less completely by the rise of the tide.

## MULTIPATH

As related to echo sounding, sonar signals arriving at a target, or returning to a transducer from a single source but along different paths. Multipath returns in imaging sonars typically occur in shallow water or around complex structures, such as petroleum platforms or near piers and pilings. A classic multipath environment for side scan sonar is in shallow water with a flat sea surface. Acoustic echoes will return to the transducer along 3 different paths: 1. transducer - target - transducer; 2. transducer - target - sea surface - transducer; and 3. transducer - sea surface - target - sea surface - transducer. If these 3 return paths take 3 different times, the result will be 3 images of the same target in the data. As related to navigation systems (e.g., GPS) multipath is the corruption of the direct GPS signal by reflection from the local surroundings which adversely affects measurements in a GPS receiver.

## 7.14 N

### NALL

See Navigable Area Limit Line

### NARROWS

A navigable narrow part of a bay, strait, river, etc.

### NATIONAL GEODETIC VERTICAL DATUM of 1929 [NGVD (1929)]

Previously called the Sea Level Datum of 1929, it was a vertical control datum established for vertical control in the United States by the general adjustment of 1929. The datum was derived for surveys from a general adjustment of the first-order leveling nets of both the U.S. and Canada. In the adjustment, which was made in 1929, mean sea level was held fixed as observed at 21 tide stations in the U.S. and 5 in Canada. The datum (was) not mean sea level, the geoid, or any other equipotential surface. Therefore it was renamed, in 1973, the National Geodetic Vertical Datum on 1929. This vertical datum was in use until the adoption, in 1991, of the North American Vertical Datum of 1988 which held fixed the height of the primary tidal bench mark, referenced to the new International Great Lakes Datum of 1985 local mean sea level height value, at Father Point/Rimouski, Quebec, Canada.

### NATIONAL TIDAL DATUM EPOCH (NTDE)

The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g. mean lower low water, etc.) for tidal datums. It is the policy of NOS to consider a revised NTDE every 20-25 years in order to take into account relative sea level changes caused by global sea level change and the effects of long term local land movement due to subsidence or

glacial rebound. The present NTDE is 1983-2001. Previous tidal epochs were determined for periods 1924-42, 1941-59, and 1960-78.

#### NATURAL HARBOR

A harbor possessing natural shelter in a large degree. Natural harbors require only the provision of such facilities as quays or piers and sometimes deepening by artificial means to make them serviceable as shipping ports.

#### NATURAL SHORELINE

The line of contact between the surface of a body of water and natural land, including islands. It does not include the water line along floating or man-made features, or along rocks smaller than those considered to be islands.

#### NAUTICAL

Of or pertaining to ships, navigation (chiefly marine), or seamen. In contrast, navigational refers to navigation only; marine refers to the sea; maritime indicates relationship or proximity to the sea; and naval refers to the navy.

#### NAUTICAL CHART

A representation of a portion of the navigable waters of the earth and adjacent coastal areas on a specified map projection, and designed specifically to meet requirements of marine navigation. Included on most nautical charts are: depths of water, characteristics of the bottom, elevations of selected topographic features, general configuration and characteristics of the coast, the shoreline (usually the mean high water line), dangers, obstruction, aids to navigation, limited tidal data, and information about magnetic variation in the charted area.

#### NAUTICAL MILE

A unit of distance used in marine navigation, which may be taken as equal to the length of a minute of arc along the equator or a minute of latitude on the map which is being measured. Nearly all maritime nations have adopted the International Nautical Mile of 1,852 m proposed in 1929 by the International Hydrographic Bureau. See Mile.

#### NAVIGABLE

Affording passage to a craft; capable of being navigated.

#### NAVIGABLE AREA LIMIT LINE (NALL)

An alongshore survey line that is also known as a shoreline buffer. The shoreline buffer or NALL should be run at or near low water prior to acquiring mainscheme hydrography in the near shore area. The shoreline buffer is a way of providing the hydrographer a "first look" at the near shore detail, which may identify gross discrepancies in the source or charted shoreline, and reveal significant offshore features that may pose a risk to a survey launch at higher water.

#### NAVIGABLE AREA SURVEYS (NAS)

Basic hydrographic surveys with restricted area coverage. By restricting the area of coverage while retaining the "basic" hydrography concept within surveyed waters, a more rapid progression of field work is realized. The coverage is typically reduced by omitting requirements for: (1) development of the 0-foot depth curve and (2) foul, nearshore areas not considered navigable. Navigable Area Surveys may also be restricted to the main navigable channel or corridor.

#### NAVIGABLE WATERS

Waters usable, with or without improvements, as routes for commerce in the customary means of travel on water.

#### NAVIGABLE WATERS OF A STATE

Navigable waterways that lie wholly within the limits of a state and have no navigable connection with any navigable

waters outside the boundaries of that state. Such intrastate waters are subject to regulation and control by state laws and do not fall within the jurisdiction of Congress nor of the laws enacted by it for the preservation and protection of the navigable waters of the United States.

#### NAVIGABLE WATERS OF THE UNITED STATES

Waters which form, in their ordinary condition by themselves, or by uniting with other waters, a continuous highway over which commerce is or may be carried on with other states or foreign countries in the customary modes in which such commerce is conducted by water. This applies also to an artificial canal, even though the canal is wholly within the body of a state and subject to its ownership and control.

#### NAVIGATION RESPONSE TEAMS

Navigation Response Teams are Office of Coast Survey field units that perform surveys for emergency responses, such as following groundings or hurricanes, and for updating NOS nautical charts. An NRT unit typically consists of a small survey boat capable of being transported by trailer, an office trailer, and a crew of three hydrographers.

#### NAVIGATIONAL AID

An instrument, device, chart, method, etc., intended to assist in the navigation of a craft. This expression should not be confused with the term "Aids to Navigation", which refers only to devices external to a craft.

#### NEAT LINE

A line, usually a grid or a graticule, bounding the detail of a map. Also referred to as inner neat line, to differentiate it from a border drawn outside of a neat line.

#### NECK

The narrow strip of land with water on each side and connecting two larger bodies of land; an isthmus.

#### NEW CHART

A chart usually constructed to satisfy the needs of navigation in a particular area, e.g., because the area had no prior adequate chart coverage of the same scale, or because the limits are radically changed. The new chart may cancel an existing chart.

#### NEW EDITION

A chart issue that cancels a previous issue. If the new information renders that existing chart obsolete, the new printing is designated a new edition. A new edition reflects one or more changes of such importance to navigation that all previous printings are obsolete. Changes may be based on corrections from the Notice to Mariners (NTM) in addition to other sources. The date of a new edition is the date of the latest NGA NTM from which the chart has been corrected. The edition number and date are printed in the lower left corner of the chart.

#### NIMA (National Imagery and Mapping Agency)

Former name of the National Geospatial-Intelligence Agency (NGA), which was adopted in November 2003.

#### NOISE

Extraneous signals detected by a sonar that affect the system's efficiency to display, and the operator's efficiency to interpret, the signals of interest. Noise can originate from many different sources both internal and external to the sonar system. See Interference.

#### NOMINAL RANGE

The maximum distance a light may be seen in clear weather (meteorological visibility of 10 Nautical Miles (NM), without regard to the curvature of the earth, the height of the eye, or the height of the light. Listed for all federal lighted aids, except range lights and directional lights.

## NON-TIDAL WATERS

Waters not subject to tidal influence. Under Public Law 31, lands beneath such waters of a state which were navigable when the state entered the Union are granted to the state.

## NORTH AMERICAN DATUM (NAD)

A horizontal control datum which is the same as United States Standard Datum. The name was changed to North American Datum early in 1913 when Canada and Mexico adopted the United States Standard Datum for their triangulation. This change in name reflected the continental character the datum now assumed.

## NORTH AMERICAN DATUM of 1927 (NAD27)

The name to which the North American Datum was changed in 1932 as a result of the unified adjustment of the triangulation in the western half of the country. The North American Datum of 1927 (NAD 27) was the horizontal control datum for the U.S. that was defined by a location and azimuth on the Clarke spheroid of 1866, with its origin at the survey station Meades Ranch, Kansas. The geoidal height at Meades Ranch was assumed to be zero. As of 1963, all of the conterminous United States and the whole of Alaska (including the offshore islands in the Bering Sea) were connected by one continuous triangulation and placed on NAD27.

## NORTH AMERICAN DATUM of 1983 (NAD83)

The modern horizontal control datum for the United States, Canada, Mexico, and Central America which is based on a geocentric (earth centered) origin and the Geodetic Reference System 1980. NAD 83 is based on the adjustment of 250,000 points including 600 satellite Doppler stations which constrain the system to a geocentric origin. The computation of the NAD 83 removed significant local distortions from the network which had accumulated over the years, using the original observations, and makes NAD 83 much more compatible with modern survey techniques.

## NOTICE TO MARINERS (NTM)

A weekly publication of the NGA, which corrects NGA and National Ocean Service (NOS) charts using information collected from many sources including the U. S. Coast Guard Local Notice to Mariners. The publication contains only those chart corrections of interest to ocean going vessels. NRT See Navigation Response Teams.

## NUMERICAL SCALE

The scale of a survey (or chart) expressed in terms of the distance on the earth represented by one unit on the survey, e.g., "1 inch equals 20 miles," "3 inches to the mile."

## NUN BUOY

An unlighted buoy of which the upper part of the body (above the waterline), or the larger part of the superstructure, has approximately the shape of a cone with vertex upwards.

## 7.15 O

### OBLATE SPHEROID

An ellipsoid of revolution, the minor axis of which is the axis of revolution. The Earth is approximately an oblate spheroid.

### OBSCURED

Said of the arc of a light sector designated by its limiting bearings in which the light is not visible from seaward.

#### OBSOLETE CHART

A chart which is not considered safe to use for navigation because it does not contain the latest important navigational information.

#### OBSTRUCTION

Anything that hinders or prevents movement, particularly anything that endangers or prevents passage of a vessel or aircraft. The term is usually used to refer to an isolated danger to navigation, such as a submerged rock or pinnacle in the case of marine navigation.

#### OBSTRUCTION BUOY

A buoy used alone to indicate a dangerous reef or shoal. The buoy may be passed on either hand.

#### OBSTRUCTION MARK

A navigation mark used alone to indicate a dangerous reef or shoal. The mark may be passed on either hand.

#### OCCULTING LIGHT

A light in which the total duration of darkness in a period is shorter than the total duration of light and appearances of darkness are usually of equal duration.

#### OCEANOGRAPHY

The study of the ocean, embracing and integrating all knowledge pertaining to the ocean's physical boundaries, the chemistry and physics of sea water, marine biology and submarine geology.

#### OCEAN SURVEY SHEETS (OSS)

Antiquated term that refers to survey sheets that cover large areas of the ocean. Limits of the OSS series were designed to conform closely to the U.S. Navy Bathymetric series.

#### OFFSHORE

In NOAA operational hydrographic terms, the zone extending seaward from depths of 8 m. In general terms, the comparatively flat zone of variable width which extends from the outer margin of the rather steeply sloping shoreface to the edge of the continental shelf.

#### OFFSHORE WIND

A wind blowing from the land toward the sea.

#### OFF STATION

Used to describe a floating navigational aid that is not "on station" or in its assigned geographic location.

#### OLD HAWAIIAN DATUM

The standard horizontal datum for the main Hawaiian islands. Old Hawaiian Datum is an independent datum that was derived from the North American Datum 1927 (NAD27).

#### ON STATION

Used to describe a floating navigational aid that is in its assigned geographic location. Opposite of Off Station.

#### ONSHORE WIND

A wind blowing from the sea toward the land.

## OOZE

A fine-grained pelagic sediment containing more than 30% organic material combined with amorphous claysized material and found only in the greater ocean (abyssal) depths off the Continental Shelf on the abyssal plains. Ooze is a classification by composition, not grain size. Accordingly, considering grain size, ooze is mud but mud is not necessarily ooze. Soft mud is, commonly, improperly referred to as ooze.

## OPEN COAST

The coast that fringes the marginal sea, as distinguished from the coast that fringes inland waters. ORIGIN In surveying, the reference position from which angles or distances are reckoned. In cartography, (1) the point of intersection of the coordinate axes, from which the coordinates are reckoned; (2) the origin of coordinates is the point to which the coordinate values (0, 0) are assigned, irrespective of its position with reference to the axes; (3) the origin of coordinates is the point from which the computation of the elements of the coordinate system (projection) proceeds.

## ORTHOMETRIC HEIGHT

The distance of a point above the geoid.

## ORTHOGONAL

Pertaining to or composed of right angles.

## ORTHOPHOTOGRAPH

A photographic copy, prepared from a perspective photograph, in which the displacements of images due to tilt and relief have been removed.

## ORTHOPHOTOMAP

A map made by assembling a number of orthophotographs into a single, composite picture. A grid is usually added. It may be further improved, cartographically, by photographically bringing edges out sharply in the picture, or by adding color or symbols.

## ORTHOPHOTOQUAD

An orthophotograph, or mosaic of orthophotographs, at the size of a standard U.S.G.S quadrangle (a scale of 1:24,000) with little or no cartographic work added to it.

## OUTER CONTINENTAL SHELF

All submerged lands lying seaward and outside of the area of "lands beneath navigable waters," as defined in section 2(a) of the Submerged Lands Act (43 U.S.C. 1301(a), and of which the subsoil and seabed appertain to the U.S. and are subject to its jurisdiction and control.

## OUTER EDGE OF MARSH

The line delineated on topographic surveys as the dividing line between land and water, rather than the high-water line, for use on nautical/navigational charts.

## OUTFALL

A structure extending into a body of water for the purpose of discharging sewage, storm runoff or cooling water.

## OUT-OF-RANGE

Target echoes displayed by the sonar resulting from hard reflectors that are beyond the system range setting. When an imaging sonar transmits an acoustic pulse, it propagates into the environment. After the pulse travels beyond the set range of the system, another pulse is transmitted. However, the first pulse is still moving away from the transducer and sending back echoes. Even though those echoes are returning from out-of-range, this is not normally a problem because the sonar system gains are reduced in the near field (for the second outgoing pulse).

In a quiet environment, where there is little backscatter in the near field and there are hard targets out of range, these targets will be imaged after the second pulse starts its propagation. In radar, this phenomenon is called a “second sweep return.”

#### OUTSIDE SOURCE DATA (OSD)

Previously called Third Party Data. Source data that originates from sources other than the Office of Coast Survey (OCS) hydrographic field units and contractors. Outside sources would include the U.S. Army Corps of Engineers, U.S. Naval Oceanographic Office, USGS, state and local governments, academic institutions and commercial entities not conducting surveys under contract to NOAA/OCS.

#### OVERFALLS

Short, breaking waves occurring when a strong current passes over a shoal or other submarine obstruction or meets a contrary current or wind.

#### OVERLAP

The area of seabed between survey lines that is ensonified twice, once by the swath on each side. Planned overlap is useful to assure efficient 100% coverage of the seabed. Since a vessel's track line is not a perfectly straight line, overlap of one swath with a portion of the next will help ensure that there are no data gaps between tracks.

#### OVERLAY

1. A printing or drawing on a transparent or semitransparent medium at the same scale as a map, chart, etc., to show details not appearing, or requiring special emphasis, on the original. 2. Additional data, or a pattern, printed after the other features so as to “overlay” them. 3. A sheet containing explanatory or modifying data, placed over and keyed to the existing or basic copy. Sometimes used as a means of correcting the underlying copy.

#### OVERPRINT

Information printed or stamped upon a map or chart, in addition to that originally printed, to show data of importance or special use.

#### OVER-THE-GROUND

A measurement of the speed or course of a vessel with respect to the seabed, independent of movement in relation to wind or water.

## **7.16 P**

#### PANTOGRAPH

An instrument which makes use of the properties of a parallelogram, for the mechanical copying of drawings at a predetermined reduced (or enlarged) scale. Once used extensively within NOAA's chart production program to transfer information from a source map to a nautical chart. The tool is no longer used, having been replaced by digital techniques, such as vector digitization.

#### PARALLEL

A circle (or approximation of a circle) on the surface of the Earth, parallel to the equator and connecting points of equal latitude.

#### PARITY BIT

A data bit, set at “0” or “1,” that provides information on whether the total number of bits in a data field is even or odd. This is used to ensure data integrity and that no data is lost. PASS A single procession by a seabed anomaly during a sonar survey. Multiple passes by a target may be necessary for target classification and interpretation. For

example, thermal discontinuities rarely look the same on any two passes. A target that may be a school of fish can be properly identified by multiple passes because fish schools rarely stay in one place over any length of time.

#### PASSAGE

A narrow navigable channel, especially one through reefs or islands. Sometimes called a pass or, in New England waters, a hole.

#### PASSING LIGHT

A term applied to a lower candlepower light mounted on a light structure. Used where a mariner passes out of the main light beam (such as a range light) but still needs to keep the structure in sight during transit.

#### PASSIVE SONAR

A sonar system having only a hydrophone, and capable of receiving signals but not transmitting them.

#### PATH-TRACKING

The ability of a towed body to accurately follow the path along which it is towed. In the absence of high velocity currents and using short cables, most side scan sonar towfish will track along the ship's path well. However, if the sonar is towed at 90 degrees to a strong current and over long cable, it will tend to be displaced from the vessel's path and heading. See Lateral Offset.

#### P-CODE

A term related to GPS signals. A bi-phase shift modulated on both the L1 and L2 carrier frequencies. P-code has a 10.23 MHz bit rate and, as implemented in GPS, has a period of 1 week. Each satellite has a unique P-code that is used to distinguish that satellite from all others.

#### PEBBLES

Beach material, usually well-rounded and between 4 - 64 mm in diameter.

#### PECKED LINE

A cartographic term describing a symbol consisting of a line broken at regular intervals.

#### PERCH

A staff placed on top of a buoy, rock, or shoal as a mark for navigators. A ball or cage is sometimes placed at the top of the perch as an identifying mark.

#### PENINSULA

A body of land jutting into and nearly surrounded by water, frequently (but not necessarily) connected to a larger body of land by a neck or isthmus.

#### PERIOD

The interval of time necessary for a regularly recurring motion to make a complete cycle. The period of a navigational light is the time taken to exhibit one complete sequence of intervals of light and darkness.

#### PHASE

Relative measurement describing the temporal relationship between two waves with the same frequency. Phase is measured in degrees, and one full oscillation cycle has 360 degrees. One way to think of phase is this: If two pendulums are swinging at the same frequency and are in the same position at the same instant, then they are in phase with each other.

## PHOTOGRAMMETRIC COMPILATION

The production of a map or chart, or portion thereof, from aerial photographs and geodetic control data. When compilation involves stereo instruments, this is called stereocompilation.

## PHOTOGRAMMETRIC SURVEY

A survey of a portion of the land surface utilizing aerial photographs and reduced to map form by stereoscopic or other instrumental equipment.

## PHOTOGRAMMETRY

1. The science of obtaining reliable measurements from photographic images. 2. The science of preparing charts and maps from aerial photographs using stereoscopic equipment and methods.

## PHOTOMOSAIC

1. An assemblage of photographs, each of which shows part of a region, put together in such a way that each point in the region appears once and only once in the assemblage, with scale variation minimized. A photomosaic is assembled by trimming, warping, and fitting together the individual photographs. If the photographs were taken at different heights, the individual photographs must be enlarged or reduced to a common scale. 2. An assemblage of parts of aerial photographs joined together to leave as few variations of scale as possible.

## PHOTOTRIANGULATION

The determination of horizontal or vertical coordinates from measurements of angle, distance, or coordinates of points on overlapping photographs. Phototriangulation is classified as terrestrial or aerial, depending on whether the photographs were taken on the ground or from the air. Aerial phototriangulation is commonly called "aerotriangulation."

## PIER

A long, narrow structure extending into the water approximately perpendicular to a shore or a bank to providing berthing for ships, to serve as a promenade or place for other use, as a fishing pier.

## PIERHEAD

That part of a pier or jetty projecting farthest into the water.

## PIERHEAD LINE

The line fixing the boundaries of the fairway to which wharf or pier structures (of open construction) may be built.

## PILE

A long substantial timber or section of wood, concrete, or metal, forced into the earth or seabed to serve as a support, as a pier, or to resist lateral pressure.

## PILING

Plural form of Pile. Sometimes used to describe a row of piles.

## PILLAR BUOY

A buoy composed of a tall central structure mounted on a broad flat base. Also called a beacon buoy.

## PILOT

One who provides guidance to a vessel's captain regarding the movements of a vessel through pilotage waters; usually, one who has demonstrated extensive knowledge of channels, aids to navigation, dangers to navigation, etc., in a particular area and is licensed for that area.

## PILOT AREA

A pilot area represents a meeting or boarding place where vessels pick up or disembark licensed pilots. A pilot vessel may either cruise in the area continuously or come out upon request.

## PING

A single transmitted output pulse of a sonar system; also, the reflected return signal from a single output.

## PINNACLE

On the sea floor, a high tower or spire-shaped pillar of rock or coral, alone or cresting a summit. It may extend above the surface of the water. It may or may not be a hazard to surface navigation.

## PIPE

A hollow metal tube embedded in the bottom in a manner similar to a pile. Pipes will vary in diameter and length, and are often used as privately maintained aids to navigation.

## PITCH

An instability in vessel or towfish attitude expressed by the alternate rise and fall of the bow/nose and stern/tail about a horizontal axis.

## PLANE RECTANGULAR COORDINATES

A system of coordinates in a horizontal plane, used to describe the positions of points with respect to an arbitrary origin. The origin is established by a pair of axes which intersect at right angles. The position of a point is determined by the perpendicular distances to these axes. Also call plane coordinates.

## PLANETABLE

A surveying instrument used in topographic mapping by which the surveyor plots his survey in the field directly from the observations, without the necessity of keeping notes for later office plotting. It consists essentially of a drawing board on a tripod to which the survey sheet is clamped and adjusted in the horizontal plane, an alidade (a telescope mounted on a metal, straight-edge ruler) for measuring directions and distances to salient features of the terrain, and a telemeter rod graduated for the optical measurement of distances from the observer.

## PLANIMETER

A mechanical integrator for measuring the area of a plane surface.

## PLANIMETRIC SURVEY

A survey which presents the horizontal position only for the features represented; distinguished from a topographic map by the omission of relief.

## PLAT

A diagram drawn to scale showing land boundaries and subdivisions, together with all data essential to the description and identification of the several units shown thereon, and including one or more certificates indicating due approval. A plat differs from a map in that it does not necessarily show additional cultural, drainage, and relief features.

## PLATFORM

1. In oceanographic terminology, any man-made structure (aircraft, ship, buoy, or tower) from which or on which oceanographic instruments are suspended, installed, or operated. 2. Any offshore fixed or floating structure providing a flat or specially designed working surface above the water which serves a specific and/or specialized purpose, e.g., drilling, survey, research, potable water intake, swimming-diving, or storage functions.

## PLOT

1. A map, chart, or graph representing data of any sort. 2. To represent on a diagram or chart the position or course of a target in terms of angles and distances from known position; to locate a position on a map or a chart. 3. A portion of a map or overlay on which are drawn the outlines of the areas covered by one or more photographs. 4. To generate graphic images according to a given system of coordinate values, such as scale factor. 5. To use a plotter.

## PLOTTING SHEET

(Used prior to digital plotters) A blank chart, usually on the Mercator projection, showing only the graticule and a compass rose, so that the plotting sheet can be used for any longitude. In hydrographic surveying, a working sheet on which the main stations of the survey are plotted. It formed the framework of the survey and provided the basis for accurately locating and plotting all the detail of the survey.

## POINT

1. The extreme end of a cape, or the outer end of any land area protruding into the water (less prominent than a cape). 2. A place having position, but no extent. 3. One thirty-second of a circle, or  $11 \frac{1}{4}^{\circ}$ . A cardinal point is any of the 4 principal directions, north, east, south, or west; an intercardinal point is any of the 4 directions midway between the cardinal points, northeast, southeast, southwest, or northwest. Also called compass points when used in reference to compass directions.

## POINT FEATURE

A point feature is a single point item such as a pile, wreck, rock, obstruction, etc. located at one specific geographic location. This may include detached positions for data types such as bottom samples, sound velocity cast locations, navigational aids, feature disprovals, existing navigationally significant features, and AWOIS items.

## POINT SYMBOL

A symbol employed to indicate that a particular phenomenon occurs at, or a particular value may be attributed to, a specific point on a map.

## POLAR COORDINATES

1. A coordinate system based on a sphere. 2. An alternative system of marking a point on a plane by its radial distance ( $r$ ) from an "origin" and a polar angle ( $f$ ). When 3-dimensional polar coordinates overlap a Cartesian ( $x$ ,  $y$ ,  $z$ ) system,  $q$  is the angle between the line to the origin and the  $z$ -axis, while  $f$  is the (counter-clockwise) angle between the projection of that line onto the ( $x$ , $y$ ) plane and the  $x$ -axis. Concerning( $q$ ,  $f$ ), see also latitude and longitude, declination, azimuth and elevations. 3. An alternative to the usual Cartesian method of addressing image pixels. Polar coordinates use the coordinate pair, angle and radius from an origin instead of column and row. 4. A 2-D coordinate system used to locate a point in a plane by specifying a distance and an angle from the coordinate origin. If another distance normal to the coordinate origin is added, cylindrical coordinates can be specified.

## POLE

An elongated rod of wood or metal driven into the bottom to serve a particular purpose. Of smaller diameter than a pile, but larger diameter than a stake.

## POLYCONIC PROJECTION

A map projection having the central geographic meridian represented by a straight line, along which the spacing for lines representing the geographic parallels is proportional to the distances between the parallels; the parallels are represented by arches of circles that are not concentric, but whose centers lie on the line representing the central meridian, and whose radii are determined by the lengths of the elements of cones which are tangent along the parallels. All meridians except the central ones are curved. The projection is neither conformal nor equal area, but it has been widely used for maps of small areas because of the ease with which it can be constructed. The origin

of the projection, at least in concept, is credited to Ferdinand R. Hassler, the first Superintendent of the Coast Survey, and was used for all the hydrographic surveys of the agency until the 1990s.

#### PONTOON BRIDGE

A bridge supported on pontoons.

#### PORT

A place for the loading and unloading of vessels recognized and supervised for maritime purposes by the public authorities. The term includes a city or borough for the reception of mariners and merchants, and therefore denotes something more than a harbor. A port may possess a harbor but a harbor is not necessarily a port. Any natural creek or inlet on the sea shore with adequate depth of water and sufficient shelter for ships fulfills the essential conditions of a harbor. To make it a port, in the accepted sense of the word, there must be additional accommodations and facilities for landing passengers and goods.

#### PORT SERIES

A series of reports, published jointly by the U.S. Army Corps of Engineers (USACE), the Maritime Administration (MARAD), and the U.S. Department of Transportation (DOT). The reports describe in detail pilotage information for the principal ports of the United States, as well as the facilities and services available to shipping at selected U.S. seaports.

#### POSITION

Data which define the location of a point with respect to a reference system. The coordinates that define a location. The place occupied by a point on the surface of the Earth, or in space.

#### POSITION APPROXIMATE

Of inexact position. The expression is used principally on charts to indicate that the position of a wreck, shoal, etc., has not been accurately determined or does not remain fixed. Usually shown by the abbreviation "PA."

#### POSITION DOUBTFUL

Of uncertain position. The expression is used principally on charts to indicate that a wreck, shoal, etc., has been reported in various positions and not definitely determined in any. Usually shown by the abbreviation "PD."

#### POSITION NUMBERS

Numbers historically assigned to a "fix" of the survey boat's position at one particular time, starting with number 1 at the beginning of the survey and continuing consecutively to the end of the survey.

#### POSITION REPORTED

The reported location of a feature. Usually, this refers to the geographic location of a feature that has been reported to proper authorities, such as the U.S. Coast Guard or local marine agencies. Usually shown on charts by the text "reported."

#### POST

A small beacon used for marking channels. This beacon is usually more substantial than a perch, and has a diameter larger than that of a stake but smaller than that of a pile.

#### POST-PROCESSING

Data processing performed after real-time data acquisition.

### POTABLE WATER INTAKE (PWI)

A structure designed for the intake of drinking water. The intake is usually elevated above the bottom, and supported and protected by a debris-screening structure (crib), usually a separately charted feature.

### POUND NET

A set net composed of vertical netting supported and held in place by stakes. It consists of three essential parts, the pot (pound, pocket, bowl), the wings or hearts, and the leader or lead. The pound consists of a bag of stout netting with 1-in meshes the margin of which is supported by upright stakes. The bottom of the pound is spread and secured by ropes which pass through loops near the lower end of the stakes. The wings or heart are vertical fences of netting diverging from the entrance of the net. The mesh is ½ -in and is supported by stakes. The leader, which may vary in length from about 150 - 1,000 ft or more, extends from shore or shallow water into deeper water, and deflects the fish towards the heart or wings.

### PRECAUTIONARY AREA

A routing measure comprising an area within defined limits where ships must navigate with particular caution and within which the direction of traffic flow may be recommended.

### PRECISION

The degree of refinement of a value; not to be confused with its accuracy, which is the degree of conformance with the correct value.

### PREDICTED TIDES

Tide levels that are predicted by combining the harmonic constituents over time at a particular tidal location.

### PRELIMINARY CHART

A chart for which there is a requirement, but for an area in which some or all of the survey data does not meet modern standards. The deficiencies in such surveys may be due to small scale, out-moded, or non-standard survey techniques, outdated, unprocessed, or unapproved data, or other factors causing the survey data to fall below customary standards for the scale of the chart. A preliminary chart may or may not be published in full color. Included on the chart shall be a source diagram and a warning note stating that (all or much of) the hydrography shown on the chart is not of customary quality. The chart will retain the "Preliminary" label until it has been recompiled using contemporary, processed, and approved source material, and all standard chart colors shown.

### PRELIMINARY SURVEY

As used in historical NOAA terminology, this was a survey that was of higher order than a reconnaissance, but did not have the detail of a complete survey.

### PRIMARY GAUGE (Primary Control Water Level station)

A water level station at which continuous observations have been made over a minimum of 19 years. Its purpose is to provide data for computing accepted values of the harmonic and nonharmonic constants essential to tide predictions and to the determination of tidal datums for charting and for coastal and marine boundaries. The data series from these stations serves as a primary control for the reduction of relatively short series from subordinate tide stations through the method of comparison of simultaneous observations and for monitoring long-period sea level trends and variations.

### PRIME MERIDIAN

The meridian of longitude 0°, used as the origin for measurement of longitude. The meridian of Greenwich, England, is almost universally used for this purpose.

## PRINCIPAL MERIDIAN

A true north-south line (a meridian), extending both north and south of the initial point in the rectangular system of surveys. Together with the base line, principal meridians constitute the axes of a system and the initial point of origin of that system.

## PRIVATE AIDS TO NAVIGATION

In U.S. waters, those aids to navigation not established and maintained by the U.S. Coast Guard. Private aids include those established by other federal agencies with prior U.S. Coast Guard approval, those aids to navigation on marine structures or other works which the owners are legally obligated to establish, maintain, and operate as prescribed by the U.S. Coast Guard, and those aids which are merely desired, for one reason or another, by the individual corporation, state or local government, or other body that has established the aid with U.S. Coast Guard approval. Although private aids to navigation are inspected periodically by the U.S. Coast Guard, the mariner should exercise special caution when using them for general navigation.

## PROBABLE ERROR

An error (or deviation from the mean) of such magnitude that the likelihood of its being exceeded in a set of observations is equal to the likelihood of its not being exceeded (50% probability); its value is that of the standard error multiplied by 0.6745. The use of standard error is sometimes preferred {to probable error} in statistical studies.

## PROJECT INSTRUCTIONS

A document issued by NOAA's Office of Coast Survey containing the unique requirements for a hydrographic survey project. It pertains only to those projects to be conducted by NOAA survey platforms and hydrographers and is not intended to be used by others working under contract. This term supersedes the term Letter Instructions.

## PROJECT/VESSEL/DAY/LINE (PVDL)

Hierarchical format used to store CARIS hydrographic data.

## PROJECTION

The representation of a figure on a surface, either plane or curved, according to a definite plan. In a perspective projection this is done by means of projecting lines emanating from a single point, which may be infinity. In cartography, any systematic arrangement of meridians and parallels portraying the curved surface of the sphere or spheroid upon a plane. Also called map projection or chart projection.

## PROJECTOR

A sonar transducer that translates electrical signals into pressure waves (sound signals), and transmits them through the water.

## PROLATE SPHEROID

An ellipsoid of revolution, the major axis of which is the axis of revolution.

## PROOF

In cartography, an advanced copy of a map produced to check the design, register and/or to enable errors to be detected and corrected before final printing.

## PROOF CHECKING

The examination of the proof and comparison with its sources to point out any errors, omissions, and necessary improvements.

## PROPORTIONAL DIVIDERS

An instrument consisting in its simple form of two legs pointed at both ends and provided with an adjustable pivot, so that for any given pivot setting, the distance between one set of pointed ends always bears the same ratio to the distance between the other set. A change in the pivot changes the ratio. The dividers are used in transferring measurements between different charts or drawings that are not at the same scale.

## PROVISIONAL CHARTS

A special chart for which there is an urgent need. The chart is compiled from processed and approved source material and may be smooth drafted for direct reproduction. All charted information is combined on the black plate and no colors are shown. The chart will retain the "provisional" label until all smooth drafted detail is engraved and standard chart colors are added.

## PUBLICATION NO. 9

American Practical Navigator; a publication of the NGA, originally by Nathaniel Bowditch, comprising an epitome of navigation and navigational astronomy and providing tables for solution of navigational problems. Popularly called Bowditch.

## PUBLIC LAW 31 (SUBMERGED LANDS ACT)

An act passed during the 1st session of the 83rd Congress and signed into law on May 22, 1953. Confirms and establishes the titles of the states to lands beneath navigable water within their boundaries and to the natural resources within such lands and water. The act also established jurisdiction and control of the United States over the natural resources of the seabed of the continental shelf seaward of state boundaries.

## PUBLIC LAW 212 (OUTER CONTINENTAL SHELF LANDS ACT)

An act passed during the 1st session of the 83rd Congress and signed into law on August 7, 1953. Provides for the jurisdiction, control, and administration by the United States over the submerged lands seaward of the states' boundaries as defined in Public Law 31, that is, over the outer continental shelf.

## PUBLISHER'S NOTE

A marginal note which indicates the publisher and usually the place of publication.

## PULSE

A short burst of sonar, typically measured as a function of time, distance, or power. Each pulse of sonar is also known as a ping.

## PULSE LENGTH

The length of time that an active sonar is transmitting one pulse, typically expressed in milliseconds. Longer pulse lengths allow more power to be put into the water at the expense of across track resolution. This has the effect of gaining range for large area surveying.

## PULSE WIDTH

The distance of the ensonified water, in the range dimension, at a given point in time, expressed in meters and determined by multiplying the pulse length by the speed of sound through the water. Pulse widths are measured to determine the maximum theoretical resolution of an imaging sonar.

## PUMPING PLATFORM COMPLEX (PPC)

A single platform or a series of inter-connected platforms that have one or more of the following capabilities: (1) Pumping oil between a vessel and the shore; (2) berthing and messing facilities for assigned personnel; (3) a landing area for helicopters; (4) mooring and loading for small vessels.

## 7.17 Q

### QUAD

A commonly used slang expression for “quadrangle.” The term used to refer to a topographic map published by the U. S. Geological Survey.

### QUALITY ASSURANCE

A continuing evaluation of the quality control process. It is not a double check on each product, but rather a “check on the checkers.” Quality assurance techniques often employ a statistical sampling method to examine just enough of the products to determine that the quality control system is effective. Quality assurance is not intended to catch all the deficiencies, but only to determine if the rates of deficiencies that pass through the quality control system are within the acceptable limits established by management. Any problem identified by the quality assurance process should result in corrective action in the quality control process. Since quality assurance evaluates part of the production system, i.e., quality control, it must be organizationally separately from the production manager in order to ensure objectivity.

### QUALITY CONTROL

A routine inspection to insure that the product conforms with certain minimum standards and specifications that have been established by management. Quality control is usually performed at the work site by supervisors or by designated inspectors. Products that fail to meet the minimum standards are reprocessed or destroyed.

### QUALITY CONTROL REPORT

Historically, a report comprising a critique of the quality and adequacy of the field data acquisition and processing of a given survey. Significant errors, conflicts, or discrepancies which cannot be expeditiously corrected in the records or on the smooth sheet were discussed, and appropriate recommendations regarding corrective action were included in the report. During the period from October 1975 through September 1982, all hydrographic surveys were subjected to a quality control inspection.

### QUAY

A structure approximately parallel to the shoreline and accommodating ships on one side only, the other side being attached to the shore. It is usually of solid construction, as contrasted with the open pile construction usually used for piers. A similar facility of more open construction is called a wharf.

### QUENCH

The loss of a sonar signal, most often due to water-borne discontinuities and resulting in blank sonar display areas. Quenching will affect both the outgoing sonar pulse and the returning echoes.

### QUENCHING

The great reduction in underwater sound transmission or reception resulting from absorption and scattering of sound energy by air bubbles entrapped around the sonar dome.

## 7.18 R

### RACE

Swiftly flowing water in a narrow channel or river; also the channel itself, which may be artificial, as in a mill-race. Also, a swift rush of water through a narrow channel in tidal waters, caused by the tidal movement of the waters.

### RADIO ACOUSTIC RANGING (RAR)

A method of position determination in offshore hydrographic surveying which utilized underwater sound

transmission and radio to determine the distance of the survey vessel from two or more known stations. This method was discontinued during World War II and has since been superseded by electronic methods.

#### RADIO BEACON

Electronic apparatus which transmits a radio signal to provide a line of position for marine navigation.

#### RAMP

A sloping structure that can be used, either as a landing or launching place, at variable water levels, for small vessels, landing ships, or amphibious airplanes, or for hauling a cradle carrying a vessel.

#### RANDOM ERROR

An error whose occurrence depends on the laws of chance only. Random errors are typically very small with a mean value of zero.

#### RANGE

1. In hydrographic positioning, the distance between the vessel or observer and a remote control station or range measuring instrument. 2. In navigation, two or more objects in a line. Such objects are said to be in a range. An observer having them in range is said to be on the range. Two beacons are frequently located for the specific purpose of forming a range to indicate a safe route or the centerline of a channel. 3. When referring to side scan sonar, a sonar setting which represents a distance, usually measured in meters, that is the maximum distance from the towfish that the sonar will display (the range setting on the sonar also determines the time between outgoing sonar pulses); also synonymous with the across-track dimension. Once the range setting on the system is set, when returning echoes arrive from that distance away from the transducer, the ping cycle starts again and a new acoustic pulse is transmitted in to the water.

#### RANGE-AZIMUTH

A method of determining a geographic position using both (a) the range or distance from a control point to a survey vessel, and (b) the azimuth or direction as observed from the same control point to that vessel.

#### RANGE OF TIDE

The difference in height between consecutive high and low waters. The mean range is the difference in height between mean high water and mean low water.

#### RANGE RESOLUTION

The ability of the sonar to image, separately and distinctly, objects perpendicular to the towfish heading. The range resolution is determined, in part, by the pulse length of the sonar. A short pulse length will display two targets close together as separate and distinct anomalies. The same two targets, when ensonified by a longer pulse length can be simultaneously enveloped by the pulse. This results in the two objects appearing as one in the sonar display.

#### RASTER

A matrix of row and column data points whose values represent energy being reflected or emitted from the object being viewed. These values, or pixels, can be viewed on a display monitor as a black and white or a color image. Raster images are made up of individual dots, each of which has a defined value that precisely identifies its specific color, size, and place within the image. Unlike a vectorized raster, which contains attributed information, a raster image does not contain any feature information. Also known as a bitmapped image.

#### RAY BENDING

See Refraction

## REACH

The comparatively straight segment of a river or channel between two bends. That part of a winding river between the last bend and the sea is called a sea reach; that part between the harbor and the first bend is called the harbor reach.

## REAL TIME KINEMATIC (RTK)

A DGPS process where GPS carrier-phase (which delivers the most accurate GPS information) corrections are transmitted in real-time from a reference receiver at a known location to one or more remote rover receivers.

## RECIPROCAL BEARING

A bearing differing by 180°, or one measured in the opposite direction, from a given bearing.

## RECOGNITION

The acknowledgment by the sonar operator of the existence of a target or anomaly as displayed in the sonar data. Lack of anomaly recognition can be problematic particularly during side scan sonar operations. Catastrophic towfish altitude loss, severe fish instability, and search targets all should be recognized by the operator any time they occur. Recognition is distinguished from detection as being operator-dependent. See Detectability.

## RECONNAISSANCE SURVEY

A hasty preliminary survey of a region made to provide some advance information regarding the area which may be useful to the mariner, pending the execution of more complete surveys.

## RECONSTRUCTED CHART

This term is used when the accumulation of new charting information is sufficiently extensive enough to affect most of an existing chart. This may also occur if there are changes to the chart limits or if the chart is to be recompiled on a new projection using computer-supported compilation and scribing techniques.

## RECOVERY OF STATION

In surveying, the identifying and checking of an original station. This is considered as recovered when its mark (monument) is identified as authentic and proved to be occupying its original site.

## RECREATIONAL CHARTS

These agency charts are a series of large-scale charts providing sequential page coverage for selected Great Lakes areas. These charts are published in book format with each page being a large-scale, small-sized chart.

## RECTANGULAR COORDINATES

Magnitudes defining a point relative to two perpendicular lines called axes. The magnitudes indicate the perpendicular distance from each axis. The vertical distance is called the ordinate and the horizontal distance the abscissa. This is a form of Cartesian coordinates.

## REDUCTION OF SOUNDINGS

The correction of observed depths for instrument errors, systematic bias, sound velocity variation, draft and water level above datum.

## REEF

A rocky or coral elevation which may be dangerous to surface navigation, sometimes uncovering at the sounding datum. A rocky reef is always detached from shore; a coral reef may or may not be connected with the shore.

## REFERENCE LINE

Any line which can serve as a reference or base for the measurement of other quantities. Also called a datum line.

## REFERENCE MARK

In surveying, a supplementary mark of permanent character close to a station or to a base terminal, to which it is related by an accurately measured distance and direction, and/or a difference in elevation.

## REFERENCE POINT

Any point which can serve as a reference or base for the measurement of other quantities. Also called a datum point.

## REFERENCE SPHEROID (OR ELLIPSOID)

A theoretical figure whose dimensions closely approach the dimensions of the geoid. The exact dimensions are determined by various considerations of the section of the Earth's surface considered. The Spheroids of Bessel, Clarke, Delambre, Everest, Hayford, Helmert, and others have been adopted as reference spheroids in geodetic work by different countries.

## REFLECTING PROJECTOR

An instrument by means of which the image of a photograph can be projected onto a map. By varying the position of the projector lens, the scale of the projected image can be varied.

## REFRACTION

The change of direction of a sound beam when passing obliquely from one medium into another, where its wave velocity is different. Refraction is a type of ray bending that will affect acoustic returns for proper sonar imaging. This occurs when sonar pulses encounter thermal and haline discontinuities. In a normal summer thermocline environment, a side scan beam can be refracted sharply to the seafloor, severely limiting range.

## REGISTER MARKS

Designated marks, such as small crosses, circles, or other patterns applied to original copy prior to reproduction to facilitate registration of plates and to indicate the relative positions of successive impressions. Also called corner marks, corner ticks, register ticks, registration ticks, or ticks.

## REGISTRATION

Correct positioning of one component of a composite map image in relation to the other components. Map registration (also called geo-referencing) is the process of converting file or page coordinates to map coordinates. For example, a scanned map can have an origin point and a raster association where each point on the map is identifiable by its file coordinates, whether by numerals or by pixels. The task is to then convert these numeral coordinates to map coordinates (e.g., latitude, longitude: x, y).

## REGISTRY NUMBER

A number assigned to topographic and hydrographic surveys within NOAA for identification and filing purposes. Topographic surveys are identified by a variety of designations, depending on vintage, e.g., "T," "TP," "DM," and "GC." Hydrographic surveys are similarly identified with designations such as "H," "FE," "S," and "D." Registry numbers beginning with the letter "W" are used to identify surveys originating with sources other than those under the direct administrative control of NOAA.

## REMOTE HEAVE

The apparent vertical motion of a sensor due to vessel roll and/or pitch acting on a lever arm between the sensor and the vessel's center of motion.

## REPEATABILITY

A measure of the variability of a series of measurements of the same quantity/position/depth. High repeatability is indicative of high precision.

## REPRESENTATIVE FRACTION (RF)

The scale of a map or chart expressed as a fraction or ratio that relates unit distance on the map to distance measured in the same unit on the ground. Also called natural scale, fractional scale.

## REPRINT

A reprinting of a chart without revision, necessitated by the depletion of stock. The issue is an exact duplicate of the current issue with no changes in printing or publication dates.

## RESIDUAL ERROR

The difference between any value of a quantity in a series of observations, corrected for known systematic errors, and the value of the quantity obtained from the adjustment of that series. Sometimes called residual.

## RESTRICTED AREA

A specified area designated by appropriate authority and shown on charts within which navigation is restricted in accordance with certain specified conditions.

## RESTRICTED WATERS

Areas which for navigational reasons, such as the presence of shoals or other dangers, confine the movements of shipping within narrow limits.

## RETRACTABALE BRIDGE

A bridge with a movable span that can be withdrawn horizontally or within the remaining structure of the bridge.

## REVERBERATION

The echoing of a sonar signal from a target or targets. Echo and reverberation are often used interchangeably, although targets are more often described as returning an echo whereas large ensonified areas such as the seafloor are described as reverberating under the influence of sonar.

## REVETMENT

A retaining wall or facing constructed of riprap or concrete, etc., built to protect an embankment or shore structure against erosion by wave action or currents.

## REVIEW

The final step in the processing of the field data or a hydrographic survey. Its purpose was to consider the survey in its broader aspects, to correlate it with all prior surveys of the agency covering the same area, with historical data that may have been received from other sources, and to lay the foundation for future surveys in the area because of indicated changes, inadequate development, or conflicting information. In 1982, this step was effectively merged into a process called Evaluation, the results of which are documented in an Evaluation Report.

See also Review Report, Verifier's Report.

## REVIEW REPORT

A report, formerly prepared in agency headquarters, which summarizes pertinent facts relating to a given hydrographic survey. Included in the report are sections which address the quality of the hydrographic survey and detailed comparisons made with prior hydrographic surveys and the appropriate nautical charts. Included in the report are specific evaluations and recommendations regarding the adequacy of the survey to supersede prior survey data and charted information. The formal review function was transferred to the Office of Marine Operations in October, 1975, and the former "Review Report" was renamed the "Verifier's Report." See Review, Evaluation Report, and Verifier's Report.

#### REVISED PRINT

A chart issue that does not cancel a current edition; the revisions are minor and the edition number remains the same, but the print date is changed, and the chart is designated a revised print of that chart. The date of a revised print is shown to the right of the edition date.

#### RHUMB DISTANCE

The length of the tack a ship makes when sailing from one place to another without changing course.

#### RHUMB LINE

A line on the surface of the earth making the same oblique angle with all meridians; a loxodrome or loxodromic curve spiraling toward the poles in a constant true direction. Parallels and meridian, which also maintain constant true directions, may be considered special cases of the rhumb line. A rhumb line is a straight line on a mercator projection.

#### RIFFLE

A shoal, reef, or shallow in a stream, producing a stretch of ruffled or choppy water.

#### RIGHT BANK

The river bank on the right-hand side as one proceeds downstream.

#### RINGING

In a transducer, this is the reception of the transducer output pulse at the time of transmission. In active sonar systems, the projector and the hydrophone are one and the same, so the hydrophone receives its own outgoing pulse. In a target, this is a well-documented phenomenon resulting from multiple echoes from certain types of targets due to the acoustical physics of sound pulse wrap-around and reflections internal to the target.

#### RIPARIAN BOUNDARIES

Water boundaries, or boundaries formed by the sea or a river. The general rule is that riparian boundaries shift with changes due to accretion or erosion but retain their original location. Such changes may be due to rapid erosion of the shoreland by waves during a storm, sudden cutting off of land by flood, currents, or change in course of a body of water, or by artificial causes.

#### RIP-RAP

A layer, facing, or protective mound of stones or similar durable material, emplaced as in a revetment to prevent erosion, scouring, or sloughing of a structure or embankment.

#### RISE

A long, broad elevation that rises gently and generally smoothly from the sea floor.

#### RIVER

A natural stream of water, of greater volume than a creek or rivulet, flowing in a more or less permanent bed or channel, between defined banks or walls, with a current which may either be continuous in one direction or affected by the ebb and flow of the tide.

#### ROAD

An open anchorage affording less protection than a harbor. Some protection may be afforded by reefs, shoals, etc. Often used in the plural. Also called roadstead.

## ROADSTEAD

An area of the sea used for the anchorage of vessels and transshipment of cargo, usually without the protection from weather associated with ports and harbors. Roadsteads are part of the territorial sea but are not inland waters.

## ROCK

An isolated rocky formation or a single large stone, usually one constituting a danger to navigation. It may be always submerged, always uncovered, or alternately covered and uncovered by the tide.

## ROCK AWASH

In tidal areas, a rock that uncovers, or nearly uncovers, near the vertical datum of reference prescribed for that area. See Sunken Rock.

## ROCKY AREA

An area with a rocky bottom.

## ROLL

The rhythmic movement of a ship or towbody about its longitudinal axis.

## ROOT MEAN SQUARE ERROR

See Standard Error.

## ROTATION

Turning of a body about an axis within the body, as the daily rotation of the Earth.

## ROV

Acronym for Remotely Operated Vehicle (submersible), an unmanned underwater vehicle that is connected to an operator via a power and/or communication tether. See AUV.

## ROUTE CHARTS

Nautical charts produced by the agency and designed for river and narrow waterway coverage, and for much of the Intracoastal Waterway. They are published in the small-craft pocket fold format.

## RUINS

A ruin is a structure in a decayed or deteriorated condition resulting from neglect or disuse, or a damaged structure in need of repair. A ruin is considered hazardous if it extends over or into navigable waters and thus represents a danger to surface navigation.

## RUB-TEST

The process of manually creating friction on a transducer face in order to test system electrical continuity. Before a sonar towbody is put in the water, it is a common practice to test the system on deck. Because air is a high impedance medium for sonar, the best method of testing system function is to rub the transducer face. In a dual channel side scan sonar, one transducer is rubbed, then the opposite is rubbed to clarify that the transducers are not wired to the wrong display channels.

## 7.19 S

## SAILING CHARTS

Charts of scales 1:600,000 and smaller for planning and for fixing the mariner's position as she approaches the coast from the open ocean, or for sailing between distant coastwise ports. The shoreline and topography are generalized

and only offshore soundings, principal navigational lights and buoys, and landmarks visible at considerable distances are shown.

#### SAILING DIRECTIONS

Publications similar in scope to the Coast Pilots of the agency, published by other hydrographic offices.

#### SALINITY

A measure of the quantity of dissolved salts in sea water. It is normally defined as the total amount of dissolved solids in sea water in parts per thousand (0/00) by weight when all the carbonate has been converted to oxide, the bromide and iodide converted to chloride, and all organic matter is completely oxidized. In practice, salinity is not determined directly but is computed from chlorinity, electrical conductivity, refractive index, or some other property whose relationship to salinity is well established.

#### SAND

An unconsolidated mixture of inorganic soil (which may include disintegrated shells and coral), consisting of small but easily distinguishable grains ranging in size from about 0.062 mm to 2.0 mm.

#### SANDING

An irregular dot pattern used on some of the early hydrographic surveys to accentuate the area between the high- and low-water lines.

#### SAND SPIT

A narrow embankment, created by an excess of deposition at its seaward terminus, with its distal end (the end away from the point of origin) terminating in open water.

#### SAND WAVES

1. Longshore sand waves are large-scale features that maintain form while migrating along the shore with speeds on the order of kilometers per year. 2. Large-scale asymmetrical bedforms in sandy river beds having high length to height ratios and continuous crestlines.

#### SATELLITE POSITIONING SYSTEM

A positioning system consisting of a radio-receiver, or a receiver and transmitter, at the point whose location is to be determined, one or more beacons or transponders in orbit about the Earth, and a computing system for determining and predicting the orbits. The satellites can be considered points of known location. The radio receiver may measure times of travel of radio pulses, directions to the satellites, or the Doppler shift in the frequency of the radio waves emitted by the satellites. The most common system used today is the Global Positioning System (GPS).

#### SCALE

The relation that a measured distance on a survey, map, or chart bears to the corresponding actual distance on the earth; for example, if 1 inch on the survey or chart corresponds to 1,000 ft (12,000 inches) on the ground, the scale would be expressed as 1 inch = 1,000 ft. Expressed as a ratio, this would be a scale of 1:12,000.

#### SCALE BAR

A graduated line on a map, plan, photograph, or mosaic, by means of which actual ground distances may be determined.

#### SCALE FACTOR

A multiplier for reducing a distance obtained from a map by computation or scaling to the actual distance on the datum of the map.

## SCALE MARKS

Equidistant, regular marks on a sonar display used to assist in the mensuration of targets above the seafloor, or to provide information on the range displacement of targets from a side scan sonar towfish path.

## SCATTERING

The diffusion of a sonar signal in many directions through refraction, diffraction and reflection, primarily due to the material properties of the ensonified areas. Scattering is one of the causes of attenuation in sonar, resulting in signal weakening. See Backscatter.

## SEA

1. A large body of salt water, second in rank to an ocean, more or less landlocked, and generally part of, or connected with, an ocean or a larger sea. 2. State of the surface of the ocean or lake with regard to wave or swell, as a calm sea.

## SEABOARD

The region of land bordering the sea. The terms seaboard, coast, and littoral have nearly the same meanings. Seaboard is a general term used somewhat loosely to indicate a rather extensive region bordering the sea. Coast is the region of indefinite width that extends from the sea inland to the first major change in terrain features. Littoral applies more specifically to the various parts of a region bordering the sea, including the coast, foreshore, backshore, beach, etc.

## SEA BUOY

The outermost buoy marking the entrance to a channel or harbor.

## SEA CLUTTER

The images created in a sonar display by acoustic returns from a rough sea surface. When using side scan sonar, some energy is projected above the horizontal from the wide vertical beam. If the sea surface is rough and within the range setting of the system, formless patches may overlay the normal seabed returns.

## SEAFLOOR

The bottom of the ocean when there is a generally smooth gentle gradient. Also referred to as the sea bed or sea bottom.

## SEA GRASS

Members of marine seed plants that grow chiefly on sand or sand-mud bottom. They are most abundant in water less than 9 m deep. The most common varieties are: eel grass, turtle grass, manatee grass.

## SEA MILE

An approximate mean value of the nautical mile equal to 6080 feet, or the length of a minute of arc along the meridian at latitude 48°.

## SEAMOUNT

An isolated or comparatively isolated elevation rising 1000 meters or more from the seafloor and of limited extent across the summit.

## SEA STATE

The numerical or written description of ocean surface roughness. For more precise usage, sea state may be defined as the average height of the highest one-third of the waves observed in the wave train.

## SEAWALL

A structure built along a portion of a coast primarily to prevent erosion and other damage by wave action. It retains earth against its shoreward face.

## SEA WATER

The water of the seas, distinguished from fresh water by its appreciable salinity. The degree of salinity greatly affects the water's physical characteristics.

## SECCHI DISK

Circular disk used to measure the transparency of the water column.

## SECONDARY GAUGE (Secondary Control Water Level Station)

A water level station at which continuous observations have been made over a minimum period of 1 year but less than 19 years. The series is reduced by comparison with simultaneous observations from a primary gauge. This station provides for a 365-day harmonic analysis including the seasonal fluctuation of sea level.

## SECONDARY PHASE FACTOR CORRECTION

A correction for additional time (or phase delay) for transmission of a low-frequency signal over an all-seawater path when the signal transit time is based on the free-space velocity. The LORAN-C lattices as tabulated in tables or overprinted on the nautical chart normally include compensation for secondary phase factor.

## SEDIMENT

Loose fragments of rocks, minerals, or organic material that are transported from their source for varying distances and deposited by air, wind, ice, and water. Other sediments are precipitated from the overlying water or form chemically in place. Sediment includes all the unconsolidated materials on the sea floor.

## SELECTIVE AVAILABILITY (SA)

Selective Availability is a process once used by the U.S. Department of Defense to dither the satellite clock and/or broadcasts erroneous orbital ephemeris data to create a pseudo range error to prevent adversaries from using the extremely accurate GPS positioning data.

**SEMIDIURNAL** Having a period or cycle of approximately one-half of a tidal day. The predominant type of tide throughout the world is semidiurnal, with two high waters and two low waters each tidal day.

## SEPARATION ZONE

A zone or line separating traffic proceeding in one direction from traffic proceeding in another direction. A separation zone may also be used to separate a traffic lane from the adjacent inshore traffic zone.

## SET

The direction toward which a current flows.

## SETTLEMENT

Vertical displacement of a moving vessel, relative to what its level would be were it motionless. Settlement is due to the regional depression of the surface of the water in which the ship moves. It is not an increase in displacement. At low speeds the effect of moving the hull through the water causes a local depression in the water surface around the hull. The effect of increasing speed on vessels with planing hulls is to cause them to lift out of the water. Not to be confused with squat which is the change in vessel trim as it moves through the water.

## SEXTANT

A double-reflecting instrument used for measuring angles, primarily horizontal angles between two objects when used in hydrographic surveying. The sextant has an arc of 60 degrees, a sixth of a circle, from which it derives its name.

## SEXTANT FIX (also called a Three-Point Fix)

A position determined by measuring with a sextant 2 adjacent angles between 3 objects whose relative positions are known.

## SHADED RELIEF

A cartographic technique that provides an apparent 3-dimensional configuration of the terrain on maps and charts by the use of graded shadows that would be cast by high ground if light were shining from the northwest.

## SHADOW

A light area on a normal sonar record that is less ensonified than the surrounding region; most often caused by signal blocking from an acoustically opaque object on or above the seafloor. Shadows in side scan data are an important aid to accurate record interpretation. Often, an acoustic shadow will divulge more about a reflector than the actual acoustic returns. Shadows are also used to calculate the height of an object standing proud of the seabed. The calculation uses an algebraic solution of similar triangles formed by the height of the towfish, the range to the target and the length of the shadow.

## SHALLOW WATER

Water of such depth that surface waves are noticeably affected by bottom topography. Typically, this implies a water depth equivalent to less than half the wave length. Recent usage extends the definition of shallow water seaward to those depths deemed significant to surface navigation – 30 to 40 meters.

## SHALLOW WATER MULTIBEAM (SWMB)

A multibeam echosounder system designed specifically for shallow water operations.

## SHINGLE

Rounded, often flat waterworn rock fragments larger than approximately 16 millimeters.

## SHIPPING LANE

A term used to indicate the general flow of merchant shipping between two departure/ terminal areas.

## SHOAL

1.(n) A detached area of any material except rock or coral. The depths over such an area are a danger to navigation, i.e., minimal depths are 11 fm ( 20 m) or less. Shallow areas consisting of coral or rock are referred to as reefs, rather than as shoals. 2. (verb) To become shallow gradually. 3. (adj.) Shallow.

## SHORE

According to riparian law, the land between ordinary high- and low-water marks, where the common law prevails; the land over which the daily tides ebb and flow. The civil law concept of shore has been interpreted as extending to the line of mean higher high tide as it intersects land and some man-made features. See Foreshore and Riparian Boundaries.

## SHORELINE

The line of contact between the land and a body of water. On NOAA nautical charts and survey sheets, the shoreline approximates the mean high-water (MHW) line. In OCS, this term is sometimes considered to be synonymous with coastline but the use of the term coastline is discouraged.

## SHORELINE MAP

The graphic representation of photogrammetric surveys. The maps contain graphic data relating to the shoreline, and alongshore natural and man-made features, and may include a narrow zone of such features inland from the shoreline. The original sources of a shoreline map are aerial photographs, but may also include ground survey data. Shoreline maps are generated primarily to support hydrographic operations and nautical chart compilation and maintenance. Also called Shoreline Manuscript.

## SHORELINE PLANE OF REFERENCE (SPOR)

The vertical datum accepted as the reference plane for shoreline, typically MHW.

## SIDE SCAN SONAR (SSS)

A form of active sonar in which fixed acoustic beams are directed into the water perpendicularly to the direction of travel to “scan” the bottom and generate a record of the bottom configuration.

## SILL

A submarine ridge or rise of relatively shallow depth separating the sea floor of adjoining basins.

## SILT

Sediment particles with a grain size between 0.004 mm and 0.062 mm, i.e., coarser than clay but finer than sand.

## SINGLE BEAM ECHO SOUNDER (SBES)

An echo sounder that transmits and receives only one sound pulse at a time; contrasted to a multibeam echo sounder which records multiple soundings over a swath of the seafloor for each transmission. See Vertical Beam Echo Sounder (VBES)

## SKEWED PROJECTION

Any standard projection used in map or chart construction, which does not conform to a general north-south format with relation to the neat lines of the map or chart. Alternatively called rotated projection.

## SLACK WATER

The state of a tidal current when its speed is near zero, especially the moment when a reversing current changes direction and its speed is zero. The term is also applied to the entire period of low speed near the time of turning of the current when it is too weak to be of any practical importance in navigation. The relation of the time of slack water to the tidal phases varies in different localities.

## SLANT RANGE

The straight-path time of arrival of a sonar signal along the hypotenuse of a triangle described by the towfish, the seafloor directly below it, and the seabed point of interest. In side scan sonar, because the imaging source point (transducer) is not on the seafloor but rather above it, slant range does not represent the true range between any 2 objects. Below the towfish, the data is compressed. Farther away from the towfish, the data becomes less compressed, with the least error at the outermost ranges. The near range compression can be corrected for most modern sonar systems.

## SLANT RANGE CORRECTION

A computerized repositioning of sonar data on the display to counteract range data compression. See Slant Range.

SLIP See Dock.

## SLIP RING

An electromechanical component, most often used on a winch that allows full electrical continuity of a side scan

sonar cable during winch drum operation. Poor quality or dirty slip rings will cause noise in sonar data during drum movement and a bad individual ring can cause a blank sonar channel.

#### SLOUGH

A small muddy marshland or tidal waterway which usually connects 2 or more bodies of water. See Bayou.

#### SMALL CRAFT CHARTS

Agency nautical charts at scales from 1:10,000 to 1:80,000 that are designed for easy reference and plotting in limited spaces. In some areas these charts represent the only chart coverage for all marine users. They portray regular nautical chart detail and other specific details of special interest to small-craft operators, such as enlargements of harbors; tide, current, and weather data; rules-of-the-road information; locations of marine facilities; anchorages; courses; and distances.

#### SMALL SCALE

A scale involving a relatively large reduction in size. A small-scale chart is one covering a large area. The opposite is large-scale. In agency usage, a scale of 1:105,000 (1 inch on survey sheet or chart = 105,000 inches on the ground) or smaller would fall in this classification. See Large-scale survey (chart).

#### SMOOTH SHEET

The name given to a plotted representation of data acquired during a hydrographic survey. Essentially, it is a record of the soundings taken during the field survey, but historically it contained other data necessary for a proper interpretation of the survey, such as depth curves, bottom characteristics, names of geographic features, and control stations.

#### SNAG

A tree, tree stump, or tree branch embedded in the bottom of a body of water, thereby constituting a hazard to navigation or to fishing gear, e.g., nets. A snag may be submerged, awash, or visible at mean high water.

#### SNIPPET

That portion of the backscatter time series that fall within the footprint of an individual beam from a multibeam sonar. This results in a geo-referenced high resolution sidescan image.

#### SONAR GEOMETRY

The spatial relationship between sonar transducers and their environment, including the seafloor, targets, and the sea surface. Because of acoustic paths in the ocean environment, sonar imagery may be puzzling at times. Accurate data interpretation sometimes requires an understanding of the sonar geometry. A good example of this is when sonar signals return to the transducer over several different paths. See Multipath.

#### SONARGRAM

A hard copy display of sonar data (typically from side scan) generated either in real time or from recorded data. Also known as sonographs/sonograms, hard copy "records" of side scan sonar data are generated either by a sonar printer, a specialized graphics printer or, with modern computerized sonar displays, by any drafting printer in color or black and white. Early sonar printers used a wet paper technology creating dark and light zones on the paper. Dry paper recorders were developed in the 1970's followed by thermal paper recorders in the 1990's. Many sonar manufacturers and users now depend upon digitally recorded data.

#### SONOGRAPH

See Sonagram. SOUND 1. (n) A relatively long arm of the sea or ocean forming a channel between an island and a mainland or connecting two larger bodies, as a sea and the ocean, or two parts of the same body, usually wider and more extensive than a strait. 2. (v) To measure the depth of the water.

## SOUNDING

A measured depth of water; or the act of measuring depth.

## SOUNDING LINE

The path followed by a vessel during the acquisition of soundings.

## SOUNDING LINE CROSSINGS

The intersection of two systems of sounding lines at which the depths must agree within specified limits. See= Crosslines.

## SOUNDING MACHINE

A historically used instrument for measuring depth of water, consisting essentially of a reel of wire to one end of which is attached a weight which carries a device for recording the depth. A crank or motor is provided for reeling the wire.

## SOUNDING POLE

A graduated pole for sounding in shallow water.

## SOUNDING RECORDS

Historically consisted of bound record books in which all of the data taken during a hydrographic survey were entered, and became part of the permanent records of the agency. A typical sounding record of a launch hydrographic survey using an echo sounder and 3-point fix control contained position numbers, times of taking the soundings, uncorrected soundings, corrections to be applied, reduced soundings, boat's headings by compass, position control data, and pertinent remarks. Soundings acquired during a modern survey are routinely filed in digital form. The modern sounding record contains a variety of information, depending on the particular system in use.

## SOUND VELOCITY

The rate at which acoustic energy moves through a medium. This term is often used incorrectly instead of the more technically precise term speed of sound. The rate at which sound energy moves through water is a scalar quantity and has no specified direction. Hence, speed is the more correct term since velocity is a vector and implies direction. See speed of sound.

## SOURCE MATERIAL

Data of any type required for the compilation of NOAA products including, but not limited to, ground control, aerial and terrestrial photographs, sketches, maps, and charts; topographic, hydrographic, hypsographic, magnetic, geodetic, oceanographic and meteorological information; and intelligence documents and written reports pertaining to natural and man-made features of the area to be mapped or charted.

## SOUTHEAST ALASKA DATUM

An independent horizontal datum established toward the end of 1901 by joining together 9 different groups of triangulation to form 1 continuous scheme on one datum. Applied to all triangulation in Alaska between Dixon Entrance and Mount St. Elias.

## SPECULAR REFLECTOR

An object to which incident sonar beams are largely normal to its surface, making it a strong reflector from a variety of angles. Objects in this category include cylindrical objects such as pipes and pilings, and spherical objects such as subsurface floats. Specular reflectors may provide very strong sonar returns and will result in hyperbolic shaped lines in side scan data. The hyperbola is formed when a target is reflective enough to return even the low level energy in the side lobes of the sonar's horizontal beam.

## SPEED

Rate of motion. The terms speed and velocity are often used interchangeably, but speed is a scalar, having magnitude only, while velocity is a vector quantity, having both magnitude and direction.

## SPEED CORRECTION

The proportional matching of sonar recorder chart length with the over-the-ground speed of the survey vessel. When towing side scan sonar at a constant speed over the bottom, if the image generation on the recorder or display unit is too slow, objects in the data will appear to be compressed in the transverse dimension. If the image generation is too fast, they will appear to be stretched.

## SPEED OF SOUND

The rate at which acoustic energy moves through a medium. The speed of sound in sea water is a function of temperature, salinity, and the changes in pressure associated with changes in depth. An increase in any of these factors tends to increase the speed. Often incorrectly referred to as Sound Velocity - velocity is a vector and implies direction and the speed of sound is a scalar quantity as it has no specified direction. See also Speed and Velocity.

## SPHERICAL EXCESS

The amount by which the sum of the 3 angles of a triangle on a sphere exceeds 180°.

## SPHEROID

A type of ellipsoid which is formed by revolving an ellipse about one of its axes. If the minor axis is the axis of revolution, the resulting figure is called an oblate spheroid (ellipsoid) which approximates the shape of the earth. In geodesy, this term is frequently used to mean reference spheroid.

## SPIKE

Sharp deviation from a line, caused by erroneous data or an anomalous event.

## SPIRE

A slender pointed structure surmounting a building such as a church. Sometimes depicted as a landmark on nautical charts.

## SPIT

A long narrow accumulation of sand or shingle, lying generally in line with the coast, with one end attached to the land and the other projecting into the sea or across the mouth of an estuary.

## SPLIT

1. In wire-drag surveying, an area between drag strips not covered by the drag. 2. In hydrographic surveying, one or more sounding lines accomplished between mainscheme lines to provide a more detailed development or to eliminate a holiday in coverage.

## SPOIL

Mud, sand, silt, or other deposits obtained from the bottom of a body of water (usually a channel or harbor) by dredging.

## SPOIL AREA

An artificial formation created by the deposit of dredged materials on the seabed. Spoil banks that are connected to the natural coastline are part of the baseline from which maritime zones are measured. Those that are unattached are artificial islands and are not part of the baseline. Alternatively, spoil bank.

## SQUAT

A change in vessel trim as it moves through the water. This change of level of the bow and stern from a still water condition is in response to the elevation and depression of the water level about the hull resulting from the bow and sternwave systems. Not to be confused with settlement which is the vertical displacement of a moving vessel, relative to what its level would be were it motionless.

## SSS

Acronym for Side Scan Sonar.

## STACK

A tall smokestack or chimney. The term is used on nautical charts when the stack is more prominent as a landmark than the accompanying buildings.

## STAKE

An elongated wood or metal pole embedded in the bottom. A stake plotted on a hydrographic survey is assumed to be wooden unless otherwise annotated. Its diameter is smaller than that of a pole.

## STANDARD (for charts)

A file begun about 1908 by means of which a record is kept of all incoming charting information, except aids to navigation. The file consists of a complete set of the published charts. When an individual Standard becomes cluttered with annotations, it is filed and replaced with another chart, which then becomes the contemporary Standard. The file is an invaluable source of historical information and is used in the preparation of project instructions. Also called a Chart Standard.

## STANDARD ERROR

The square root of the arithmetic mean of squared deviations from the mean. Also called standard deviation (when the deviations do not represent errors) or root mean square error. In statistics, the standard error is defined as the standard deviation of an estimate. That is, multiple measurements of a given value will generally group around the mean (or average) value in a normal distribution. Standard error is a common measure of the uncertainty associated with a numerical estimate. In a regression analysis, standard errors are often reported with (or below) the coefficient estimates. As a rough rule of thumb, one can be 95% confident that the true coefficient is within  $\pm 2$  standard errors of the estimate.

## STANDARD PARALLEL

A parallel of latitude which is used as a control in the computation of a map projection. For a tangent cone, this is the parallel of tangency. For a secant cone, the two parallels of intersection are the standards.

## STANDPIPE

A tall cylindrical structure in a waterworks system, whose height is several times greater than its diameter. It extends from the ground and may be supported by a skeleton-type framework. Sometimes depicted as a landmark on nautical charts.

## STATE PLANE COORDINATE SYSTEM

One of the plane rectangular coordinate systems (one for each State in the Union), established by the U.S. Coast and Geodetic Survey in 1933 for use in defining locations of geodetic stations in terms of plane-rectangular Cartesian coordinates.

## STATUTE MILE

5280 ft, 1609.3 meters, or 80 chains. Also known as a "land mile" or "English mile."

## STRAIT

A relatively narrow waterway between two larger bodies of water.

## STRAND

1. The portion of the seashore between high and low water line. 2. To run aground. The term strand usually refers to a serious grounding, while the term “ground” refers to any grounding, however slight.

## STRANDED

The terms “stranded” and “sunken” apply exclusively to items that once were afloat but are now resting on the bottom. “Stranded” items project above the sounding datum, while “sunken” items do not project above the sounding datum. These terms apply most often to wrecks. Masts, funnels, and other extensions of wreck superstructure should be disregarded when applying the above definition; i.e., such features may project above the sounding datum and still have the wreck classified as “sunken.” See Sunken.

## STRANDING

The destruction or loss of a vessel by its being sunk or broken up by the violence of the sea or by its striking or stranding upon a rock, shoal, etc. The term stranding refers particularly to the accidental or voluntary driving or running aground of a vessel.

## STRUCTURE

The term includes, without limitation, any pier, wharf, dolphin, weir, boom, breakwater, bulkhead, revetment, riprap, jetty, permanent mooring structure, power transmission line, permanently moored floating vessel, pile(s), aid to navigation, or any other obstacle or obstruction.

## SUBMARINE CABLE

An insulated, waterproofed wire or bundle of wires for carrying an electric current under water. Such a cable is placed on or near the bottom.

## SUBMERGED

Under water; not showing above water (commonly used to refer to features covered at MLLW). This term applies to objects and features that never possessed the ability to float and are now attached to, or resting on, the bottom. All items in this category, except rocks, reefs, and rock or reef formations, are submerged if they are totally below the shoreline datum.

## SUBMERGED LANDS ACT

See Public Law 31.

## SUBORDINATE GAUGE (Subordinate Water Level Station)

A water level station from which is a relatively short series of observations is reduced by comparison with simultaneous observations from a water level station with a relatively long series of observations.

## SUBSIDENCE

Sinking or down warping of a part of the earth's surface.

## SUNKEN

The terms “sunken” and “stranded” apply exclusively to items that once were afloat but are now resting on the bottom. “Stranded” items project above the sounding datum, while “sunken” items do not project above the sounding datum. These terms apply most often to wrecks. Masts, funnels, and other extensions of wreck superstructure should be disregarded when applying the above definitions; i.e., such features may be above the sounding datum and still have the wreck classified as “sunken.” See Stranded.

## SUNKEN ROCK

A rock potentially dangerous to surface navigation, the summit of which is below the lower limit of the zone for a rock awash. See Rock Awash.

## SURDEX

An index of polygons defining the limits of sounding coverage obtained during a hydrographic survey conducted or sponsored by the agency. The figures are contained within a geographic information system. See Survey Indices (Indexes).

## SURF

Collective term for breakers. The wave activity in the area between the shoreline and the outermost limit of breakers.

## SURVEY

The act or operation of making measurements for determining the relative position of points on, above, or beneath the Earth surface. The result of such operations.

## SURVEY INDICES (INDEXES)

Printed sheets showing the dates, areas covered, and scales of planetable and hydrographic surveys along the Atlantic, Gulf, and Pacific coasts to include Alaska and Hawaii. Historically, the indexes were maintained manually, but in more recent times digital technology has begun to replace the system with information maintained in a geographic information system. Also referred to as Surdex.

## SWAMP

A tract of stillwater abounding in certain species of trees and coarse grass or boggy protuberances; a tract of wet, spongy land, saturated, but not usually covered with water; a boggy marshland and stream.

## SWATH WIDTH

The lateral coverage of sonar on the seabed. Because a sonar projects a beam(s) laterally to the vessel heading, it creates a wide region of ensonified seafloor. Swath width changes with depth and is a factor in determining coverage and lane spacing.

## SWEEP

To drag. "Drag" and "sweep" have nearly the same meanings. In NOAA usage, a drag was typically deployed when the objective was to locate and ascertain the minimum clearance depth over an obstruction. A sweep was used when the objective was simply to verify that no obstructions existed in a channel or waterway. It was not effective in determining clearance depths. See Wire Drag.

## SWMB

See Shallow Water Multibeam.

## SYSTEMATIC ERROR

Biases in measurement which lead to measured values being systematically too high or too low. All measurements are prone to systematic error. A systematic error is any biasing effect, in the environment, methods of observation or instruments used, which introduces error into an experiment and is such that it always affects the results of an experiment in the same direction. Constant systematic errors are very difficult to deal with, because their effects are only observable if they can be removed. Such errors cannot be removed by repeating measurements or averaging large numbers of results. A common means to remove systematic error is the observation of a known process, i.e. through calibration. Another means to remove systematic error is by a subsequent measurement with more sophisticated experiment equipment.

## 7.20 T

### TABLES FOR A POLYCONIC PROJECTION OF MAPS

Special Publication No. 5, U.S. Coast and Geodetic Survey, contains the true lengths in meters of meridional arcs and arcs of the parallel, as they appear on the Clarke spheroid of 1866, for use in the construction of projections, together with the “x, y “ coordinates for plotting the intersection of parallels and meridians in constructing a polyconic projection. The tables are based on the legal value of the meter in the United States, which is 39.3700 inches, and corresponds to  $1 \text{ m} = 3.2808333 \text{ ft}$  and  $1 \text{ ft} = 0.3048006 \text{ meters}$ . Also referred to as Table of Meridional Parts.

### TAGLINE

A line, either marked at equal intervals or run over a registered sheave, used in large-scale surveys to take equally spaced soundings at predetermined distances from a control station or known location, e.g., a pier face.

### TANK

In NOAA usage, a fixed structure for storing liquids. Sometimes depicted as a landmark on nautical charts.

### TERMINAL MORAIN

A moraine formed across the course of a glacier at its farthest advance, at or near a relatively stationary edge, or at places marking the termination of important glacial advances.

### TERRITORIAL LIMITS

The seaward or most offshore limits of a littoral or coastal nation over which it has exclusive jurisdiction.

### TERRITORIAL SEA

The water area bordering a nation over which it has exclusive jurisdiction, except for the right of innocent passage of foreign vessels. It extends seaward from the low-water mark along a straight coast and from the seaward limits of inland waters where there are embayments. These waters commonly extend to 12 nautical miles from the coast, per the United Nations Convention on the Law of the Sea.

### TERRITORIAL WATERS

Includes the territorial sea (marginal seas) and the inland waters of a country (lakes, rivers, and bays, etc.). Sometimes used as synonymous with Territorial Sea.

### TERTIARY GAUGE (Tertiary Tide Station)

A water level station at which continuous observations have been made over a minimum period of 30 days but less than 1 year. The series is reduced by comparison with simultaneous observations from a secondary control water level station. This station provides for a 29-day harmonic analysis.

### THEODOLITE

A precise surveying instrument, consisting of an alidade with a telescope mounted so that it can be rotated about a vertical axis; the amount of rotation is measured on an accurately graduated, stationary horizontal circle. See also transit.

### THERMOCLINE

A layer of water where the vertical temperature gradient is greater than that in the water above it or in the water below it. Thermoclines affect the ray path of acoustic signals underwater and can result in a range-limiting type of banding visible in side scan sonar data. Similar to the effects of a haline front, this banding is most evident at the outer ranges of sonar data where the beam's angle of incidence to the thermocline is high. Changing the sonar geometry will minimize or eliminate the effects of thermoclines.

### THREE-ARM PROTRACTOR

An instrument (metal or plastic) for plotting sextant fixes in hydrographic surveying. It consists of a graduated circle with a fixed center arm and right and left movable arms pivoted at its center so that the extension of each fiducial edge always passes through the precise center of the graduated circle. The observed left angle is set with the left arm and the right angle with the right arm, and each fiducial edge is made to pass through the corresponding control station on the survey sheet. The center of the protractor marks the position of the survey boat.

### THREE POINT FIX METHOD

One of the principal methods used historically on inshore hydrographic surveys for establishing the position of the survey boat. It involves the measurement with sextants of two angles between three known stations, the middle station being common to both angles, and plotting the boat's position graphically with a three-arm protractor.

### TIDAL BENCH MARK

A bench mark near a tide station to which the tide staff and tidal datums are referred.

### TIDAL DATUM

A base elevation used as a reference from which to reckon heights or depths specifically defined in terms of a certain phase of the tide. Tidal datums are local datums and should not be extended into areas which have differing hydrographic characteristics with substantiating measurements.

### TIDE

The periodic rise and fall of the water resulting from gravitational interactions between Sun, Moon and Earth. The vertical component of the particulate motion of a tidal wave.

### TIDE GAUGE

Also referred to as a water level gauge. A device for measuring actual water levels. It can be as simple as a graduated staff in the water where visual observations can be made or it may consist of an elaborate recording instrument making a continuous graphic record of water levels over time. Until recent technological advances, most tide gauges were actuated by a float in a pipe communicating with the sea through a small hole which filters out shorter waves.

### TIDE LANDS

The zone between the mean high-water line and the mean low-water line, commonly referred to as the "beach." Waters above the tidelands are inland, being landward of the coastline.

### TIDE RANGE

See Range of Tide.

### TIDE STATION

See water level station.

### TIME VARIED GAIN (TVG)

A process where amplifier gain is changed based on time and matched with the returning signals between outgoing pulses of a sonar. Because of attenuation of a sonar beam, the receiver gain must be increased as the acoustic returns from greater and greater distances arrive at the transducer. Because these returns are received over a predictable and consistent time, the gains can be increased over a time curve. In many sonar systems, this curve can be adjusted by the operator.

### TOP MARK

A characteristic shape secured at the top of a buoy or beacon to aid in its identification.

## TOPOGRAPHIC MAP

A map which presents the vertical position of features in measurable form, as well as their horizontal positions.

## TOPOGRAPHIC SURVEY

As used in NOAA, a record of a survey, of a given date, of the natural features and the culture of a portion of the land surface and their delineation by means of conventional symbols. Alternately, it is the original field survey sheet and is the authority for the high-water line and all information inshore of that line, including geographic names of topographic features.

## TOTAL PROPAGATED Uncertainty(TPU)

TPU is an estimate of the uncertainty of any individual sounding, taking into account the error estimates of the component measurements (tide, sound speed, draft, range measurement, angle measurement, attitude, offsets, etc), and expressed as a separate value in horizontal and vertical planes. The uncertainty is sometimes expressed as a variance (in meters<sup>2</sup>) but more often as a confidence level (in meters) based on the assumption that the uncertainty is a Gaussian distribution. In the latter case, a specification of the level of confidence (e.g., "at 95% CI") must be appended for correctness and completeness. Horizontal uncertainties are generally expressed as a single 'Circular Error Probable' (CEP) value implying a symmetric distribution of uncertainty in the plane. Note that 'error' could be considered a misnomer, as there is no implication that the sounding is incorrect, just that its true value is uncertain.

## TP SHEET (MAP)

The term "TP Sheet" refers to photogrammetric surveys planned and executed after 1968. Photogrammetric surveys of the "TP" series are graphically depicted in the form of a shoreline map. Shoreline maps of the "TP" series generally depict shoreline in detail. In special survey projects, the shoreline map may consist of the base map and one or more overlays. "TP" stands for Topographic Photogrammetry.

## TRACK

The actual path or route of a craft over the ground or sea bottom, or its graphic representation.

## TRAINING WALL

A structure built alongside a channel to direct the tidal stream or currents through the channel to promote a scouring action.

## TRANSDUCER

The electromechanical component of a sonar system that is mounted underwater and converts electrical energy to sound energy and vice versa. The transducer formation determines the beam shape and is the basis for image formation in side scan sonar.

## TRANSFORM

To change the form of data according to specified rules, without significantly changing the meaning of the data.

## TRANSIT

A surveying instrument composed of a horizontal circle graduated in circular measure and an alidade with a telescope which can be reversed in its supports without being lifted therefrom. Also, the act of making such reversal. A theodolite having a telescope that can be transited in its supports is a transit, and is sometimes termed a transit theodolite. All modern theodolites are transits. See theodolite.

## TRANSVERSE MERCATOR PROJECTION

A projection of the cylindrical type, being in principle equivalent to the regular Mercator Projection turned 90°

in azimuth. In this projection, the central meridian is represented by a straight line, corresponding to the line which represents the equator on the regular Mercator Projection. Neither the geographic meridians, except the central meridian, nor the geodetic parallels, except the equator (if shown), are represented by straight lines. It is a conformal projection. Also called transverse cylindrical orthomorphic projection.

#### TRANSVERSE RESOLUTION

The ability of the sonar to image, as separate and distinct, objects that lay in a line parallel with a side scan sonar towfish track. Transverse or along-track resolution is determined, in part, by the horizontal beam width of the sonar. A narrow beam width will display two targets close together as separate and distinct anomalies. The same two targets, when encompassed by a wider beam, can be simultaneously enveloped by the single outgoing pulse. This can result in the two objects appearing as one in the sonar display. Transverse resolution decreases with range from the towfish because of beam spreading.

#### TRAVERSE

A route and a sequence of points on it at which observations are made; or the route, the points, and the observations at those points; or the process by which the route and sequence are established. In particular, a survey traverse. Unless specifically stated otherwise, a traverse is horizontal, i.e., a procedure for determining only the horizontal coordinates of the points in the traverse.

#### TRIANGULATION

A method of surveying in which the stations are points on the ground at the vertices of a chain or network of triangles, whose angles are observed instrumentally and whose sides are derived by computation from selected triangle sides called base lines, the lengths of which are obtained from direct measurement on the ground.

#### TRILATERATION

A method of extending horizontal control where the sides of triangles are measured rather than the angles as in triangulation.

#### TRIGGER PULSE

The signal provided to sonar transducer firing circuitry to initiate the outgoing pulse; also, two parallel lines on the center of a side scan sonar record that represent the position of the fish in relation to the sonar image. Many sonar displays sense the trigger pulse in order to synchronize other subroutines with the trigger. Because the display of the trigger pulse in data is caused by transducer firing, it is useful in system troubleshooting.

#### TRUE NORTH

Geographic or astronomic north; coincides with the true meridian rather than magnetic north.

#### T- SHEET

Planetable topographic and certain photogrammetric surveys conducted by the agency and its predecessors during the period 1834 - 1980. These surveys were recorded graphically in the form of a map which should be referred to a "topographic survey" or "shoreline map," as appropriate.

#### TURBIDITY

Reduced water clarity resulting from the presence of suspended matter. Water is considered turbid when its load of suspended matter is visibly conspicuous, but all waters contain some suspended matter and therefore are turbid. As turbidity increases, the maximum depth that water penetrating bathymetric LIDAR can measure decreases.

#### TURNING BASIN

A water area used for turning vessels.

TVG

See Time Varied Gain.

TWO POINT FEATURE

A cartographic feature that can be positioned with 1 set of coordinates describing its location and a second set of coordinates defining its orientation.

## 7.21 U

UNALASKA DATUM

An independent datum in Alaska used along the south coast of the Alaska Peninsula from Cape Kuyuyukak to Umnak Island.

UNITED STATES STANDARD DATUM

The first standard geographic datum adopted by the Coast and Geodetic Survey for all the triangulation in the United States. It was adopted on March 13, 1901, and is defined by station Meades Ranch, whose position on the Clarke spheroid of 1866 is: Latitude  $39^{\circ} 13' 26.686''$ , longitude  $98^{\circ} 32' 30.506''$ , and azimuth to station Waldo  $75^{\circ} 28' 14.52''$ .

UNIVERSAL TRANSVERSE MERCATOR (UTM) GRID

A military grid system based on the transverse Mercator map projection, applied to maps of the earth's surface extending to  $84^{\circ}\text{N}$  and  $80^{\circ}\text{S}$ .

UPPER LIMIT OF NAVIGATION

The character of a river will, at some point along its length, change from navigable to non-navigable. Very often that point will be at a major fall or rapids, or other place where there is a marked decrease in the navigable capacity of the river. The upper limit will therefore often be the same point traditionally recognized as the head of navigation, but may, under some of the tests described above, be at some point yet farther upstream.

UUV

Acronym for Unmanned Underwater Vehicle. There are two categories of UUVs, AUVs and ROVs. See AUV and ROV.

## 7.22 V

VALDEZ DATUM

Vicinity of Cape St. Elias to Wide Bay on the Alaska Peninsula, and for the triangulation around Kodiak Island.

VARIATION

The angle between the magnetic and geographic meridians at any place, expressed in degrees and minutes east or west to indicate the direction of magnetic north from true north. Also called magnetic declination.

VELOCIMETER

Same as Velocity Profiler.

VELOCITY

A vector quantity equal to speed in a given direction.

## VELOCITY PROFILE

The gradient of acoustic velocity in water displayed as a graph of distance below the sea surface against the speed of sound. This term is often used incorrectly instead of speed-of-sound profile, when referring to a scalar magnitude rather than a vector quantity.

## VELOCITY PROFILER

An instrument used for the “in situ” measurement of the speed-of-sound in the sea and other natural waters. Also called velocimeter.

## VERIFICATION

As used in NOAA, the process by which a hydrographic survey undergoes a check of the field observations. It deals primarily with a specific survey and its accompanying records, and with correlating it to other contemporary surveys.

## VERIFIED WATER LEVELS

Recorded 6-minute water level observations that have undergone both rudimentary data consistency checks in the CO-OPS Data Processing and Analysis System (DPAS) and verification by a technician at CO-OPS. Any gaps in data will have been recovered or interpolated from other gauge data. Verified water levels have been reduced to MLLW.

## VERIFIER'S REPORT

The renamed, but approximately equivalent, successor to the “Review Report.” On the transfer of the formal hydrographic survey review to the Office of Marine Operations in October, 1975, it was considered appropriate to revise the title of the report, although the format and content remained essentially unaltered. Effective October 1, 1982, the title of this report was again revised to “Evaluation Report.” The “Review Report,” “Verifier’s Report,” and “Evaluation Report” are essentially equivalent documents, i.e., they serve the same purpose. See Evaluation Report and Review Report.

## VERTICAL BEAM ECHO SOUNDER (VBES)

A term created by NOAA hydrographers to identify the dual-frequency, dual beam width nature of nonmultibeam depth measuring sonars. Although the transducer of Vertical Beam Echo Sounders is not gyro-stabilized (a requirement for a true single beam vertical echo sounder) it is assumed that through all vessel motions where depth measurements are taken a portion of the wider beam is indeed vertical. See Single Beam Echo Sounder (SBES)

## VERTICAL CONTROL

Term used to describe points with established elevations relative to a specific vertical datum which are used as fixed references for surveying and/or mapping activities.

## VERTICAL DATUM

Any level surface taken as a surface of reference from which to reckon elevations. A level surface is one which, at every point, is perpendicular to the direction of gravity, i.e., an equipotential surface. The geoid, or in general, any surface parallel to it, is a level surface. In order that they may be recovered when needed, such datums are referenced to fixed points known as bench marks.

## VESSEL

The term “vessel” includes every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on the waters of the U.S.

## VESSEL CONFIGURATION FILE (VCF)

A digital file used to set the parameters for sensors and other equipment for data processing. See HIPS Vessel File (HVF)

## VESSEL REFERENCE UNIT (VRU)

See Motion Reference Unit (MRU).

## 7.23 W

### W SURVEY

A hydrographic survey originating from outside the administrative control of the agency; alternately referred to as outside source data. These data are considered to have the potential to be applied to nautical charts. They are assigned a registry number consisting of the “W” prefix followed by a 5-digit numerical identifier, e.g., W00001.

### WAAS

See Wide Area Augmentation System.

### WATER COLUMN

A vertical section of water from the surface to the bottom. Typically used when describing sonar performance, characteristics, and corrections.

### WATER LEVEL GAUGE

See Tide Gauge.

### WATER LEVEL STATION

The geographic location at which water level observations are conducted. Also, the facilities used to make water level observations. These may include a tide house, tide gauge, tide stall, and tidal bench marks. Also referred to as a tide station.

### WATERFRONT

Land at the end of a stream, harbor, etc.; the part of a city or town on such land; a wharf or dock area.

### WATERLINE

1. The line marking the junction of water and land. This line migrates, changing with the tide or other variation of the water level. Also written as two words. 2. The line marking the junction of water and the hull of a vessel.

### WATERWAY

A water area providing a means of transportation from one place to another, principally a water area providing a regular route for water traffic, such as a bay, channel, passage, or the regularly traveled parts of the open sea. The terms waterway, fairway, and thoroughfare have nearly the same meanings. Waterway refers particularly to the navigable part of the water area. Fairway refers to the main traveled part of a waterway. A thoroughfare is a public waterway.

### WAVELENGTH

The distance, measured in the direction of propagation, between 2 successive points in a wave that are characterized by the same phase of oscillation. In sonar technology, along with the transmit power of a sonar, the wavelength (directly related to sonar frequency) will determine the ultimate range of the system. Decreases in wavelength (increases in frequency) bring higher resolution with the tradeoff of reduced range.

## WAY POINT

1. A mark or place at which a vessel is required to report or establish its position. 2. A notable point, often the point at which course changes, in a planned vessel route.

## WD

See Wire Drag.

## WEIR

A fence-like structure set in a stream or along a shoreline to catch fish. It differs from a pound because it is mainly constructed of brush hedging or narrow boards with or without nettings. Coastal weirs are generally built where there is a large expanse of ground left uncovered at low water. Weirs are usually kept in position all year round.

## WELL HEAD

A submarine structure projecting some distance above the seabed and capping an oil or gas well on which drilling activity has been temporarily abandoned or suspended.

## WHARF

A structure of open, rather than solid, construction parallel to the shoreline, providing only one face, which serves as a berthing place for vessels, and which generally provides cargo-handling facilities. A similar facility of solid construction is called a quay. A structure extending into the water with accommodations for vessels on both sides is called a pier.

## WIDE AREA AUGMENTATION SYSTEM (WAAS)

The Wide Area Augmentation System (WAAS) is a network of 25 ground reference stations, ranging from the US to Canada to Mexico, which monitor GPS satellite information and create a GPS correction message. This correction accounts for GPS satellite orbit and clock drift plus signal delays caused by the atmosphere and ionosphere. The corrected differential message is then broadcast through one of two geostationary satellites, or satellites with a fixed position over the equator. A WAAS-corrected signal can result in a GPS positional accuracy of within 3 meters.

## WINTER MARKER

A lighted or unlighted buoy without sound signal, which is established as a replacement during the winter months when other aids are closed or withdrawn due to potential severe weather conditions such as ice.

## WIRE DRAG

An apparatus once used in hydrographic surveying for determining the maximum clearance depth. It also was used for the detection of isolated dangers to navigation which might escape detection by ordinary sounding methods, e.g., rocks, pinnacles, ledges, boulders, coral reefs, etc. It consisted of a horizontal bottom wire supported at intervals ranging from 300 - 600 ft by adjustable upright cables suspended from buoys on the surface and towed at the desired depth by 2 ships or launches. These uprights could be lengthened or shortened for various required depths. They were kept in a nearly vertical position by means of weights attached to their ends. The end weights and buoys were larger than the intermediate weights, and buoys and the towing gear was attached to them.

## WIRE-DRAGGED AREAS

Areas that have been swept to a safe depth with the wire drag. Symbolized on nautical/navigational charts by a green tint.

## WIRE-DRAG SURVEY

A hydrographic survey utilizing wire drag apparatus.

## WIRE SWEEP

A modification of the wire-drag apparatus. Drag and sweep have nearly the same meanings. The wire sweep was similar to the wire drag, differing only in the length of dragged sections between buoys. It consisted of end buoys and intermediate buoys set at intervals of 2,000 - 2,500 ft. It was used in areas where the general depth was considerably greater than the depths to be investigated and where few, if any, obstructions were believed to exist. The sweep could be set out more quickly and required less equipment than the wire-drag apparatus. The use of the sweep would not necessarily indicate closely the position of any obstruction encountered, due to the great distances between buoys. In addition, the sweep depth would be only an approximation because of the sag of the bottom-wire between buoys.

## WORLD GEODETIC SYSTEM 1984 (WGS 84)

WGS 84 is comprised of a consistent set of parameters describing the size and shape of the earth, the positions of a network of points with respect to the center of mass of the earth, transformations from major geodetic datums, and the potential of the earth. It represents the National Geospatial-Intelligence Agency's (NGA's) modeling from a geometric, geodetic, and gravitational standpoint using data, techniques, and technology available in 1984. Satellite positions, including GPS observations, are based on WGS 84 which is both an ellipsoid and a datum.

## WRECK

The ruined remains of a vessel which has been rendered useless, usually by violent action of the sea and weather, on a stranded or sunken vessel. In hydrography, the term is limited to a wrecked vessel, either submerged or visible, which is attached to or afoul of the bottom or cast up on the shore. In nautical cartography, wrecks are designated visible, dangerous, or non-dangerous according to whether they are above tidal datum, less than, or more than 20 m (66 ft; 11 fm) below tidal datum, respectively.

## WRECKAGE

Goods or parts of a wrecked vessel either washed ashore, afloat, or submerged and resting on the bottom; i.e., the remains of a wreck.

## WRECK BUOY

A buoy marking the position of a wreck. It is usually placed on the seaward or channel side of the wreck and as near to the wreck as conditions will permit. To avoid confusion in some situations, 2 buoys may be used to mark the wreck. The possibility of the wreck having shifted position due to sea action between the times the buoy was established and later checked or serviced should not be overlooked.

## 7.24 X

### X-AXIS

A horizontal axis in a system of rectangular coordinates; that line on which distances to the right or left (east or west) of the reference line are marked, especially on a map, chart, or graph.

## 7.25 Y

### Y-AXIS

A vertical axis in a system of rectangular coordinates; that line on which distances above or below (north or south of) a reference line are marked, especially on a map, chart, or graph. The line which is perpendicular to the X-axis and passes through the origin.

## YARD

A fundamental unit of length in the English system of measurement. The metric equivalent prior to July 1, 1959, was  $1 \text{ yd} = 0.914440183 \text{ m}$ . On that date, the value was changed to  $1 \text{ yd} = 0.9144 \text{ m}$ .

## YAW

An instability characterized by the side-to-side movement of a ship or towed body about its vertical axis. Vessel and towfish yaw most often occur at low speeds and with quartering seas. Towfish yaw is distinctive in sonar data.

## 7.26 Z

### “ZERO” SOUNDINGS

Soundings that reduce to heights above the sounding datum but are shown on the smooth sheet as zero soundings, regardless of height; a practice followed prior to 1860.

### ZULU TIME

See Coordinated Universal Time.

# Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of  
Coast Survey

2014

## Chapter 1 Appendices:

SSS Calibration Table  
Sounding System Comparison Log  
POS\_MV Calibration Report  
MBES Calibration Report  
Leadline Sounding Pole Directions  
Leadline Sounding Pole Calibration Report  
Hydrographic Systems Readiness Memo  
Coordinate Systems

### Please Note:

The Standard Operating Procedure's (SOP's) within the FPM Appendices are in the process of being transferred to the "Documents" section of the Hydroforum and the SOP's will reside in both places for the remainder of the 2014 field season.

## Side Scan Sonar Calibration

Field Unit:

Date of Test:

Calibrating Hydrographer(s):

### SIDE SCAN SYSTEM INFORMATION

Side Scan System: Klein System 3000

System Location: Launch 1005

TPU Serial Number:

Towfish Serial Number:

Cable Type: stainless steel armored w/ grease termination

Date of Most Recent EED / Factory Checkout:

Date of Most Recent Pressure Sensor Verification (if applicable):

### VESSEL INFORMATION

Sonar Configuration: towed

Cable Measurement System (if applicable): Dynapar cable counter

Date of Current Vessel Offset Measurement / Verification:

Date of Current Cable Measurement / Verification (if applicable):

### TEST INFORMATION

Test Date(s) / DN(s):

System Operator(s):

Wind / Seas / Sky:

Locality:

Sub-Locality:

Description of Bathymetry: steep

Bottom Type: rocky

Approximate Water Depth:

Description of Target: ping pong ball target

Approximate Target Size: (should be approximately 1m L x 1m W x 1m H)



## Sounding Systems Comparison

Field Unit:

Date & Time	Location (Lat, Lon)	Sounding System Models & Serial Numbers	Raw Depth (m)	Processed Depth (m)	System Operator	Comments
1/15/2005		Non-traditional lead line: FA-LL1 Reson 8101 (Launch 1): DLDG MODIII:	60.0 58.5 59.2	60.0 59.7 60.1	ST GF ST JA CST LM	Annual Systems Certification comparison. Sea conditions calm, 1 ft swell. No corrections necessary.

# POS/MV Calibration Report

Field Unit: \_\_\_\_\_

## SYSTEM INFORMATION

Vessel: \_\_\_\_\_

Date: \_\_\_\_\_

Dn: \_\_\_\_\_

Personnel: \_\_\_\_\_

PCS Serial # 786

IP Address: 129.100.1.231

POS controller Version (Use Menu Help > About) 2.10d

POS Version (Use Menu View > Statistics) MV320 Ver3

**GPS Receivers**

Primary Receiver SGN 99330009

Secondary Receiver SGN 98370085

## CALIBRATION AREA

Location: Ketchikan, AK

Approximate Position:

Lat

Lon

D	M	S
55	19	46
131	37	27

DGPS Beacon Station: Annette Island, AK

Frequency: 323 KHZ

### Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

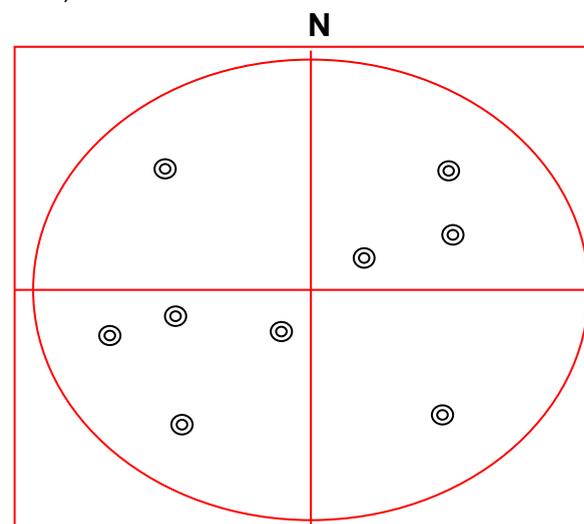
HDOP: 0.873

VDOP: 1.033

Sattelites in Use: 9

1,4,11,13,16,20,23,25,30

PDOP 1.352 (Use View> GAMS Solution)



**Note:** Secondary GPS satellite constellation and number of sattelites were exactly the same as the Primary GPS

## POS/MV CONFIGURATION

### Settings

#### Gams Parameter Setup

(Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

1.834	Two Antenna Separation (m)
0.30	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0	X Component (m)
0	YComponent (m)
0	Z Component (m)

**Configuration Notes:** GAMS needed re-calibration because the leverarm for IMU to Port Antenna was incorrect

## POS/MV CALIBRATION

### Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 10:18 UTC

End time: 10:20 UTC

Heading accuracy achieved for calibration: 0.099

### Calibration Results:

#### Gams Parameter Setup

(Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values

1.831	Two Antenna Separation (m)
0.300	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.002	X Component (m)
1.831	YComponent (m)
0.021	Z Component (m)

GAMS Status Online? X

Save Settings? X

**Calibration Notes:** Took over an hour to get fixed OTF solution and GAMS Ready Offline

### Save POS Settings on PC

(Use File > Store POS Settings on PC)

File Name: POSMV\_09012004.nvm

## GENERAL GUIDANCE

### The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

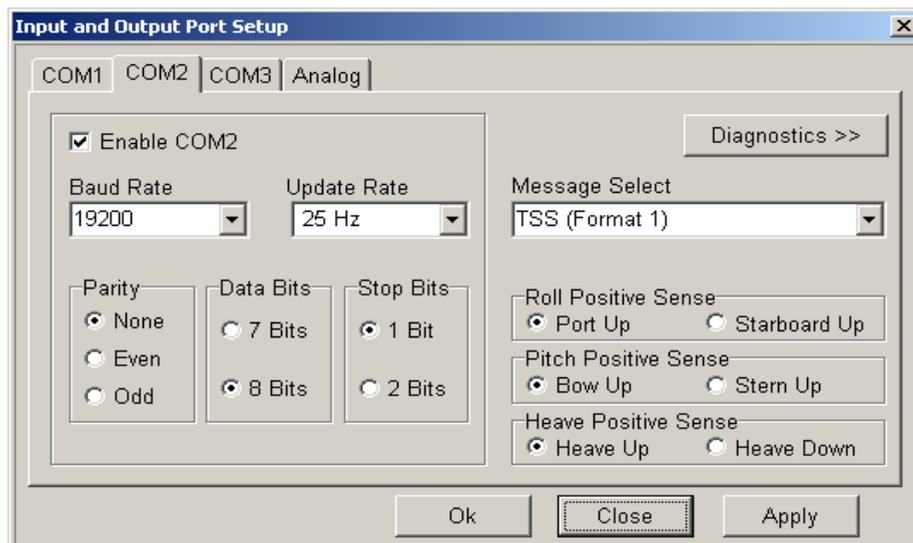
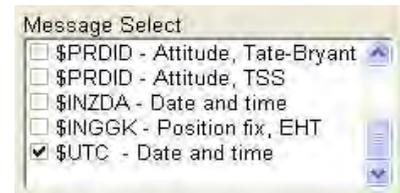
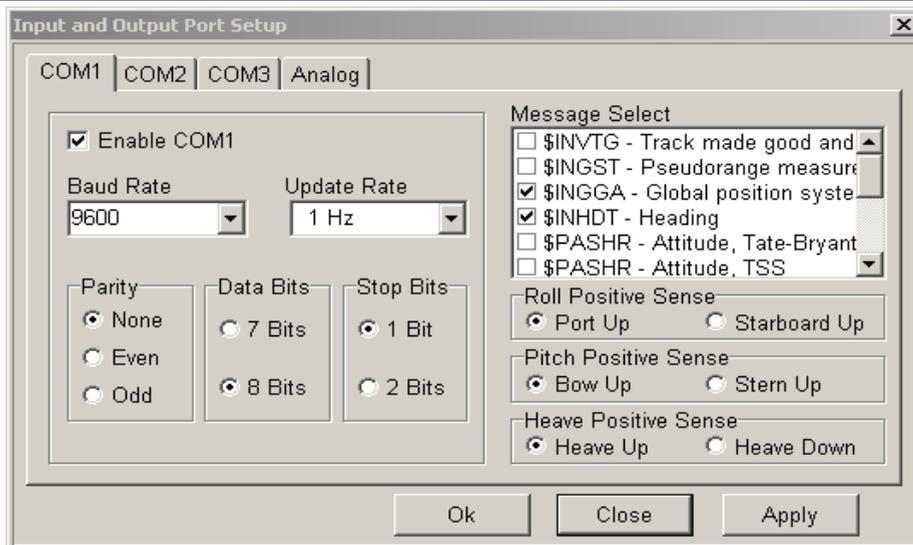
### The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

- a) Heading rotation - apply a right-hand screw rotation  $\theta_z$  about the z-axis to align one frame with the other.
- b) Pitch rotation - apply a right-hand screw rotation  $\theta_y$  about the once-rotated y-axis to align one frame with the other.
- c) Roll rotation - apply a right-hand screw rotation  $\theta_x$  about the twice-rotated x-axis to align one frame with the other.

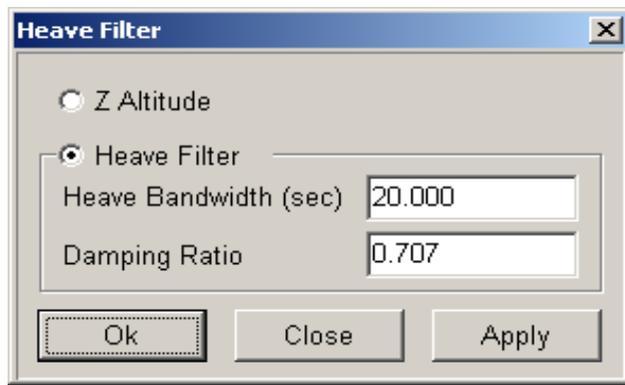
## SETTINGS (insert screen grabs)

Input/Output Ports (Use Settings > Input/Output Ports)



NOTE: COM3 and Analog are not used.

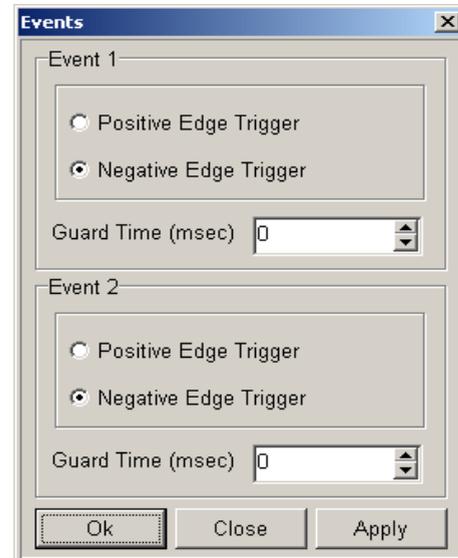
**Heave Filter** (Use Settings > Heave)



The Heave Filter dialog box contains the following elements:

- Radio buttons for  Z Altitude and  Heave Filter.
- Text input for Heave Bandwidth (sec) with value 20.000.
- Text input for Damping Ratio with value 0.707.
- Buttons: Ok, Close, Apply.

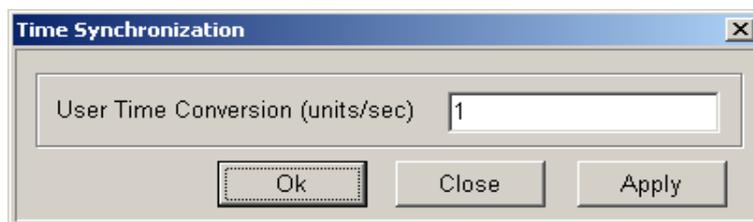
**Events** (Use Settings > Events)



The Events dialog box contains the following elements:

- Event 1 section:
  - Radio buttons for  Positive Edge Trigger and  Negative Edge Trigger.
  - Guard Time (msec) input with value 0.
- Event 2 section:
  - Radio buttons for  Positive Edge Trigger and  Negative Edge Trigger.
  - Guard Time (msec) input with value 0.
- Buttons: Ok, Close, Apply.

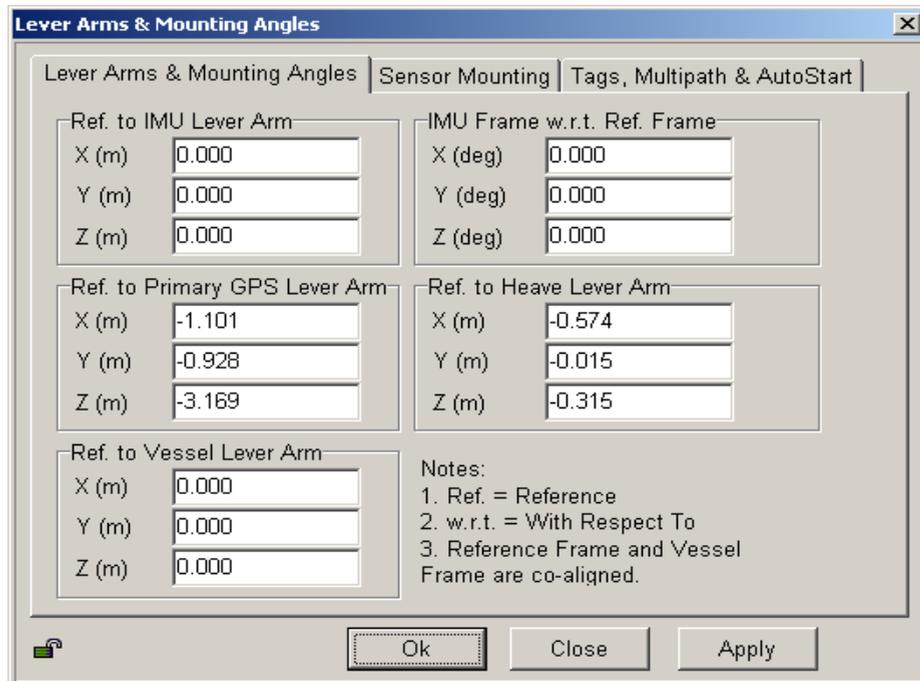
**Time Sync** (Use Settings > Time Sync)



The Time Synchronization dialog box contains the following elements:

- Text input for User Time Conversion (units/sec) with value 1.
- Buttons: Ok, Close, Apply.

**Installation** (Use Settings > Installation)



The Lever Arms & Mounting Angles dialog box contains the following elements:

- Tabbed interface with tabs: Lever Arms & Mounting Angles, Sensor Mounting, Tags, Multipath & AutoStart.
- Ref. to IMU Lever Arm:
  - X (m): 0.000
  - Y (m): 0.000
  - Z (m): 0.000
- IMU Frame w.r.t. Ref. Frame:
  - X (deg): 0.000
  - Y (deg): 0.000
  - Z (deg): 0.000
- Ref. to Primary GPS Lever Arm:
  - X (m): -1.101
  - Y (m): -0.928
  - Z (m): -3.169
- Ref. to Heave Lever Arm:
  - X (m): -0.574
  - Y (m): -0.015
  - Z (m): -0.315
- Ref. to Vessel Lever Arm:
  - X (m): 0.000
  - Y (m): 0.000
  - Z (m): 0.000
- Notes:
  - 1. Ref. = Reference
  - 2. w.r.t. = With Respect To
  - 3. Reference Frame and Vessel Frame are co-aligned.
- Buttons: Ok, Close, Apply.

**Tags, Multipath and Auto Start** (Use Settings > Installation > Tags, Multipath and Auto Start)

The screenshot shows the 'Tags, Multipath & AutoStart' tab of the 'Lever Arms & Mounting Angles' dialog box. It contains three sections of settings:

- Time Tag 1:** Radio buttons for POS Time, GPS Time, and UTC Time. UTC Time is selected.
- Time Tag 2:** Radio buttons for POS Time, GPS Time, UTC Time, and User Time. POS Time is selected.
- Multipath:** Radio buttons for Low, Medium, and High. Low is selected.
- AutoStart:** Radio buttons for Disabled and Enabled. Enabled is selected.

At the bottom, there are 'Ok', 'Close', and 'Apply' buttons.

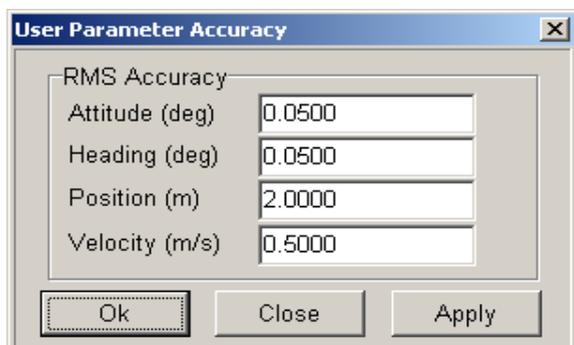
**Sensor Mounting** (Use Settings > Installation > Sensor Mounting)

The screenshot shows the 'Sensor Mounting' tab of the 'Lever Arms & Mounting Angles' dialog box. It contains six sections of settings for two sensors:

- Ref. to Aux. 1 Gps Lever Arm:** X (m) 0.000, Y (m) 0.000, Z (m) 0.000
- Ref. to Aux. 2 GPS Lever Arm:** X (m) 0.000, Y (m) 0.000, Z (m) 0.000
- Ref. to Sensor 1 Lever Arm:** X (m) 0.000, Y (m) 0.000, Z (m) 0.000
- Sensor 1 Frame w.r.t. Ref. Frame:** X (deg) 0.000, Y (deg) 0.000, Z (deg) 0.000
- Ref. to Sensor 2 Lever Arm:** X (m) 0.000, Y (m) 0.000, Z (m) 0.000
- Sensor 2 Frame w.r.t. Ref. Frame:** X (deg) 0.000, Y (deg) 0.000, Z (deg) 0.000

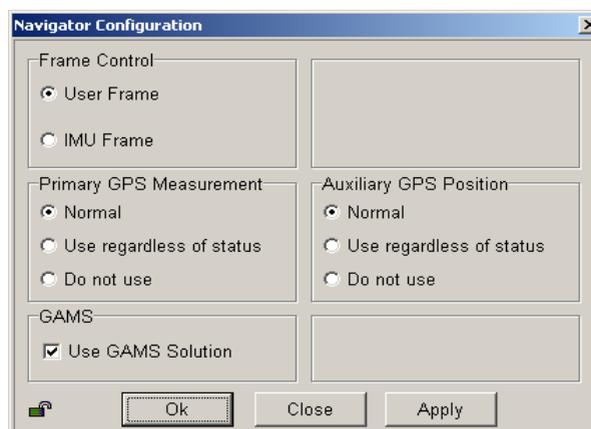
At the bottom, there are 'Ok', 'Close', and 'Apply' buttons.

**User Parameter Accuracy** (Use Settings > Installation > User Accuracy)



The dialog box titled "User Parameter Accuracy" contains four input fields under the heading "RMS Accuracy":  
Attitude (deg): 0.0500  
Heading (deg): 0.0500  
Position (m): 2.0000  
Velocity (m/s): 0.5000  
At the bottom are three buttons: "Ok", "Close", and "Apply".

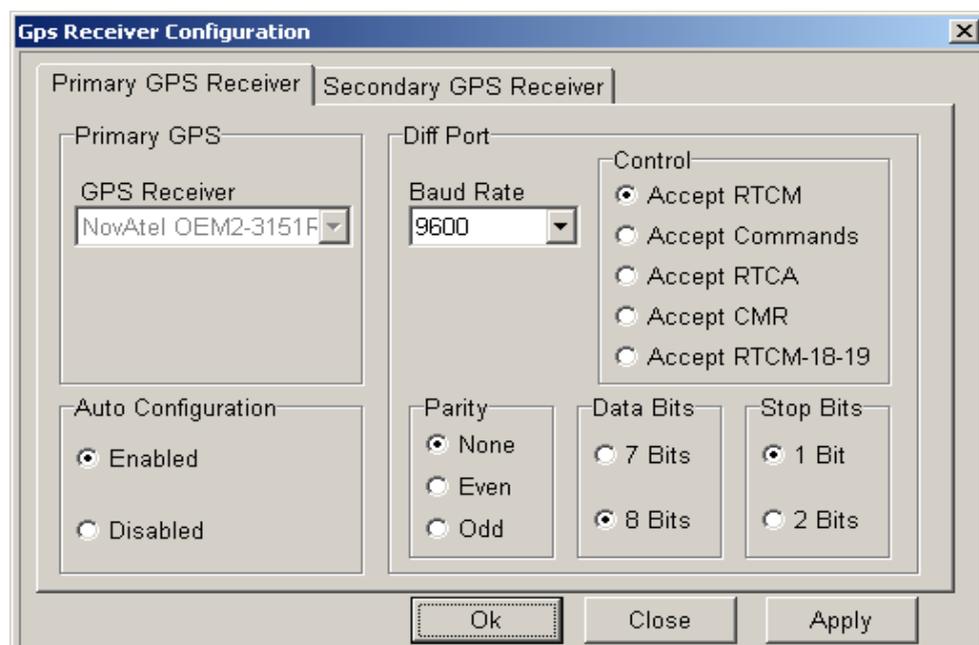
**Frame Control** (Use Tools > Config)



The dialog box titled "Navigator Configuration" has several sections:  
- "Frame Control": Radio buttons for "User Frame" (selected) and "IMU Frame".  
- "Primary GPS Measurement": Radio buttons for "Normal" (selected), "Use regardless of status", and "Do not use".  
- "Auxiliary GPS Position": Radio buttons for "Normal" (selected), "Use regardless of status", and "Do not use".  
- "GAMS": A checked checkbox for "Use GAMS Solution".  
At the bottom are three buttons: "Ok", "Close", and "Apply".

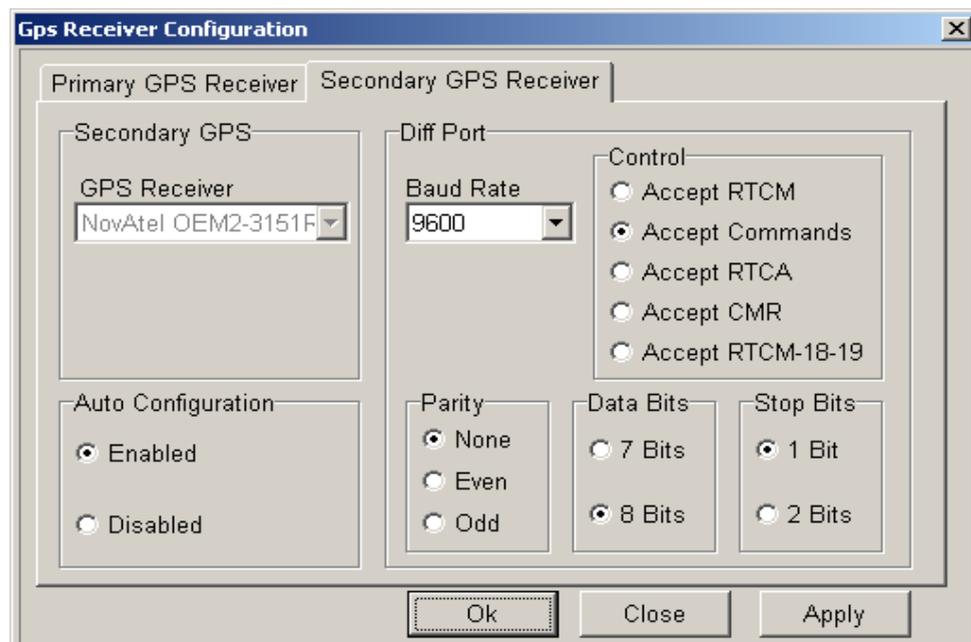
**GPS Receiver Configuration** (Use Settings> Installation> GPS Receiver Configuration)

**Primary GPS Receiver**



The dialog box titled "Gps Receiver Configuration" has two tabs: "Primary GPS Receiver" (selected) and "Secondary GPS Receiver".  
- "Primary GPS": A dropdown menu for "GPS Receiver" showing "NovAtel OEM2-3151F".  
- "Diff Port": A dropdown menu for "Baud Rate" showing "9600".  
- "Control": Radio buttons for "Accept RTCM" (selected), "Accept Commands", "Accept RTCA", "Accept CMR", and "Accept RTCM-18-19".  
- "Auto Configuration": Radio buttons for "Enabled" (selected) and "Disabled".  
- "Parity": Radio buttons for "None" (selected), "Even", and "Odd".  
- "Data Bits": Radio buttons for "7 Bits", "8 Bits" (selected), and "2 Bits".  
- "Stop Bits": Radio buttons for "1 Bit" (selected) and "2 Bits".  
At the bottom are three buttons: "Ok", "Close", and "Apply".

**Secondary GPS Receiver**



The dialog box titled "Gps Receiver Configuration" has two tabs: "Primary GPS Receiver" and "Secondary GPS Receiver" (selected).  
- "Secondary GPS": A dropdown menu for "GPS Receiver" showing "NovAtel OEM2-3151F".  
- "Diff Port": A dropdown menu for "Baud Rate" showing "9600".  
- "Control": Radio buttons for "Accept RTCM", "Accept Commands" (selected), "Accept RTCA", "Accept CMR", and "Accept RTCM-18-19".  
- "Auto Configuration": Radio buttons for "Enabled" (selected) and "Disabled".  
- "Parity": Radio buttons for "None" (selected), "Even", and "Odd".  
- "Data Bits": Radio buttons for "7 Bits", "8 Bits" (selected), and "2 Bits".  
- "Stop Bits": Radio buttons for "1 Bit" (selected) and "2 Bits".  
At the bottom are three buttons: "Ok", "Close", and "Apply".

## Multibeam Echosounder Calibration

Field Unit:

Date of Test:

Calibrating Hydrographer(s):

### MULTIBEAM SYSTEM INFORMATION

Multibeam Echosounder System:

System Location:

Sonar Serial Number:

Processing Unit Serial Number:

Date of Most Recent EED / Factory Checkout:

### VESSEL INFORMATION

Sonar Mounting Configuration: pole-mount on port side of vessel

Date of Current Vessel Offset Measurement / Verification:

Description of Positioning System: POS/MV version 4 w/ Precise Timing

Date of Most Recent Positioning System Calibration:

### TEST INFORMATION

Test Date(s) / DN(s):

System Operator(s):

Wind / Seas / Sky:

Locality: Chesapeake Bay

Sub-Locality: Tail of the Horseshoe

Bottom Type: sandy

Approximate Average Water Depth: 20 meters

### DATA ACQUISITION INFORMATION

Line Number	Heading	Speed

## TEST RESULTS

Navigation Timing Error:

Pitch Timing Error:

Roll Timing Error:

Pitch Bias:

Roll Bias:

Heading Bias:

Resulting CARIS HIPS HVF File Name:

## NARRATIVE

Briefly and succinctly summarize the MBES Certification Test, focusing on those aspects of the test. Particular attention shall be paid to interpretation of test results, with discussion on residual biases in roll, pitch, heading, and navigation timing error. Any changes to configuration made based on these results shall be described.

## **DIRECTIONS FOR CREATING TRADITIONAL LEAD LINES AND SOUNDING POLES**

(excerpted from the *NOAA Hydrographic Manual*, July 1976, with modifications)

### **Traditional Lead Line Construction**

#### **I. Material**

Standard lead line material is mahogany-colored tiller rope with a phosphor-bronze wire center. The center consists of six strands of seven 33-B (S-gage) wires each. The wire core is flexible and should not break after continual use and coiling. The rope is size 8 (about 0.24 in. in diameter), and is made of waterproofed, solid braided, long-staple cotton. The braid should be tight enough so that broken wire strands will not protrude through the covering and injure a leadsman's hands. Material for lead lines may either be requisitioned from the Marine Centers or be purchased from a well-equipped marine supply dealer.

#### **II. Fabrication and Marking**

Depending on the depths in which they will be used and on the size of the vessel, lead lines should be 30 to 60 meters long. Each lead line is identified by a consecutive number stamped on a metal disk attached at the inboard end of the line. Identification is made when a line is initially graduated. This number is to be retained throughout the life of the lead line or until re-marking is necessary. The braided covering of an unseasoned lead line tends to shrink when wet causing the wire core to buckle and the strands to break. Broken strands are likely to protrude through the covering and cause hand injuries. To prevent rupturing the core with repeated use, pre-season each lead line as follows:

1. Prepare the lead line by soaking it in salt water for 24 hours. Then, while the line is still wet, work the cotton covering along the wire by hand until the wire protrudes from the covering. The wire should protrude about 1/3 meter for each 20 meters of line. This is a tedious procedure requiring the cooperative efforts of several people. The covering can be pushed back and slackened only a few inches at a time; this length of slack must be pushed nearly the full length of the line before the next small section can be started. The excess protruding wire is cut off. The covering must not be worked back too far, or it will form bulges along the wire. Lead lines so prepared will maintain an almost constant length for future use.

2. Next, the line is dried under tension (about 50 lb) and then soaked again for 24 hr. Never boil a lead line as this destroys the waterproofing of the cover.

3. After attaching a lead to the line, the line should be wetted down again and placed under a tension equal to the weight of the lead; this tension is maintained while the line is being graduated. Temporary marks made at this time can be used for later permanent marking. Graduation marks on a new lead line may be laid off with a steel tape. The best method, however, is to mark the distances permanently on a suitable surface such as on the deck of a ship or on a wharf if the survey party is shore based. Permanent markings are convenient when verifying the graduations in the future. Lead lines for NOAA hydrographic surveys should be graduated in meters, with intermediate marks to permit readings to the nearest decimeter. Each meter should be marked by a seizing of black thread, with a leather strip clearly indicating the numerical value for even meter intervals. Each even decimeter (0.2,

0.4, 0.6, and 0.8) is marked by a seizing of white thread. Odd tenth readings are estimated. Waxed linen thread should be used to secure marks to the lead line in such a manner that there can be no possibility of slippage. Do not insert the thread through the braided covering of the line.

### III. Verification

When checks of traditional lead lines are made, the lead lines must be wet and under a tension equal to the weight of the attached lead in water. The testing standard should be a good recently calibrated steel tape or pre-measured graduation marks on deck or ashore. Replace or re-mark lead lines if the errors exceed 0.1 meter.

### IV. Sounding Leads

Each survey unit should have one or more leads. Leads come in standard weights of 5, 7, 9, 14, and 25 lb are requisitioned from the Marine Centers. Various methods may be used to attach the lead to the lead line. The preferred method is to have a galvanized thimble at the lower end of the lead line to which the lead can be attached by a shackle.

## **Traditional Sounding Pole Construction**

### I. Material

A sounding pole is made from a 5 meter length of 1.5 inch (3.81 cm) round lumber capped with a weighted metal shoe at each end to hasten sinking. Shorter poles may be used depending on the depth conditions.

### II. Fabrication and Marking

Any convenient system of marking that is symmetrical toward both ends and will minimize reading errors may be used. The following marking system is recommended:

Mark each meter and even decimeter graduation (0.2, 0.4, 0.6, and 0.8) permanently by cutting a small notch in the pole. Paint the entire pole white; then paint odd decimeter graduation marks black.

### III. Verification

Sounding poles must be verified against a known standard, such as a survey quality metal tape, to ensure that depth markings are unambiguous and accurate.





UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL OCEAN SERVICE  
Office of Coast Survey  
Silver Spring, Maryland 20910-3282

(to be dated when signed)

MEMORANDUM FOR: Jeff Ferguson  
Chief, Hydrographic Surveys Division or

Howard Danley  
Chief, Navigation Services Division

FROM: LCDR Joseph Hydrohead, NOAA  
Commanding Officer, NOAA Ship SWATH

SUBJECT: NOAA Ship SWATH Hydrographic Systems Status Summary

The hydrographic systems of NOAA Ship SWATH were reviewed in accordance with the Office of Coast Survey Field Procedures Manual (FPM) Hydrographic Systems Readiness Review procedures on January 28, 2010. The review process took place at NOAA's Marine Operations Center in Norfolk, Virginia, and was conducted by a Hydrographic Systems Review Team comprised of the following people:

Lieutenant Jane Doe, HSTP Field Support Liaison  
Lieutenant Ida Know, Field Operations Officer, NOAA Ship SWATH  
Mr. Thomas Smith, Physical Scientist, AHB

The Review Team's findings are summarized in this memorandum and reflect the condition of the SWATH field unit's hydrographic systems on the review date. These findings have been divided into three categories of deficiencies:

**CATEGORY 1** – These deficiencies indicate the failure or absence of vital equipment or preparations of systems essential to acquisition and/or processing of hydrographic data. The vessel will be required to cease or limit hydrographic survey operations due to the following deficiencies:

1. The hull of launch number 2901 has structurally cracked and the vessel has been removed from service until repairs are made. This vessel should not be used for hydrographic survey operations until the crack has been repaired.
2. The ship's multibeam echosounder (MBES) was replaced during the current dockside repair period. A calibration (patch test) has not yet been conducted for this system due to ongoing ship repairs. The ship's MBES system can not be used to acquire data for NOAA hydrographic surveys until a successful system calibration has been performed.
3. Side scan sonar (SSS) towfish S/N 8675309 failed to detect the 1 m<sup>3</sup> test object nine out of ten times during calibration. No evidence of damage was noted on the towfish. After three unsuccessful attempts to complete the SSS calibration, EED was contacted and the towfish

**Comment [J1]:** This memo is to be submitted as a digitally signed PDF document. Email a copy of this memo to OCS.HSRR@noaa.gov



returned to the manufacturer for evaluation and any necessary repairs. Towfish repairs had not been completed at the time of this review.

**CATEGORY 2** – These deficiencies indicate noncompliance with established policies, directives, instructions, or accepted hydrographic practice not addressed under Category 1. The following deficiencies shall be corrected in as timely a manner as funding, time, and/or professional assistance permit:

1. The field unit’s Diver Least Depth Gauge (DLDG) is overdue for calibration. This system must be calibrated by the manufacturer annually.
2. The side scan cable counter on Launch 2902 is broken, and the cable has been manually marked. These markings are deteriorating and no longer considered accurate. An accurate method of measuring cable out is required for side scan operations.
3. To analyze a horizontal control reference station, a second portable DGPS reference station is needed for comparison. SWATH is not equipped to set up a second portable DGPS reference station due to loss of equipment during the 2004 field season.
4. The field unit is currently performing GIS functions using MapInfo version 6.5. While this software version will perform locally without problems, OCS has upgraded to version 8.0. Project files and workspaces created using MapInfo version 8.0 may not be compatible with version 6.5.

**CATEGORY 3** – These deficiencies are associated with observations during the course of the review which merit consideration for corrective actions. These observations are included for review and dialogue related to potential problem areas and hydrographic operational efficiency. It is important to assure that resources (funds, skills, and time) are available at the operating level in order to meet the needs identified in this report and to sustain the efficient operation, upkeep, and repair of the field unit’s hydrographic systems.

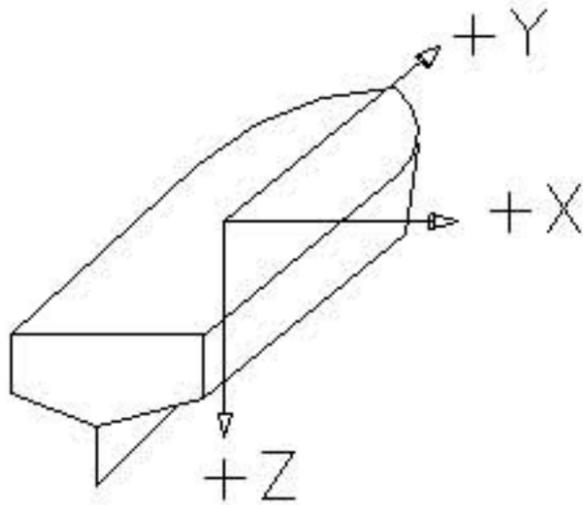
1. Offset measurement and dynamic draft measurements for SWATH have not been completed for 2006. The ship intends to operate for the 2006 field season using historical values determined when the ship’s Elac 1050D MBES was installed. Based in the inherent inaccuracy of the Elac system and the more relaxed requirements of IHO S-44 Order 2 surveying for which it is employed, the field unit considers historical offset and dynamic draft values to be adequate.
2. Launch 2901 is equipped with a POS/MV version 3 system. The review team recommends that this system be upgraded to a version 4 system so that Precise Timing methods can be implemented with the launch’s Reson 8125 MBES system.

**DATA STORAGE AVAILABILITY**

Platform	Free Space (TB)	Used Space (TB)

# Coordinate Systems for Common OCS Equipment & Software

## CARIS COORDINATE SYSTEM

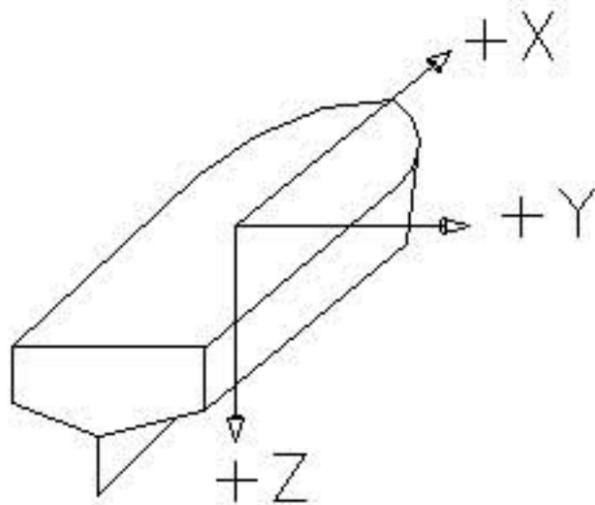


REFERENCE DATUM: WATERLINE  
ORIGIN: RP defined in vessel reference frame  
Note: Left handed coordinate system.

The Caris coordinate system is used when entering offsets in the Vessel Configuration Editor. For sidescan, these offsets are applied to ship nav to get a fish position when Recomputing SSS Nav.

For multibeam, the offsets are necessary to reference the MBES head to the IMU.

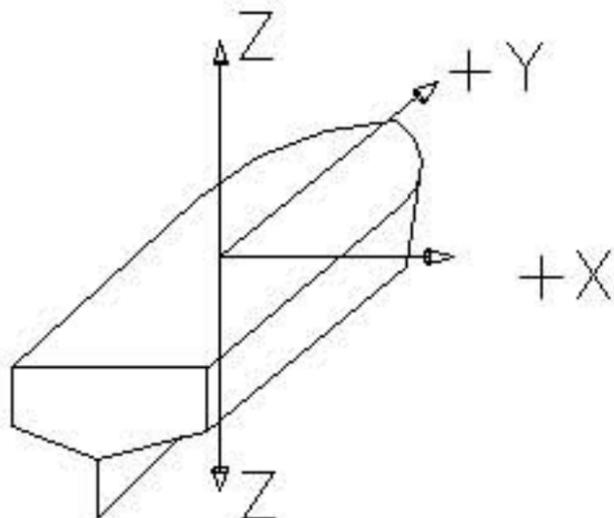
## POS/MV COORDINATE SYSTEM



REFERENCE DATUM: TOP OF IMU  
ORIGIN: Cross-hair on top of IMU  
Note: Right handed coordinate system.

POS/MV coordinate system is used to locate the GPS antennae and multibeam to the IMU for ship navigation and MB attitude. These offsets are entered in the POS/MV controller program on initial setup.

## HYPACK COORDINATE SYSTEM



REFERENCE DATUM: WATERLINE  
ORIGIN: Survey transducer phase-center

Note: For most situations, the "Y" offset is positive towards the bow, except in the case of the cable-counter layback where "Y" is positive to the stern. For the vertical offsets, the value entered will most often be positive, no matter what the direction, ie. antenna height is (+) and transducer depth in (+).

# Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of  
Coast Survey

2014

## Chapter 2 Appendices:

Digital Data Directory Structure  
Field Unit File Structure (example)  
NAVMETOCCOMINST 3142A March 2007 – OCS Deviations  
NAVMETOCCOMINST 3142A March 2007  
Basic Waterlevel Station Equipment Checklist  
Example of Fishing Gear Interaction Reimbursement Letter  
Example of Lobstermen's Association  
Letter Fishing Gear OGC Legal Opinion Memo  
Example LNM Survey Announcements

### Please Note:

The Standard Operating Procedure's (SOP's) within the FPM Appendices are in the process of being transferred to the "Documents" section of the Hydroforum and the SOP's will reside in both places for the remainder of the 2014 field season.





## **Office of Coast Survey Authorized Deviations from NAVMETOCOMINST 3142A, *Mine Warfare Survey in Support of Maritime Homeland Defense, Technical Specifications, March 2007***

Office of Coast Survey has worked with the Naval Oceanographic Office (NAVOCEANO) in developing the accompanying *Technical Specification* to ensure that OCS is capable of meeting the Navy's requirements for Homeland Security (HLS) survey work and that the data provided to the Navy is of maximum utility. NAVOCEANO and OCS have agreed upon the following deviations from the NAVOCEANO *Technical Specifications*, hereafter referred to as the HLS Spec. Every effort should be made to meet the requirements set forth in the HLS Spec in conjunction with the following deviations. In the event that it is not possible to adhere to the HLS Spec, Chief, HSD Operations Branch should be contacted to provide further guidance.

### **OCS Authorized Deviations from the NAVOCEANO HLS Spec:**

3.1.1 Datum – Provide NAVOCEANO with data in NAD83 as opposed to WGS84.

3.3.1 Data Format and Records – Provide raw data in .xtf format as opposed to UNISIPS.

3.3.2 Side Scan Sonar Parameters – Item 12; Use standard OCS quality control procedures.

3.6 Current Measurements – Not required of NOAA field units unless specified in the Project Instructions.

3.8 Water Column Optical Properties – HSTP is investigating the integration of transmissometers into the standard SeaBird CTD used by most NOAA Hydro platforms. Acquire optical property data in conjunction with CTD casts as described in the HLS Spec once the equipment has been provided and personnel are trained on its use.



## DEPARTMENT OF THE NAVY

COMMANDER

NAVAL METEOROLOGY AND OCEANOGRAPHY COMMAND

1100 BALCH BOULEVARD

STENNIS SPACE CENTER MS 39529-5005

NAVMETOCOMINST 3142A

N3/5

01 MAY 2007

NAVMETOCOMINST 3142A

From: Commander, Naval Meteorology and Oceanography Command

Subj: Mine Warfare Port and Harbor Survey in Support of  
Maritime Homeland Defense

Ref: (a) Maritime Operational Threat Response for the National  
Strategy for Maritime Security, June 2006

Encl: (1) Mine Warfare Survey in Support of Maritime Homeland  
Defense Technical Specification

1. Purpose. This instruction serves as guidance for entities involved in port and harbor environmental data collection within US territorial waters. Adherence to the guidance within will ensure that the data are collected in sufficient quantity and quality to be deemed useable to support Mine Countermeasures Operations in support of Maritime Homeland Defense as directed in the Maritime Operational Threat Response Plan

2. Discussion. The US Navy promulgates and adheres to strict environmental data collection standards globally to support MCM operations. The standards ensure that collected data is capable of formal analysis to fulfill warfighting OPLAN timeline estimation requirements. No such standards exist for data collection efforts in US waters which are beyond the US Navy's charter. However, within Ref a, the DoD [DoN] is the "...lead MOTR agency for mine countermeasures in the Maritime Domain." Consequently, this guidance is required for entities who are engaged in environmental data collection in US TTWs to be capable of collection techniques that produce usable data to facilitate US Navy execution requirements.

3. Action. Widest possible dissemination to organizations collecting pertinent environmental data within US ports and harbors.

A handwritten signature in black ink, reading "Timothy McGee", is positioned above the name "TIMOTHY MCGEE".

TIMOTHY MCGEE

Distribution:

20A Fleet Forces Command (ATTN METOC Officer)  
21A Fleet Commanders (ATTN METOC Officer)  
28A Carrier Group (ATTN METOC Officer)  
A3 Chief of Naval Operations (N84 and N852 only)  
FD2 NAVMETOCPRODEVCOM (20 Copies)  
NMAWC CC (ATTN METOC Officer 5 copies)  
NOAA Office of Coast Survey  
US Army Corps of Engineers  
USCG LANT Area  
USCG PAC Area



**MINE WARFARE**

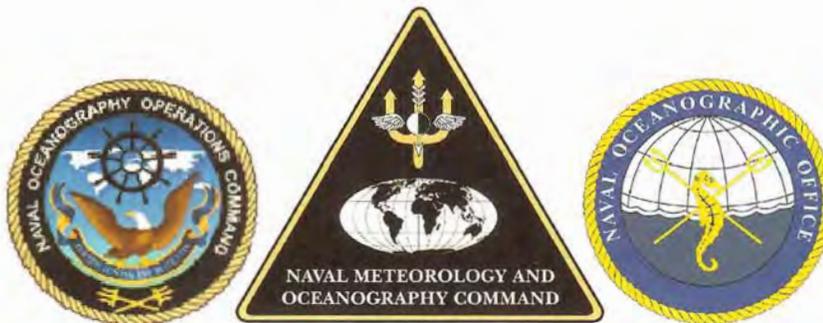
**PORT AND HARBOR SURVEY**

**IN SUPPORT OF**

**MARITIME HOMELAND DEFENSE**

TECHNICAL SPECIFICATIONS

MARCH 2007



Commander Naval Meteorology and Oceanography Command  
Stennis Space Center, Mississippi 39529-5005  
NAVMETOCOMINST 3142A

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# RECORD OF CHANGES

<i>CORRECTION OR CHANGE NUMBER</i>	<i>DATE OF CHANGE</i>	<i>DATE ENTERED</i>	<i>BY WHOM ENTERED</i>

## **1. INTRODUCTION**

The technical specifications detailed herein serve as a guideline for the collection of high quality oceanographic data and side scan sonar acoustic imagery to support Department of Defense Maritime Homeland Defense (MHD) requirements “for the prevention, detection of, and response to mines in waters subject to the jurisdiction of the United States” as directed in the Maritime Operational Threat Response plan signed by the President of the United States. This document details the requirements for the collection of critical mine warfare environmental data and its storage and delivery, by any entity engaged in oceanographic/hydrographic data collection efforts within US territorial waters, where the collected data may be used to support US Navy Mine Countermeasures (MCM) operations. These specifications are generally more restrictive and are not likely to be addressed in other oceanographic/hydrographic technical specifications. Therefore, this document should be considered as an addendum to those governing oceanographic/hydrographic technical specifications.

## **2. OPERATIONAL CONTEXT**

Understanding the environmental battle space is critical to MCM operations as it allows planners to effectively allocate resources, determine level of MCM effort and reasonably estimate clearance times. Battle space preparation includes the establishment of environmental and mine-like contact databases. These databases are used to determine the location and extent of mineable waters, location and density of significant mine-like bottom objects, degree of bottom clutter, potential for mine burial, and acoustic and magnetic propagation characteristics of a geographic region. These data are critical in order for naval forces to better understand and predict the effect of the environment on mine countermeasures operations. Additionally, information on water column physical properties such as sound velocity and optical characteristics are crucial to predicting tactical sensor performance. In addition to legacy data requirements, other data such as the location of critical infrastructure may be necessary to support MCM operations. As a whole, these data are essential for mine hunting sensor selection and for calculating estimated time and level of effort required for mine hunting operations.

Because the environment of each port is different, revisions to this specification may be required on a port by port basis pending port idiosyncrasies that are discovered through repeated survey. Additionally, periodicity requirements for each port should be expected to be unique. Scientific opinions vary with respect to which environmental element(s) are the driving factors for survey periodicity. However, particularly in ports and harbors, it is reasonable to assume that anthropogenic impacts will outpace geologic change. Consequently, the driving factor for resurvey will be human driven by the addition, removal or transport of mine like bottom objects and other debris as well as dredging and other bottom modifying activities. Even in the most dynamic oceanographic regions, bottom composition, sand waves and water column properties are dynamic but nevertheless stable and predictable once sampled. Figure 1 depicts a qualitative estimate of impacts as well as initial survey periodicity based upon area.



## 3.2 DATA TYPES

### 3.2.1 Priorities

US Government organizations or their agents may conduct surveys in selected CONUS ports to support specific Department of Defense (DoD) and Department of Homeland Security (DHS) requirements for high resolution environmental data. Survey data will be used to develop digital databases to support the prevention, detection, and Mine Countermeasures (MCM) operations for mining of U.S. ports, harbors, and approaches in support of the Maritime Operational Threat Response (MOTR) Plan. Data descriptions are outlined in Appendix A. Critical mine warfare environmental data types are listed below in order of priority.

1. Side Scan Sonar Imagery
2. Sediment Sampling (Cores and Grabs)
3. Bathymetry (Multibeam and/or Single beam)
4. Current information
5. Conductivity, Temperature, Depth (CTD) profiles
6. Water column optical properties
7. Other Environmental Data

## 3.3 SIDE SCAN SONAR IMAGERY

**3.3.1 Data Format and Records.** NAVOCEANO requests that the Data Handling and Real-time Mapping Application (DHARMA) be used to process all side scan sonar imagery into the Unified Sonar Imaging Processing System (UNISIPS) format. DHARMA converts the native format of the side scan imagery into the UNISIPS format which streamlines additional analysis at the Mine Warfare Data Center. DHARMA and UNISIPS are a NAVOCEANO developed application and format and will be made available as requested. However, most commercial side data formats are acceptable. In particular, open source formats such as eXtended Triton Format (XTF) are acceptable. Sonar records are to be annotated with time, fix marks, and length of tow cable (layback). A sonar operation log is to be maintained while towing and will contain ancillary information such as sea state, course and speed, recorder settings, and all other information pertinent to the SSS operation. Appendix B contains an example form.

**3.3.2 Side Scan Sonar Parameters.** Side scan sonar imagery is mission critical data. The side scan sonar utilized should be designed to produce high resolution images of the sea floor and bottom objects. In order to facilitate timely processing of collected acoustic imagery the following should be adhered to:

1. Side scan data will be collected with a high resolution sonar capable of detecting targets 50 cms in length (along track) by 10 cms high (proud above the bottom).
2. 200 percent bottom coverage (ensonification) shall be achieved.
3. Maximum line spacing shall be 75 meters. Shallower waters may require narrower line spacing due to limited sonar footprints.

4. When possible, survey adjacent lines on opposite headings to collect multiple aspect images of targets to help facilitate feature matching.
5. Orient survey lines parallel to the longest dimension of the transit lane giving consideration to the ability of tactical sensors to duplicate the survey line.
6. Tow the side scan sonar tow body at an altitude of 10 meters (+/- 3 meters) when practicable but in no case lower than 3m altitude.
7. Towfish pitch and roll shall be maintained to less than plus/minus 5 degrees.
8. Operate side scan sonar in highest resolution available
9. If the sonar has a "de-speckle" option, ensure it is turned off.
10. Provide NAVOCEANO with UNISIPS data files. If this is not possible, provide raw sonar imagery files in a non-proprietary data format (such as eXtended Triton Format, XTF) to NAVOCEANO on DVD, magnetic media, Ultrium/Mammoth tapes or via unclassified FTP site. Contact NAVOCEANO regarding the suitability of other data formats, media or alternate delivery mechanisms.
11. Provide single port per tape series.
12. Perform quality control of sonar imagery data in accordance with NAVOCEANO documentation, to ensure the quality of data collected.
13. Provide copies of all log sheets and data reports for side scan sonar survey.

**3.3.3 Tow Speeds.** The side scan sonar shall be towed within the operating limits as set forth in the operator's manual. However, it must be recognized that slower towing speeds increase the number of "pings" per given target and increase the probability of detection of objects. At a minimum, three pings per a 50 cm target are shall be obtained. For example, a side scan sonar with a ping rate of 10 Hz towed at approximately 3.25 knots is capable of placing three pings on a 50 cm target oriented along path up to 75 meters away from the tow fish assuming a sound speed of 1500 m/s. Most side scan sonar operations for environmental data collection are conducted in the 3 – 5 knot range with multibeam side scan sonars occupying higher speeds.

**3.3.4 Depth Range.** The side scan sonar system will be used to support mine warfare survey operations in depths ranging from a minimum depth of safe navigation to a maximum depth of 200 feet.

**3.3.5 Object Positioning.** In hydrographic surveys, the side scan sonar is an ancillary sensor used to investigate potential hazards to navigation that are detected by multibeam or single beam echo sounders. In MIW surveys, the side scan sonar is the PRIMARY sensor used to detect and position bottom objects. Consequently, the employment of differential GPS positioning techniques and disciplined accounting of tow fish position cannot be overemphasized. For targets detected in side scan sonar imagery, the following horizontal position accuracy standards shall be adhered to:

For enclosed waterways and basins—not greater than 6m

For semi-enclosed waterways and channels—not greater than 10m

For open water—not greater than 15m

*\* All horizontal positions shall be within 95% confidence*

### **3.4 SEDIMENT SAMPLING**

This section's purpose is to communicate the proper techniques and procedures for collecting sediment samples. Locations of bottom sediment samples will be based on the analysis of the acoustic side scan imagery mosaics. Bottom samples should be taken in each province type seen in the imagery; For Example, a light gray to dark gray change in the side scan sonar imagery may be indicative of a change in bottom composition from sand to mud etc. These bottom samples are critical to correct interpretation and classification of the imagery in relation the various Mine Warfare doctrinal categories (e.g., surface sediment types and mine burial). A bottom grab should be initially taken in each province indicated by mosaic analysis. If the sediment is primarily mud, a core should be taken to predict mine burial. Appendix C provides proper procedures for collection, storage and log keeping of the sediment samples.

### **3.5 BATHYMETRY**

Water depth impacts mine countermeasures operations. Surface ships, Unmanned Underwater Vehicles, divers and towed systems all require that the planner have some knowledge of water depth in order to execute. Water depth is also critical to determining mineable waters or the appropriate tactical system to employ based upon maximum operating depths. However, within the territorial waters of the United States, existing water depth requirements to address safety of navigation concerns and nautical chart updates are believed to be in satisfactory fidelity and periodicity and are readily available. Therefore, this Technical Specification does not address specific hydrographic data collection requirements. Hydrographic and engineering survey data collection activities can be tailored to fulfill the requirements set forth herein. Examples include the use of a high quality single beam echosounder for the determination of acoustic bottom/and or sediment composition. Communications between surveyors and Mine Warfare Data Center experts are key for successful collection.

### **3.6 CURRENT MEASUREMENTS**

If so equipped, an Acoustic Doppler Current Profiler (ADCP) should be connected continuously throughout the survey area when not in conflict with other sonar systems. Twenty-four hour stationary (from an anchored vessel) current observations should be collected in the approaches to harbors, anchorage areas, and several locations within the survey area. These additional areas will be determined by the lead scientist and based on observed, measured and a prior knowledge of the local oceanographic conditions. Ideally the current observations are to coincide with extremes of tidal movement during spring and neap tides (new and full moon). Appropriate areas will be determined by the lead scientist with respect for safe navigation practice. No field processing of ADCP data are required.

### **3.7 CONDUCTIVITY, TEMPERATURE AND DEPTH (CTD) PROFILES**

Sound speed is derived from Conductivity (salinity), Temperature and Depth (CTD) observations collected in the survey area. Accurate sound velocity profile data is essential for estimating sonar performance—tactical and commercial. A minimum of three CTD measurements per survey should be taken and the lead scientist will determine if more are needed. A CTD measurement must be taken when there is a noticeable change in water properties – front, river outflow – while executing a survey track. CTD casts will be distributed to provide good coverage of sound velocity profile data. It is recommended that all good CTD casts be plotted on a chart where the sonar operators can display and select the most appropriate sound speed profile in the vicinity of their operations.

### **3.8 WATER COLUMN OPTICAL PROPERTIES**

The dynamic near-shore environment is optically complex. Areas of runoff, pollutants, river outflow and biological blooms all negatively affect water clarity which affects the visual identification of bottom objects. High-frequency sonars are the primary detection and localization sensors but cannot, by themselves, make the determination as to whether a bottom object is a mine or mine-like contact. Only visual identification by a diver or onboard camera of a UUV can accomplish this. In addition, Electro-optical (EOID) sensors are emerging technologies that will allow MCM forces additional options for mine identification. EOID sensor performance is also dependent upon water clarity. Water clarity measurements must be taken throughout the water column by using an optics package, consisting of a transmissometer and a light-scattering sensor (LSS), that can be attached directly to a CTD. The transmissometer measures the transmittance of a collimated beam of light (532 nm wavelength) over a 25 cm path length. The beam attenuation measured by the transmissometer can be used to estimate water clarity.

### **3.9 OTHER ENVIRONMENTAL DATA**

Other types of environmental factors that could impact MCM operations are hazardous marine life, kelp beds, extensive fishing beds and nets and bioluminescence. This document levies no specific requirement to formally collect such data. However, any phenomena or obstacle that the survey team determines may be an impediment to MCM operations, should be noted in MIW Survey logs and report of survey.

## **4. DATA HANDLING AND DELIVERY**

At the end of the survey mission all acoustic imagery, environmental, and sediment data shall be shipped to NAVOCEANO along with logs. Retain a copy of all logs. Large plastic trash bags are handy for storing and packing a large quantity of sediment sample bags. 'Double bag' with the trash bags, label them with port name and date, secure them with tie wraps to prevent leakage, and place them in heavy-duty shipping boxes. Following these steps will insure the delivery of undisturbed and uncontaminated samples. Ship all data, logs and samples to:

Commanding Officer  
Naval Oceanographic Office  
1002 Balch Boulevard  
Attn: Mine Warfare Data Center, Code NP6  
Stennis Space Center, MS 39522-5001

## Appendix A – Data Descriptions

Parameter	Symbol	Definition	Threshold	Objective
System Depth	SD	System Depth is defined as the vertical distance from the sea surface to the instrument. System depth is required to compute bathymetry and to maintain the system at a selected depth. System depth will be determined by upward looking DVL returns and/or pressure sensor derivatives.	0 < Ds < 300 ft error ≤ 6 ft +/- 2% Ds	0 < Ds < 1000 ft error ≤ 6 ft +/- 1% Ds
Water Depth	WD	Water Depth is defined as the vertical distance from the sea surface to the sea floor. Water depth is required to define the bathymetry. Water depth will be computed from MBES/SBES or by measured system depth and measured height above bottom from downward looking sonar/DVL returns/Side Sonar first return.	0 < Dw < 300 ft error ≤ 6 ft +/- 2% Ds	0 < Dw < 1000 ft error ≤ 6 ft +/- 1% Ds
Contacts	CON	Contacts are derived from Sonar Imagery. To support Change Detection, Contact Resolution (CR) of the instrument requires the ability to define contacts 50 cm long and 10 cm above the bottom (proud).	CR ≤ 50 cm l x 10 cm h	CR ≤ 30 cm l x 8 cm h
Bottom Sediments	SED	Bottom Sediments are utilized to determine Mine Burial probabilities. They are determined from bottom samples or they are calculated from data acquired by a Parametric Acoustic Sub-Bottom Profiler. Parametric acoustic returns are transformed by the sensor to determine the ocean bottom's acoustic impedance. This value is then applied algorithmically to compute the sediment grain size and composition. Bottom Sediments are derived from Sub-Bottom Profiler data during environmental Post Mission Analysis (EPMA).	1 ≤ Zs ≤ 4 +/- 0.1 Kg/m2/s	1 ≤ Zs ≤ 4 +/- 0.01 Kg/m2/s
Sound Speed	SS	Sound speed is required as an input to determine optimal sensor depth employment and to determine system performance. Sound speed will be computed as a profile through the water column from the data collected by the CTD sensor. It will have units in feet per second, a range from 4500 to 5200, and an accuracy of 1.5 feet per second	4500 ≤ SS ≤ 5200 ft/s +/- 1.5 ft/s	4500 ≤ SS ≤ 5200 ft/s +/- 0.5 ft/s
Temperature	T	Temperature is required to compute sound speed and to determine a operational impacts due to system limitations. A temperature value will be read from a CTD sensor in units of degrees centigrade.	"-4.0 ≤ T ≤ 45.0 deg C +/- 0.1 deg C "	"-4.0 ≤ T ≤ 45.0 deg C +/- 0.05 deg C "

Parameter	Symbol	Definition	Threshold	Objective
Salinity	S	Salinity is required to compute sound speed. Also, density affects UUV buoyancy and is required as a go/no-go operational limitation. A Conductivity value will be recorded from a CTD sensor in units of Seimens/meter (S/m), with a range of 0 to 9, and an accuracy of 0.0003, and converted to Practical Salinity Units (PSU).	$0 \leq S \leq 45$ PSU $0 \leq C \leq 9$ S/m $\pm 0.0003$	$0 \leq S \leq 45$ PSU $0 \leq C \leq 9$ S/m $\pm 0.0001$
Currents	C	Currents are required for localization and navigation accuracy in addition to operational planning. Water column current speed and direction will be computed from an Acoustic Doppler Current Profiler	$0 \leq C_s \leq 10$ Kts $\pm 0.2$ Kts $0 \leq C_a \leq 360$ deg $\pm 0.5$ deg	$0 \leq C_s \leq 10$ Kts $\pm 0.2$ Kts $0 \leq C_h \leq 360$ deg $\pm 0.1$ deg
Diffuse Beam Attenuation (Kd)	Kd	The diffuse beam attenuation coefficient measures water quality to determine the optimum altitude at which to fly an electro-optic sensor to positively identify a bottom mine. Data are typically collected at 532 nm, are in units of m-1, and have a typical range of 0.02 m-1 to 12.0 m-1. Although values from 0.02 m-1 to 60 m-1 have been observed. Accuracy requirement for electro-optical applications is 0.02 m-1.	$0 \leq K_d \leq 30$ m-1 $\pm 0.02$ m-1	$0 \leq K_d \leq 60$ m-1 $\pm 0.01$ m-1
Bio-luminescence	Bio	Bioluminescence combined with water clarity measurements provides a vulnerability of optical detection. Moored objects can also be outlined by bioluminescence and can be used for mine localization. Data are collected with a photometer. Intensities range from 1e5 to 1e12 photons/sec/ml.	$1e5 \leq B \leq 1e12$ ph/s/ml	$1e5 \leq B \leq 1e12$ ph/s/ml
Water Clarity (beam c)	Cc	The collimated beam attenuation coefficient, an estimate of water clarity, calculates the estimated horizontal visibility range for a human observer or analogous sensor (e.g. camera). Data are typically collected at 532 nm, are in units of m-1, and have a typical range of 0.07 m-1 to 15 m-1. Instrument accuracy is typically 0.10 m-1.	$0.04 \leq C_c \leq 12$ m-1 $\pm 0.01$ m-1	$0.04 \leq C_c \leq 12$ m-1 $\pm 0.001$ m-1
Optical Backscatter	OBS	The optical backscattering coefficient estimates the contribution of scattering to an optical sensor image. This data is collected by an Optical Backscatter Sensor or turbidity sensor. This optical parameter can be used to estimate degree of blurring of a target in electro-optical system support applications. Data are typically collected at 532 nm in units of m-1	$0 \leq O_b \leq 0.06$ m-1 $\pm 0.01$ m-1	$0 \leq O_b \leq 0.06$ m-1 $\pm 0.001$ m-1
GPS Horizontal Dillusion of Precision	HDOP	Required metadata for data archiving. HDOP is also required to determine the accuracy of the navigational system. The HDOP range will be 1 to 6 with a resolution of 1.	$\leq 4$	$\leq 2$
Position Error	PE	Horizontal positioning error, as defined by along track error, cross track error, and heading/azimuth error, is required for localization and reacquisition.	See Section 2.2.5	



# Appendix C – Sediment Sampling Procedures

## 1. GUIDELINES

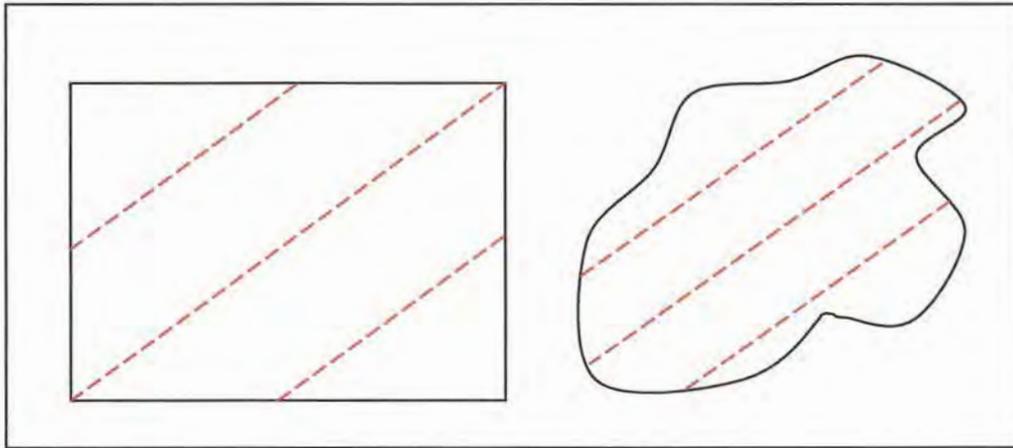
The location of bottom grabs and cores will be based on analysis of the acoustic imagery mosaics generated from the side scan sonar data. Thus, the nature of the seabed and seabed character shall be determined and delineated by sampling and inference from side scan sonar imagery (back-scatter, reflectivity) of the bottom. At the conclusion of survey operations or the completion of a survey area or sheet area these overlays shall be forwarded to NAVOCEANO.

**Table C1: This table displays the correlation between shallowest depth along center line and sampling frequency.**

<b>Shallowest Recorded Depth Along Center Line</b>	<b>Sampling Frequency</b>
0-25 meters (m) 0-82 feet (ft)	Every 1 Nautical Mile (NM)
>25-61 meters (m) >82-200 feet (ft)	Every 2 Nautical Miles (NM)

**Table C2: This table displays the correlation between the longest axis of the area and number of sampling stations**

<b>Length of Longest Axis of Area</b>	<b>Number of Samples to be Collected</b>
<1/2 Nautical Mile (NM)	1 sample station
>1/2-2 Nautical Mile (NM)	4 sample stations
>2-5 Nautical Mile (NM)	8 sample stations
>5-10 Nautical Mile (NM)	16 sample stations
>10-50 Nautical Mile (NM)	32 sample stations
>50 Nautical Mile (NM)	64 sample stations



**Figure 1:** This figure shows two sampling track line layout examples. Notice how the center sampling track line bisects the area along its longest axis and the two additional sampling track lines are parallel to and halfway from the longest axis to the outer edge of the area.

## 2. MATERIALS

1. Bottom Sediment Data Log Sheet
2. “Interlocking Seal” Plastic Bags (Ziplocs work well), either 8” x 8”,
3. 10” x 10”, or 12” x 12”
4. All-Surface, Waterproof Magic Markers (BEROL Liquid Tip work well)
5. Large ‘serving spoon’ or spatula-type utensil, to help remove sediment from sampler and place in bag.
6. Large plastic trash bags (for storing and shipping the sample bags)
7. Heavy-duty shipping boxes (for shipping samples to NAVOCEANO)

## 3. COLLECTION AND PRESERVATION

Sediment samples will be collected and labeled in numerical order (1, 2, 3 etc.). After the grab sampler is recovered and on deck, use a large spoon or spatula to carefully remove a ‘representative sample’ of sediment from the grab sampler and place in plastic bag. The amount of sample required for laboratory analysis varies with type of sediment, but generally anything from one tablespoon to ten ounces of sediment (about a cupful) will be sufficient—follow the ‘more is better’ approach. Try and avoid any sediment sample contact with the deck or other surface, as to prevent sample contamination. When an adequate amount of sediment is in the plastic bag, remove as much air as possible from the bag (‘burp it’) before closing the ‘Interlocking Seal’. Clean any excess mud and moisture from the outside of the sample bag, and place it in another plastic bag (‘Double Bagging’). On the outside of the second bag, write legibly, with waterproof marker, the Sample Number, Ship, and Date.

#### **4. RECORD KEEPING**

The Bottom Sediment Data Log Sheet is a record of the essential information that accompanies the sediment samples. The surveyor filling out the Bottom Sediment Data Log Sheet must be diligent. In addition to recording the Sample Number and Position (latitude and longitude), record the Julian Date and Time (GMT) the sample was taken. A time record provides an extra cross-reference with the BSP record and serves as a deconfliction record. After the collection of each sediment sample, confirm that the sample number written on the sample bag matches that written on the Bottom Sediment Data Log Sheet. The sample is of no value if NAVOCEANO is unable to match coordinates to the sediment sample. On the Bottom Sediment Data Log Sheet, also record Ship Name, Region, Date, Water Depth, Type of Sampler, Weight of Sampler, and Sediment Type.

#### **5. STORAGE**

If refrigeration is available aboard the vessel, it should be utilized for storage of the full sediment sample bags prior to shipping them back to NAVOCEANO. Under no circumstances should sediment samples be frozen. If refrigeration is not available, store samples in a cool, dry place.



## DESCRIPTION OF TERMS FOR BOTTOM SEDIMENT DATA LOG

**SHIP:** Name of ship from which sediment sampler was deployed.

**REGION:** General location of sediment sample collection.

**DATE, GMT (mm/dd/yy):** Dates (GMT) for when sampling occurred.

**BOTTOM SAMPLE NUMBER:** This number (1, 2, 3...) must match the number written on the outside of the sediment sample bag.

**JULIAN DAY (GMT):** Julian Day (GMT) that cast was conducted.

**TIME GMT (hh:mm):** Time (GMT) that cast was conducted.

**LATITUDE (00° 00.00' N/S):** latitude (N, S) of the cast.

**LONGITUDE (00° 000.00' E/W):** longitude (E, W) of the cast.

**WATER DEPTH (FEET):** Water depth at sample site.

**TYPE OF SAMPER:** Record the type of sampler along with serial or model number.

**WEIGHT OF SAMPLER:** Record the approximate weight of the sediment sample device.

**SEDIMENT TYPE:** Record the type of sediment that was collected and any pertinent information about the sediment sample and or grab process.

# Basic Water Level Station Equipment Checklist

## **Critical Information**

\_\_\_\_\_ determine local magnetic variation at site:  
\_\_\_\_\_ determine exact UTC time:

## **Gauge - Separate Items**

\_\_\_\_\_ gauge  
\_\_\_\_\_ tarp  
\_\_\_\_\_ nitrogen Tank  
\_\_\_\_\_ 2 batteries  
\_\_\_\_\_ GOES antenna  
\_\_\_\_\_ tripod  
\_\_\_\_\_ GOES cable  
\_\_\_\_\_ solar Panel  
\_\_\_\_\_ solar Cable  
\_\_\_\_\_ computer with RS232 connector

## **Gauge - Bag**

\_\_\_\_\_ swagelock fittings  
\_\_\_\_\_ nitrogen regulator  
\_\_\_\_\_ snoop  
\_\_\_\_\_ compass  
\_\_\_\_\_ inclinometer  
\_\_\_\_\_ parachute cord  
\_\_\_\_\_ crescent wrench  
\_\_\_\_\_ 9/16, 5/8, 11/16, & 1 1/8 wrench  
\_\_\_\_\_ lag shields (1/2"; 3/4" hole)  
\_\_\_\_\_ eyebolts (1/2" ; 3/4" hole)  
\_\_\_\_\_ orifice cutter  
\_\_\_\_\_ plastic zip ties

## **Staff - Separate Items**

\_\_\_\_\_ graduated staff  
\_\_\_\_\_ extra support lumber  
\_\_\_\_\_ electric wood drill and bits

## **Staff - Bag**

\_\_\_\_\_ wood saw  
\_\_\_\_\_ hand drill and bit  
\_\_\_\_\_ lag bolts - various lengths  
\_\_\_\_\_ lag shields (1/2"; 3/4" hole)  
\_\_\_\_\_ machine bolts - various lengths  
\_\_\_\_\_ spacers  
\_\_\_\_\_ washer and nuts  
\_\_\_\_\_ angle irons  
\_\_\_\_\_ hammer  
\_\_\_\_\_ wire snips (dykes)

## **Leveling - Separate Items**

\_\_\_\_\_ level  
\_\_\_\_\_ rods  
\_\_\_\_\_ tripod

## **Leveling - Bag**

\_\_\_\_\_ lumber crayon  
\_\_\_\_\_ IPAQ w/ Newwiz 2.0  
\_\_\_\_\_ extra battery for IPAQ  
\_\_\_\_\_ pencils, pens & calculator  
\_\_\_\_\_ steel tape  
\_\_\_\_\_ level bubbles  
\_\_\_\_\_ turtle

## **Orifice - Separate Items**

\_\_\_\_\_ Orifice Tubing w/ Orifice  
\_\_\_\_\_ Orifice Plate  
\_\_\_\_\_ chain

## **Orifice - Bag**

\_\_\_\_\_ separate Orifice  
\_\_\_\_\_ Hose clamps  
\_\_\_\_\_ Plastic zip ties  
\_\_\_\_\_ wire snips (dykes)  
\_\_\_\_\_ crescent wrenches  
\_\_\_\_\_ box wrench  
\_\_\_\_\_ flat screw driver  
\_\_\_\_\_ hammer  
\_\_\_\_\_ orifice cutter  
\_\_\_\_\_ lagbolts - various lengths  
\_\_\_\_\_ lag shields (1/2"; 3/4" hole)  
\_\_\_\_\_ eyebolts (1/2" ; 3/4" hole)

## **Diver - Separate Items**

\_\_\_\_\_ first aid  
\_\_\_\_\_ oxygen  
\_\_\_\_\_ Back Board  
\_\_\_\_\_ Save a Dive Kit  
\_\_\_\_\_ Dive Bag

## **Diver - Pneumo Bag**

\_\_\_\_\_ pneumatic drill  
\_\_\_\_\_ pneumatic drill bits  
\_\_\_\_\_ pneumatic hose

## **Diver - Toolbag**

\_\_\_\_\_ Hose clamps  
\_\_\_\_\_ Plastic zip ties  
\_\_\_\_\_ wire snips (dykes)  
\_\_\_\_\_ crescent wrenches  
\_\_\_\_\_ box wrench  
\_\_\_\_\_ flat screw driver  
\_\_\_\_\_ hammer

## **Benchmark - Separate Items**

\_\_\_\_\_ 2 Bosch drills  
\_\_\_\_\_ extra Bosch batteries  
\_\_\_\_\_ Bosch charger  
\_\_\_\_\_ fresh water  
\_\_\_\_\_ cement

## **Benchmark - Bag**

\_\_\_\_\_ benchmarks  
\_\_\_\_\_ hammer/ mallet  
\_\_\_\_\_ stamping kit  
\_\_\_\_\_ plastic bags  
\_\_\_\_\_ measuring tape  
\_\_\_\_\_ camera (w/ extra batteries)  
\_\_\_\_\_ handheld GPS



UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
National Ocean Service, Office of Coast Survey  
Navigation Services Division  
28 Tarzwell Drive  
Narragansett, RI 02882

September 25, 2013

Ms. Angela Henson  
U.S. Department of Commerce  
Office of General Counsel  
Room 5890  
1401 Constitution Avenue, NW  
Washington, DC 20230

Dear Ms. Henson,

I am forwarding for tort claim action the attached claim for damages to fishing gear submitted by Mr. Bob Fishman, captain and owner of the F/V *Lollipop*, for the amount of \$1,000.00. The damages and loss of his fixed lobster fishing gear occurred on September 3, 2013 during hydrographic survey operations conducted by the NOAA Ship *Ferdinand R. Hassler* in the area of the approaches to Portsmouth, NH. I have evaluated this claim using track-line information provided by the *Hassler* command. Based on this information, I find the claim to be reasonable and just. I recommend Mr. Fishman be reimbursed for the requested amount. Please charge this claim to the accounting code [REDACTED].

I have attached the information submitted by Mr. Fishman and the corresponding track-line information from the *Hassler*. If additional information is required, please contact me directly; I can be reached by e-mail at [brent.pounds@noaa.gov](mailto:brent.pounds@noaa.gov) or my phone at (401)782-3252 (office) or (401)545-0174 (cell).

Very Respectfully,

LCDR Brent J. Pounds, NOAA  
Navigation Manager, Northeast Region  
NOAA Office of Coast Survey





UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL OCEAN SERVICE  
Office of Coast Survey  
Silver Spring, Maryland 20910-3282

09 January 2013

Lanny Dellinger, President  
Rhode Island Lobstermen's Association, Inc.  
P.O. Box 421  
Wakefield, RI 02903

Dear Mr. Dellinger,

The National Oceanic and Atmospheric Administration (NOAA) Ship *Thomas Jefferson* will be conducting hydrographic survey operations in Block Island Sound and Long Island Sound that will take place during **May – November, 2013**.

A map showing the planned survey area(s) is included on the following page. These planned survey operations are subject to change due to weather and logistical constraints. It is the intent of the NOAA to coordinate with local regulatory authorities and lobstermen so survey operations can be conducted with minimal interference to lobster fishing.

A hydrographic survey of this type requires that *Thomas Jefferson* tow a side scan sonar towfish approximately 20 to 60 feet off the bottom in some areas of this region. The towfish is approximately five feet in length, five inches in diameter, and towed by a cable. Side scan sonar and multibeam sonar systems will acquire detailed data of the bottom, delineating and obtaining least depths of potential hazards to navigation. Multibeam sonar data will be collected by two 29-foot aluminum survey launches. **Please Note: These survey launches do not tow any sonar equipment.** Their sonar equipment is rigidly mounted to the aluminum hulls.

It is understood that a high density of pots may be in the area during the survey operations. The personnel of *Thomas Jefferson* will exercise every caution while surveying to avoid entanglement of lobster pots. If a lobster pot does become entangled, *Thomas Jefferson* will immediately take action to stop the vessel and clear the pot lines from the sonar gear. In previous survey projects, coordination with local lobstermen allowed us to postpone certain areas of the survey knowing the lobster traps were to be moved at a later time frame. This coordination works out well for both survey operations and the lobstermen.

If you have any questions on the survey operations or general comments on how we may approach an effective coordination effort, please contact our Navigation Manager for the Northeast, LCDR Brent Pounds at (401) 782-3252 or via e-mail: [Brent.Pounds@noaa.gov](mailto:Brent.Pounds@noaa.gov). Your cooperation is greatly appreciated.

Sincerely,  
Paul Turner, project planner for  
NOAA ship *Thomas Jefferson*  
(301) 713-2700 ext.106  
[Paul.Turner@noaa.gov](mailto:Paul.Turner@noaa.gov)



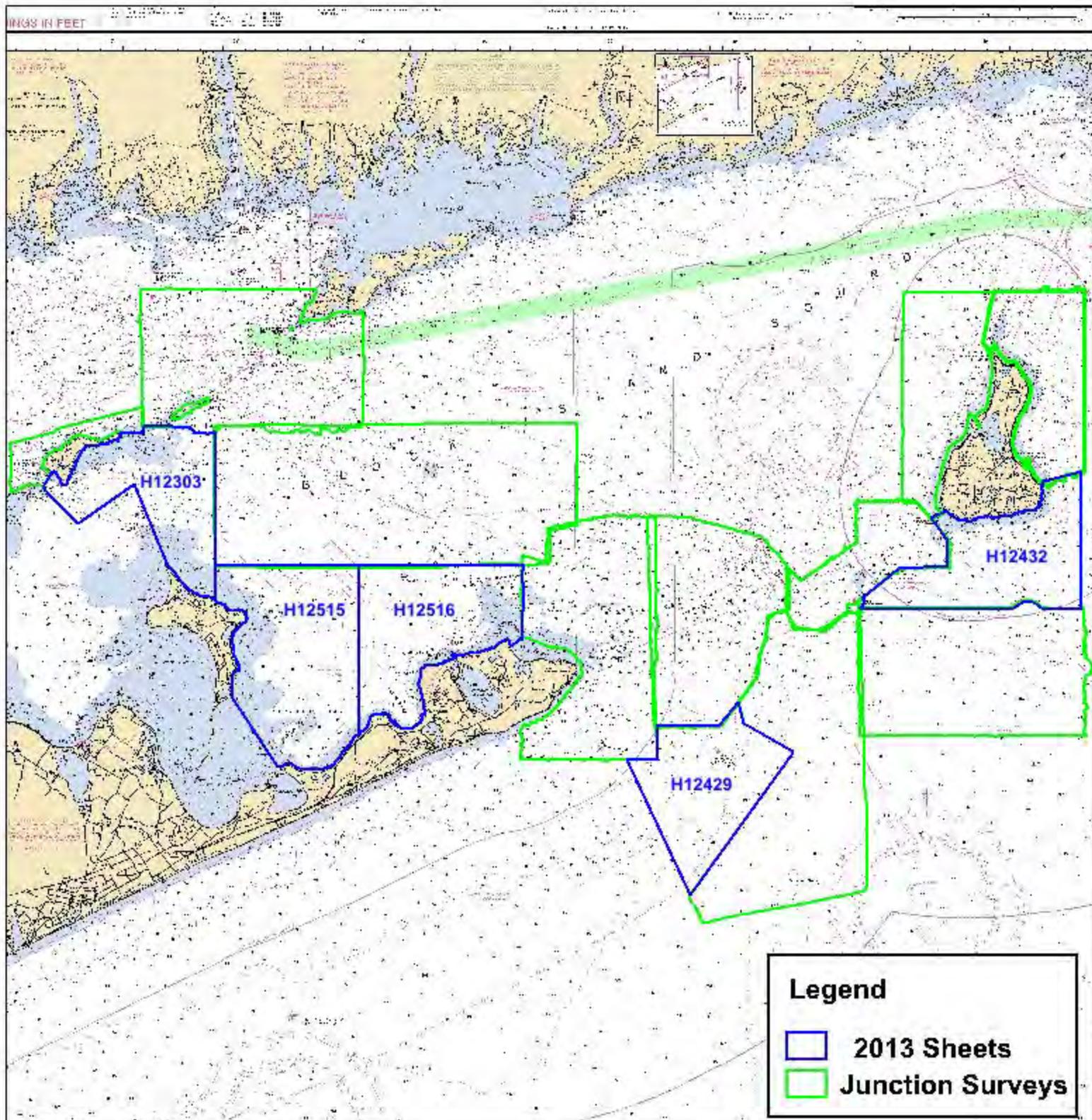
# OPR-B363-TJ-13

## Block Island Sound

### Sheet Layout

01/09/2013

Total SNM 83  
Critical Area SNM 32



## MEMORANDUM

TO: CAPT. Emily B. Christman

FROM: Suzanne Bass, Attorney Advisor,  
General Counsel Office for Ocean Service

CC: Jeffrey S. Dillen

DATE: October 25, 2007

RE: NOAA Employees' Immunity from State Prosecution

### QUESTION PRESENTED & BRIEF ANSWER

You have asked whether a State has the authority to stop and board a NOAA vessel and arrest a NOAA corps officer for alleged violations of a State law, where the vessel and its crew are engaged in operations authorized by Federal law.<sup>1</sup> As described more fully below, we have determined that the State lacks such authority absent extraordinary circumstances. Our research was informed by discussions with attorneys from the Department of Commerce and other agencies, including the U.S. Department of Justice, the U.S. Coast Guard, and the U.S. Attorney's Office in Boston.

### DISCUSSION

Under normal circumstances, a State cannot seize or board a Federal vessel. Vessels or cargo of the United States are exempt from civil seizure pursuant to the Suits In Admiralty Act, 46 U.S.C. 30908. In addition, a State may not detain and/or prosecute a NOAA officer – or indeed any Federal employee – serving on a NOAA vessel when they are engaged in the performance of their duty. Such action is barred by the so-called “Supremacy Clause” of the U.S. Constitution:

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<sup>1</sup> This question arose out of a situation near Cape Cod Bay, Massachusetts, where the NOAA Ship *Thomas Jefferson* is performing a survey mission. After local lobstermen complained of lost gear – allegedly damaged by the *Thomas Jefferson* – the NOAA Office of General Counsel was contacted by counsel for the Massachusetts Department of Marine Fisheries, who stated that the complaints, if proven, showed a violation of Massachusetts law. *See* Mass. Ann Laws, Ch. 130, 31 (2007) (“Whoever without the consent of the owner . . . destroys, injures or molests any . . . lobster or crab pot or other fishing gear . . . , shall be punished by a fine of not less than five hundred nor more than one thousand dollars or by imprisonment for two months, or both..”). After lobstermen threatened to request the Massachusetts Environmental Police seize the *Thomas Jefferson* and arrest its Commanding Officer, our office was contacted to determine whether the State, in fact, had authority to take such action. This situation is used as a case study in the following analysis.

This Constitution, and the Laws of the United States which shall be made in pursuance thereof; and all Treaties made, or which shall be made, under the Authority of the United States, shall be the supreme Law of the Land; and Judges in every State shall be bound thereby, any Thing in the Constitution or Laws of the State to the Contrary notwithstanding.

U.S. Const. Art. VI, Cl. 2.

Thus a State may not enforce laws impeding Federal law, and in many circumstances, Federal officials are immune from State prosecution when carrying out Federal laws. As the Supreme Court stated over a century ago:

...if the prisoner is held in the state court to answer for an act which he was authorized to do by the law of the United States, which it was his duty to do as marshal of the United States, and if in so doing that act he did not more than what was necessary and proper for him to do, he cannot be guilty of a crime under the law of the State of California. When these things are shown, it is established that he is innocent of any crime against the laws of the State, or of any other authority whatever.

*In re Neagle*, 135 U.S. 1, 75 (1890).<sup>2</sup>

This immunity applies, under the circumstances described in *Neagle*, despite the lack of an explicit grant of immunity in the Federal law under which the Federal employee acts. "It is not necessary for Congress to provide expressly for such immunity in the statutes under which federal officials act; Supremacy Clause immunity is 'incidental to, and is implied in the several acts by which these [federal] institutions are created, and is secured to the individuals employed in them, by the judicial power alone.'" *Wyoming v. Livingston*, 443 F.3d 1211, 1217 (10<sup>th</sup> Cir. 2006), quoting *Osborn v. Bank of United States*, 22 U.S. 738, 865-866 (1824).

*Neagle* thus provides a two-part test for Federal employee immunity under the Supremacy Clause:

1. Is the Federal employee acting within his authority under Federal law? and
- 2.) Did the employee do no more than what was necessary and proper for him to do in fulfilling his duty?

The first part of the *Neagle* test is relatively straightforward: Did the Federal employee's alleged violation of State law take place while he was performing an action which he was authorized to do under Federal law? Many cases examining this question deal with

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<sup>2</sup> *Neagle* was a Federal marshal who was charged by the State of California for killing the attacker of a Federal judge whom *Neagle* was protecting pursuant to orders from his superiors. *Neagle* was discharged from State custody by a Federal writ of habeas corpus.

Federal law enforcement officials charged with (and held to have immunity from) State crimes such as murder<sup>3</sup> and bribery.<sup>4</sup> In one notable case, the Supreme Court affirmed the immunity of a Federal administrator of a disabled Civil War soldiers' facility charged under State law with the offense of serving oleomargarine without posting notice of the fact. The Court noted that while the grounds of the facility were within State jurisdiction, the Federal administrator of the soldiers' home served food to the residents under the authority of federal provisioning statutes, and therefore was able to provide the oleomargarine without notice, notwithstanding State law. *Ohio v. Thomas*, 173 U.S. 276, 285 (1899). More recently, Federal Fish and Wildlife employees were found to be immune from state prosecution for trespassing on private land (in violation of state statutes) during the federal employees' activities in tagging wild wolves pursuant to a federal statute for reintroduction of the wolves in the West. *Livingston, supra* at 1222.

With respect the Cape Cod Bay situation, the *Thomas Jefferson* is conducting surveys pursuant to Federal authority provided in the Coast and Geodetic Survey Act, 33 U.S.C. 883a *et seq.* This statute provides the Secretary of Commerce – and those to whom he delegates his authority – with the authority to conduct surveys for navigational, scientific and other purposes. *See* 33 U.S.C. 883a. Moreover, “[t]he President is authorized to cause to be employed such of the public vessels as he deems it expedient to employ, and to give such instructions for regulating their conduct as he deems proper in order to carry out the provisions of this Act [33 USCS §§ 883a-883i],” *see* 33 U.S.C. 883h. The Hydrographic Services Improvement Act further confirms this authority in mandatory language, stating “the Administrator [of NOAA] shall...acquire and disseminate hydrographic data.” *See* 33 U.S.C. 892a(a)(1). The NOAA Ship *Thomas Jefferson*, pursuant to this authority, is conducting the Cape Cod Bay Right Whale Route survey in accordance with Hydrographic Survey Project Instructions -- project number M-A902-TJ/GM-07. This satisfies the first element of the *Neagle* test.

The second element of the *Neagle* test is more nuanced: Was the Federal employee doing no more than what was necessary and proper for him to do in fulfilling his duty, when the alleged State law violation took place? In finding what is “necessary and proper,” courts look at the specific circumstances surrounding the Federal employee’s behavior in carrying out his Federally authorized duty. This examination is fact-specific and courts have shied away from a one-size-fits-all definition of what “necessary and proper” behavior is. Rather, courts have adopted a “reasonableness” standard to gauge what activities are necessary and proper: “The substance of the standards applied ... is that of honest and reasonable belief. If ... [the Federal employee] shows without dispute that he had no motive other than to discharge his duty under the circumstances as they appeared to him and that he had an honest and reasonable belief that what he did was necessary in the performance of his duty ... then he is entitled to the relief he seeks. This

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<sup>3</sup> *See Neagle, supra.*

<sup>4</sup> *See, e.g., Baucom v. Martin*, 677 F.2d 1346 (11<sup>th</sup> Cir. 1982).

is so even though his belief was mistaken or his judgment poor.” *Petition of McShane*, 235 F. Supp. 262, 274 (D. Miss. 1964).<sup>5</sup>

The U.S. Court of Appeals for the Ninth Circuit cited *McShane* repeatedly in 1977, in the case of a Federal agent who shot and killed a man fleeing an arrest scene. In finding the agent immune from State prosecution, the Court opined that what constitutes necessary and proper “must rest not only on the subjective belief of the officer but also on the objective finding that his conduct may be said to be reasonable under the existing circumstances.” *Clifton v. Cox*, 549 F.2d 722, 728 (9<sup>th</sup> Cir. 1977); accord *Baucom*, *supra* at 1351 (finding a Federal agent immune from State prosecution for bribery instigated pursuant to an undercover “sting” operation, and stressing reasonableness under the existing circumstances).

In light of this precedent, we believe that a NOAA vessel performing a survey using normal operating procedures is engaged in “necessary and proper” conduct. Consequently, in the Cape Cod Bay situation, the *Thomas Jefferson* satisfies the *Neagle* test while performing its Federally authorized surveying duties, and is immune from State prosecution. The efforts by NOAA’s Office of Marine and Aviation Operations (OMAO) to work with local lobstermen to develop a surveying protocol that would alleviate or minimize concerns of gear loss, and its ongoing activities implementing that protocol, further demonstrates the reasonableness of OMAO’s actions. Collectively, these actions militate against any finding that the *Thomas Jefferson* and its crew are engaging in conduct outside of what is “necessary and proper.”

## CONCLUSION

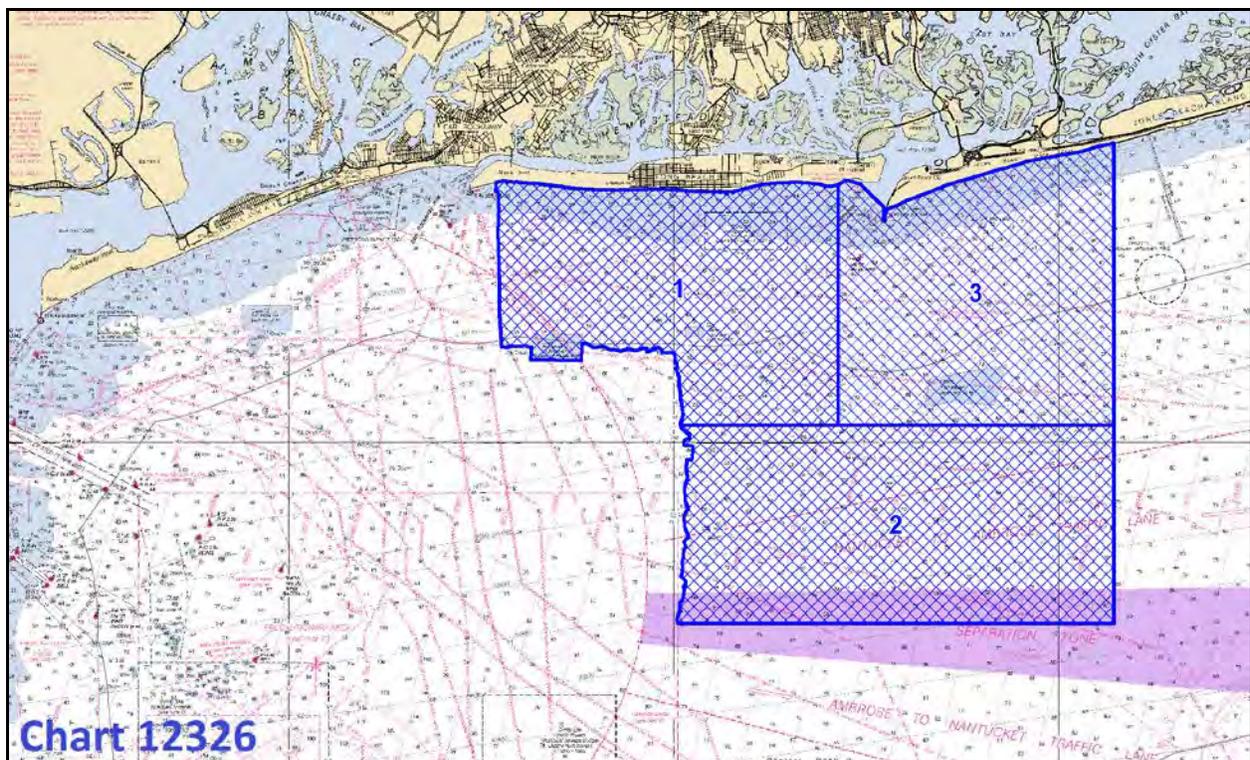
A State may not detain or prosecute a Federal vessel’s captain and crew for alleged violations of State law which occurred pursuant to the captain/crew’s conduct of their duty under Federal law, so long as these Federal employees did no more than was necessary in fulfilling their duty under Federal law. As applied to the current case, OMAO employees aboard the *Thomas Jefferson* should be immune from seizure and prosecution for alleged violations of State law while conducting the Federally authorized survey of the Cape Cod Bay area.

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<sup>5</sup> In *McShane*, a Federal marshal was charged under State law with ordering the use of tear gas on a crowd – an action the marshal felt was justified due to the perceived imminence of a riot.

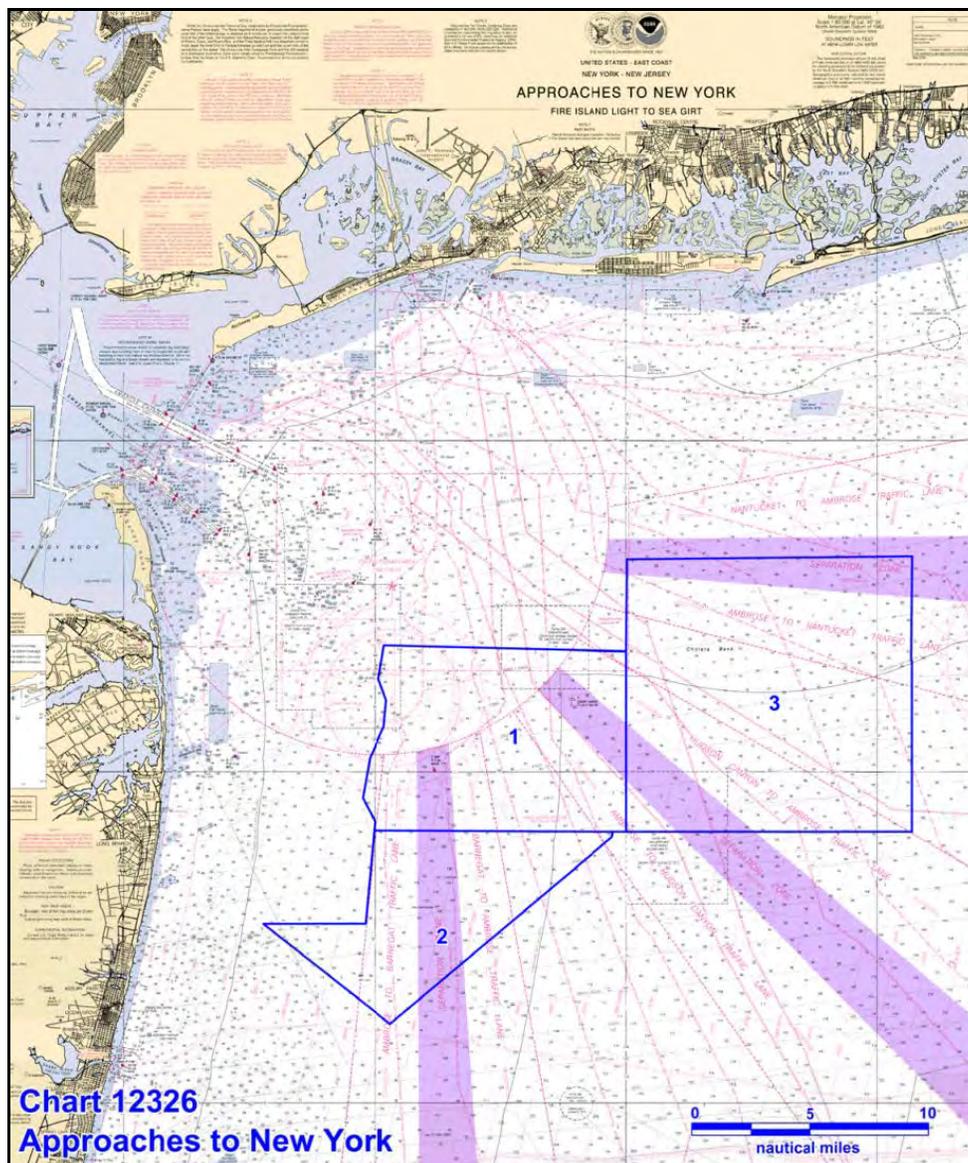
## NY/NJ – APPROACHES TO PORT OF NEW YORK AND NEW JERSEY - NOAA Hydrographic Survey Operations

NOAA Ship *Thomas Jefferson* (S222) will be conducting hydrographic survey operations throughout the area south of Long Beach and Hempstead Bay from approximately 20 March 2013 through 31 May 2013. *Thomas Jefferson* is a 208-foot, white survey vessel and deploys two 31-foot, aluminum survey launches; survey vessels carry NOAA markings, can be identified on AIS, and will be monitoring VHF channels 13 and 16. Survey operations will be conducted 24-hrs a day from the ship and from 0730 through 1800 with survey launches. Mariners are requested to exercise caution when transiting the operational area. When towed hydrographic instrumentation is deployed, *Thomas Jefferson* will be restricted in her ability to maneuver. An overview of the survey area is shown below; survey areas are numbered in order of priority. Questions or concerns can be addressed to the ship's Field Operations Officer via phone at: 757-647-0187 or 808-434-2706; or via email at: [ops.thomas.jefferson@noaa.gov](mailto:ops.thomas.jefferson@noaa.gov).



## NY/NJ – APPROACHES TO PORT OF NEW YORK AND NEW JERSEY - NOAA Hydrographic Survey Operations

NOAA Ship *Ferdinand R. Hassler* (S250) will be conducting hydrographic survey operations in the approaches to the Port of New York and New Jersey from approximately 1 October 2013 through 7 November 2013. *Ferdinand R. Hassler* is a 124-foot, white, twin-hulled survey vessel; the ship has NOAA markings, can be identified on AIS, and will be monitoring VHF channels 13 and 16. Survey operations will be conducted 24-hrs a day from the ship. Mariners are requested to exercise caution when transiting the operational area. When towed hydrographic instrumentation is deployed, *Ferdinand R. Hassler* will be restricted in her ability to maneuver. An overview of the survey area is shown below; survey areas are numbered in order of priority. Questions or concerns can be addressed to the ship's Field Operations Officer via phone at: (603) 812-8748 or via email at: [ops.ferdinand.hassler@noaa.gov](mailto:ops.ferdinand.hassler@noaa.gov).



# Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of  
Coast Survey

2014

## Chapter 3 Appendices:

Diver Least Depth Gauge Model III  
HorCon\_VerCon Observation Log  
Hysweep Device Setup SOP  
NGS-58

Standing Project Instructions for  
Coastal and Great Lakes Water Level Stations

User's Guide for GPS Observations

### Please Note:

The Standard Operating Procedure's (SOP's) within the FPM Appendices are in the process of being transferred to the "Documents" section of the Hydroforum and the SOP's will reside in both places for the remainder of the 2014 field season.

## DIVER LEAST DEPTH GAUGE MODEL III

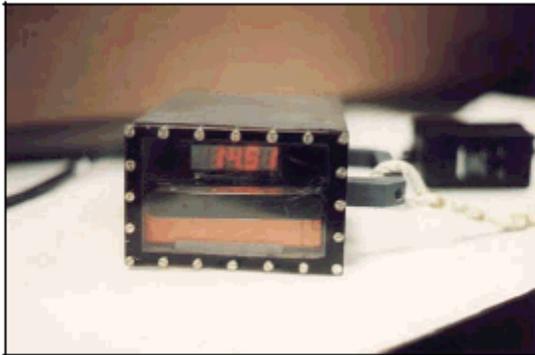
### GENERAL

The MOD III Diver Least Depth Gauge (DLDG) consists of a Micro Gauge Corporation precision absolute pressure sensor and a PTC Electronics Incorporated Model D2000 pressure readout assembly, with rechargeable batteries, housed in a specially constructed rectangular water-tight enclosure. The following are used in conjunction with the operation and care of the instrument: battery charger, underwater plug, special processing software, Sea-Bird Electronics SEACAT CTD Profiler, and barograph. **Neither the profiler nor the barograph is provided with the instrument; rather they must be resident on the ship.**

### PHYSICAL FEATURES

Figure 1 is a picture of the front of the enclosure of the MOD III DLDG. The face plate on the enclosure is clear to allow the LED display to be read (in this case, 14.51 psia).

**Figure 1**



**Front View of a Diver Least Depth Gauge Model III**

Figure 2 also shows the front of a MOD III DLDG. Shown to its left is an InSitu MiniTroll instrument, a handheld absolute pressure gauge.

**Figure 2**



The rear face of the MOD III enclosure contains the bulkhead electrical connector and the pressure port. There is a 7 cm vertical offset distance between the position of the pressure port and the bottom of the instrument case. Note that this offset is applied as a correction by program VELOCWIN in the computation of the least depth. Therefore, in order to obtain a correct value for the least depth, the MOD III gauge should be placed on top of the diver-determined least depth point and held level so that the LED readout is upright (as shown in Figures 1 and 2).

**THE GAUGE IS TO BE CONNECTED TO THE BATTERY CHARGER WHEN NOT BEING USED ON A DIVE OPERATION.** This is to increase the reliability and availability of the unit. A fully charged battery should give the gauge approximately 10 hours operating time. For the instrument to be returned from low voltage to its fully operational condition, the battery must be on charge for 18 hours.

For the InSitu MiniTroll, the pressure port is 2.9 cm from the bottom tip of the probe. The bottom tip is the end opposite the watertight screw cap covering the data port. The 2.9 cm offset is applied as a correction by program VELOCWIN in the computation of

the least depth. Therefore, for accurate results, the MiniTroll should be held upright with the bottom tip of the wand placed on the user-determined least depth point.

## SOFTWARE

The Diver submenu of program VELOCWIN provides two options to use in conjunction with the Diver Least Depth Gauge:

- (1) Least Depth Report
- (2) Daily DQA – Diver Gauge.

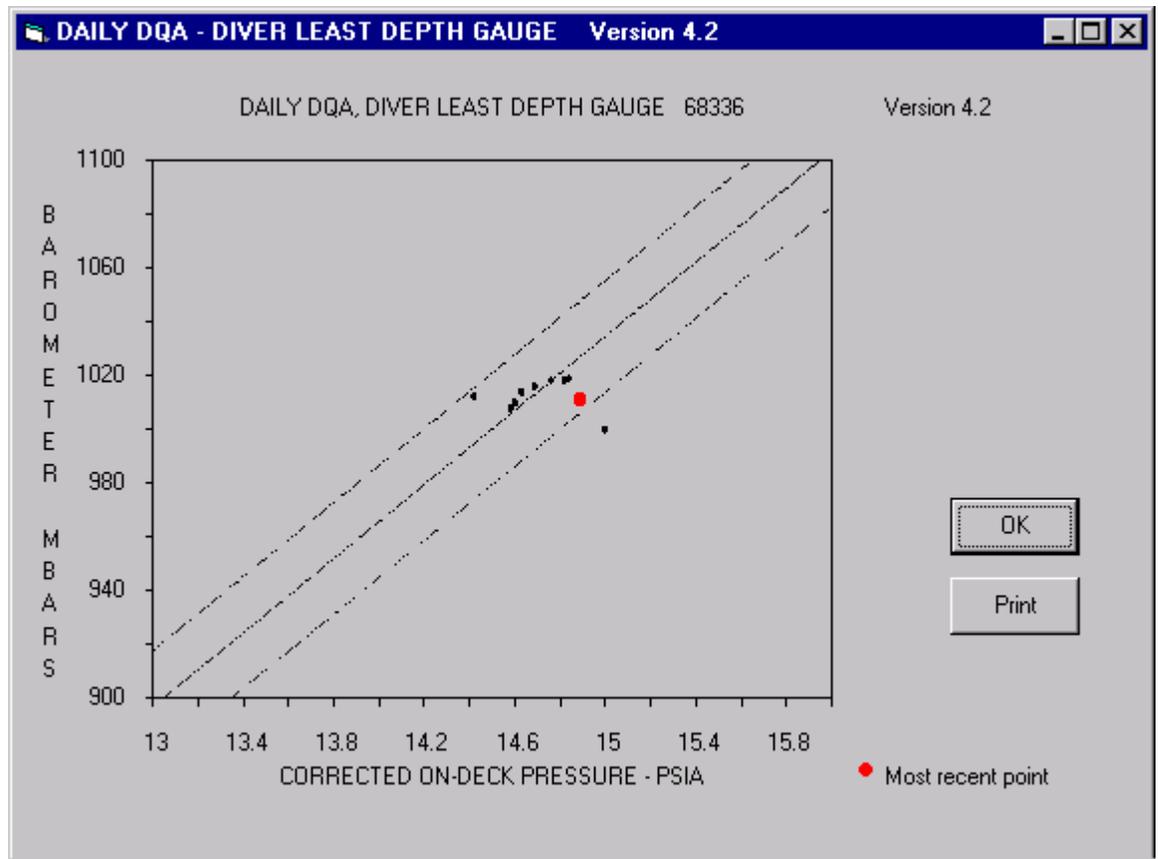
The Least Depth Report option prompts the user for several inputs including the pressure on-deck and at the user-determined least depth point. Using these two values, the calibration data for the DLDG, and the data from a Sea-Bird SEACAT CTD cast taken in the vicinity, VELOCWIN computes the least depth of the submerged object. The results of this option are shown in Figure 3 which may be printed out to obtain a hard copy record of the dive and the least depth result.

**Figure 3**

COMPLETE REMAINING ITEMS FOR LEAST DEPTH REPORT, Version 4.2			
Project	OPR-AXXXX-RU	Survey	HXXXX
NOAA Unit	RUDE	Year	1997
Awois #	NONE	Fix #	NONE
Contact #	NONE		
Cast Data			
Day UTC of Cast	275	Time UTC of Cast	16:10
Cast Table #	13	Cast Instrument	SEACAT S/N:1251
Dive Data			
Gauge #	68336	Day UTC of Dive	275
Latitude of Dive	43/04/18.25 N	Longitude of Dive	070/33/48.30 W
Time UTC of LD Measurement	17:15		
Predive Gauge Pressure, psia	14.89	Gauge Pressure at Depth, psia	39.80
Results			
Computed Least Depth, m	17.17	Save to File	
Tide Corrector, m	-.20	Save and Print	
Corrected Least Depth, m	16.97	Cancel	
Comments and Recommendations			

The Daily DQA option is a data quality assurance procedure for the DLDG. It prompts the user for the on-deck DLDG pressure in psia and the barograph reading in mbars. Using these values and the gauge's calibration data, VELOCWIN determines if the instrument is operating within acceptable bounds. The results are a running log file (DIVERDAILYDQA.DAT) and a graphical display of the relationship between the ship's barograph and the DLDG. Figure 4 is an example of the graphical display.

**Figure 4**



The calibration file for the gauge has filename, SN.CAL, where SN is the serial number of the gauge (example: 68332.CAL). The default location for this file is C:\VELOCITY, the directory of program VELOCWIN. If it is stored elsewhere, VELOCWIN will prompt the user for the location.

#### DATA QUALITY ASSURANCE

The DAILY DQA option requires that the on-deck DLDG pressure be entered in psia to two decimal places and the barograph reading be entered to the nearest millibar.

The LED readout is absolute pressure in units of pounds per square inch. This on-deck reading should be in the region of 14.70 psia. The reading will rise and fall with the local atmospheric pressure, along with variations in the distance below the water surface. The nominal depth equivalent of a 0.01 psia change in pressure is 0.5 cm. If the gauge is subjected to horizontal acceleration in a line between the pressure port and the LED readout, there may be a small change in the pressure reading.

The DAILYDQA option should be run each day. It should also be run before and after each day's dive operation to provide a pre- and post-dive record. At the end of each field season and any other time that the gauge is returned to a Marine Center, the running log file, "\\VELOCITY\\DIVERDAILYDQA.DAT", must be returned with the gauge.

The gauge uses a built-in, approximate calibration curve to derive the pressure values shown on the LED readout. The more accurate calibration curve, by gauge serial number, is employed by the VELOCWIN program to achieve high accuracy results. The data quality assurance test might not indicate an exact one-to-one relationship with the ship's barograph, but the relationship should be reasonable and regular and fall within the acceptance bounds shown in the DAILY DQA graphical display.

## DIVE OPERATION

As shown in Figures 1 and 2, the handle is attached to the gauge such that the unit must be held in the diver's right hand in order for the numerals in the LED readout to be upright. The unit should be placed on top of the diver-determined least depth point and held close to level. Below the water's surface, a depth error, in centimeters, of approximately  $15 * \sin(\text{tilt angle})$  will result from non-level operation. When the unit is at depth and fixed on the least depth point, the pressure readout will vary as a result of any overhead surface waves. The peak to peak variation due to these waves may occur over a period from 1 to 8 seconds. Therefore, it is necessary for the diver to observe the LED readout for 10 seconds or more to improve the diver's estimate of the mean pressure.

On days when dive operations are to be conducted, the gauge will be disconnected from the battery charger. The exposed electrical connector on the instrument must be capped with the underwater connector which is provided. It is not necessary to disconnect the battery charger from the ship's A/C supply. There are three pins on the electrical connector, one of which is larger than the others. The underwater plug has a flat spot over the large pin. Care should be taken when inserting the charger cable plug or the underwater blanking plug onto the instrument to be sure that the connector is correctly orientated relative to the pins of the electrical connector on the rear of the enclosure.

Previous to each dive, the pressure reading on the instrument must be observed with the unit out of the water and appropriately recorded. A diver will carry the unit on the dive to locate and measure the least depth on a designated object. The accurate least depth is determined via head pressure at the diver-designated least depth point, in conjunction

with the knowledge of the local vertical density profile. The head pressure is the difference between the on-deck (pre-dive) pressure reading and the pressure observed by the diver at depth. The density of the water column is obtained from the Sea-Bird SEACAT CTD cast taken in the vicinity. Running the Least Depth Report option of VELOCWIN computes the head pressure and converts it to the reported least depth.

Upon completion of a day's dive operations, the Diver Least Depth Gauge must be washed with fresh water and wiped dry. The underwater plug must be removed from the rear of the gauge and stored in a safe place. Finally, the battery charger should be connected to the gauge being careful of the connector orientation.

## SUPPORTING DATA

The local density profile must be independently measured in the vicinity of the dive site with a SEABIRD SBE-19 or SBE-19Plus SEACAT Profiler and processed via the VELOCWIN program. The cast should be taken in accordance with the specific SEACAT instructions, which are documented separately. However, **IT IS VERY IMPORTANT THAT THE SEACAT SHOULD BE POWERED-ON AND HELD ON-DECK FOR AT LEAST THREE MINUTES PREVIOUS TO LOWERING THE SEACAT INTO THE WATER.**

Complete instructions for taking a SEACAT cast are available from the VELOCWIN Help submenu under Precast Setup

## CALIBRATION

Each Diver Least Depth Gauge will require an annual calibration before deployment for the field season. At the end of the field season, a post-deployment verification must also be performed. Post-deployment verification and pre-deployment calibration may be performed simultaneously. The gauge must be returned to the Marine Center for forwarding to the manufacturer for calibration. Once calibration is accomplished, a hardcopy calibration report will be provided for each gauge. A copy of the report must be provided to HSTP/CSDL in order for an extended calibration curve to be generated (to accommodate deep dives). HSTP provides the extended calibration curve as a digital file named SN.CAL where SN is the DLDG serial number. The file is disseminated to all field units.

## CALIBRATION GUIDELINES

The gauge contains a 100 psia pressure transducer. Calibration between approximately 13 and 50 psia is critical for accurate least depth measurements. A data set of fourteen points, with the first point being below ambient pressure, the next point at ambient pressure, the next seven points at 1 psia increments above ambient pressure, and the remaining points at 5 psia increments will insure sufficient accuracy. Replacing

exhausted batteries will not effect calibration; however, any circuit repairs will require complete gauge calibration.

Calibration is performed by:  
PTC Electronics Inc.  
45 Whitney Road, Suite B9  
Mahwah, NJ 07430  
Attn: John C. Kicks

## PROBLEMS

If the results of the DAILYDQA test fall outside the acceptance bounds, this fact should be noted to the Marine Center and arrangements made for the gauge to be replaced and/or repaired. In addition, inform the Marine Center if any other irregular performance of the DLDG arouses suspicion.

# HORCON/VERCON OBSERVATION LOG

<b>DATE:</b>	<b>SESSION:</b>	<b>PROJECT NAME:</b>	
<b>WX CONDITIONS:</b>		<b>SITE NAME:</b> _____	<b>SITE PHOTO(S):</b> Y / N
<b>OBSERVER(S):</b>		<b>SITE TYPE:</b> HORZ. / VERT. / ATON / BM / NEW / _____	
<b>DN:</b>		<b>RECEIVER #:</b> _____	<b>FIXED HEIGHT?</b> Y / N
<b>4 CHAR. SITE ID:</b>		<b>ANTENNA #:</b> _____	<b>SPACER?</b> Y / N
<b>SESS. FILE NAME:</b>		<b>ANT. MEASUREMENTS</b>	<b>ANT. CONSTANTS</b>
<b>ELEV. MASK:</b> _____ degrees		ANT. SLANT HEIGHT (S)	ANT. RAD. (R)
<b>RECORDING INTERVAL:</b> _____ sec.s		START	STOP
		_____ m	_____ m
		_____ ft	_____ ft
		_____ m	_____ m
		_____ m	_____ m

### OBSERVATION TIMES AND STATUS

RECEIVER TIME (UTC)	PDOP	LOCAL TIME	# of SV's	POWER
START:				
STOP:				

**INSTRUCTIONS:**

*Office Check by:*

**HI to ARP** =  $((\text{SQRT}(S^2 - R^2) - C)$  (m)

**SITE SKETCH/LOC./NOTES:**

OBSTRUCTION DIAGRAM	MONUMENT RUBBING / DESCRIPTION
	<p style="text-align: center;">MONUMENT RUBBING / DESCRIPTION</p>

## ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS

### I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length (A) and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) (B)

$$\text{Antenna.Height} = H = A + B$$

### II. Instructions for Slip-Leg Tripods:

#### 1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm				
Before, inch				
After, cm				
After, inch				
Note: cm= inch x (2.54)		Overall average, cm		

$$S = \text{_____ cm}$$

#### 2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

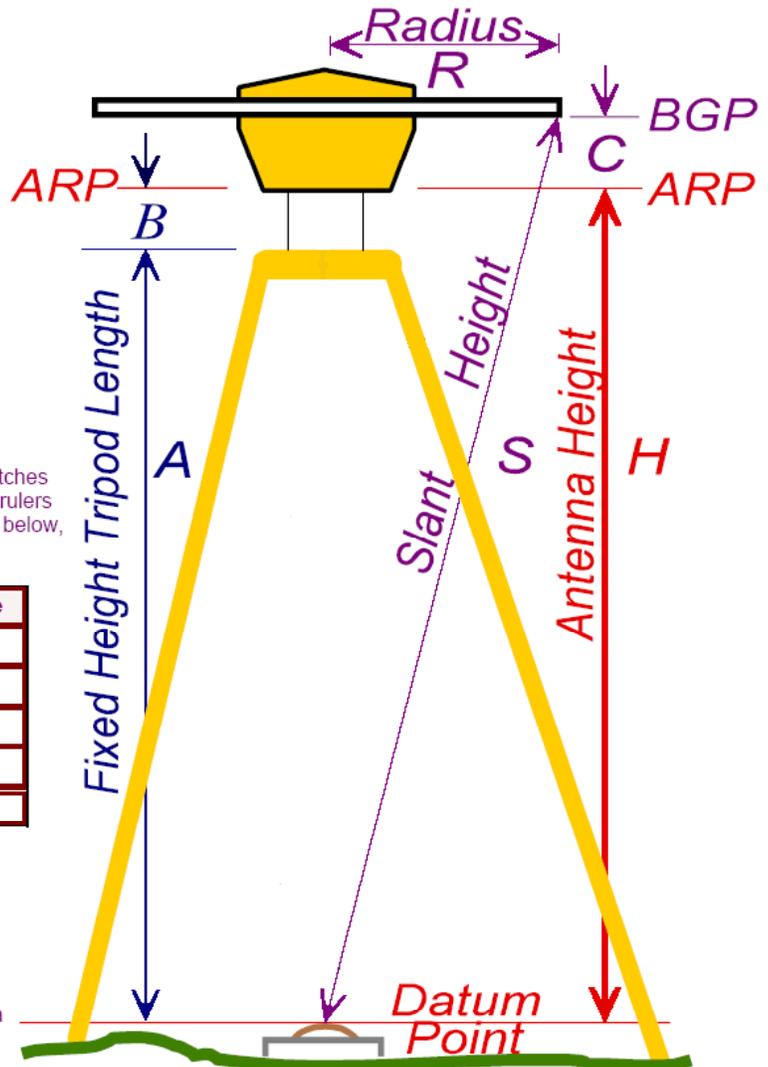
$$R = \text{_____ cm}$$

$$C = \text{_____ cm}$$

#### 3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$\text{Antenna.Height} = H = ((\sqrt{S^2 - R^2}) - C)$$





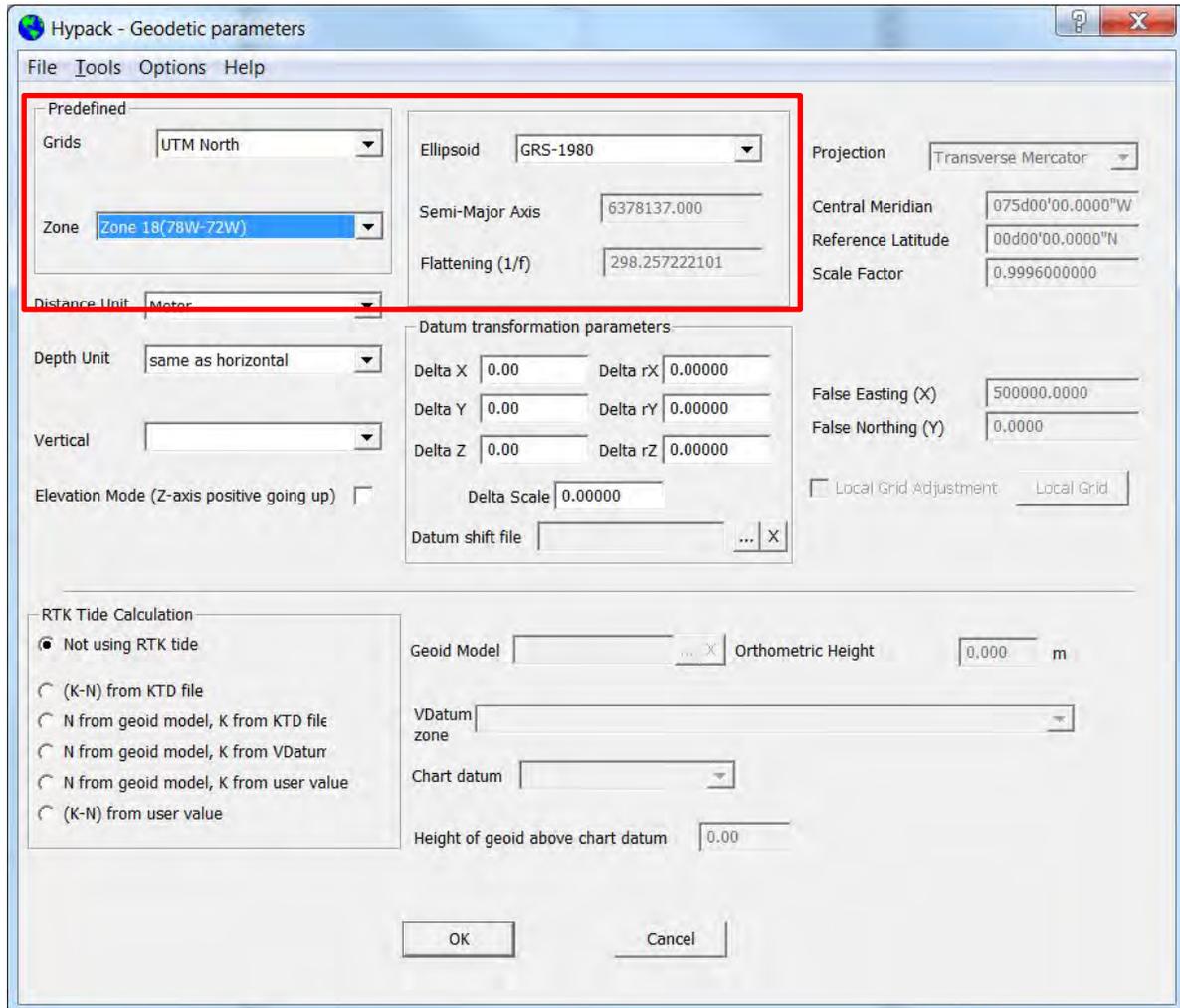


Image 2 – Geodetic Parameters

### 2.3 Hypack Hardware (Device) Configuration

Any sensor that needs to be recorded in Hypack must to be added in the Hypack Hardware window. To access Hypack Hardware, click on the “computer chip” button on the main toolbar. See Image 3.

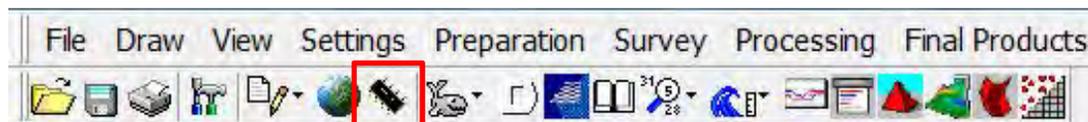


Image 3

Click on the Add Device button in the main Hypack Hardware window. The following devices are commonly used in Hypack Hardware:

### 2.3.1 Applanix POS M/V Network (posmv.dll)

- a. Enable the following in the 'Functions' box:
  - Position
  - Heading
  - Speed
  - Heave (actually Heave, Pitch and Roll)
- b. Set the following parameters for the physical connection to the POS M/V:
  - Connect – Network Port
  - Protocol – UDP
  - Role – Client
  - Host – 129.100.1.231 (this is the default IP address of the POS M/V unit. This number may be different if it was altered in the POSView software)
  - Port – 5602 for both read and write
- c. Click the Setup button
  - The “Use PPS signal for timing” should be unchecked
  - It is VERY IMPORTANT to ensure that the “Use POS M/V time-tags even when not synchronizing” box is checked. This allows the use of the raw POS M/V time tags for position and motion data.
  - Select the following options:
    - Record multibeam frame data (group 102)
    - Get heave from group 102
    - Get solution status from group 20
  - Leave other options as default. See Image 4 and 5 below for details

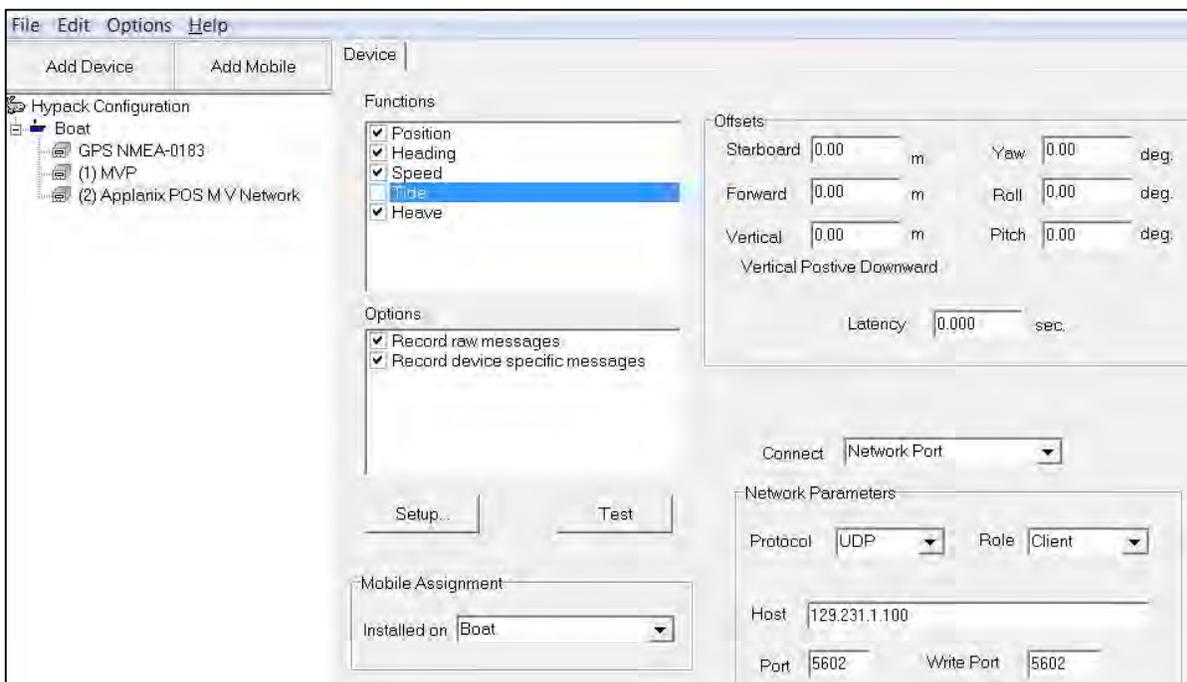


Image 4 –POS M/V device

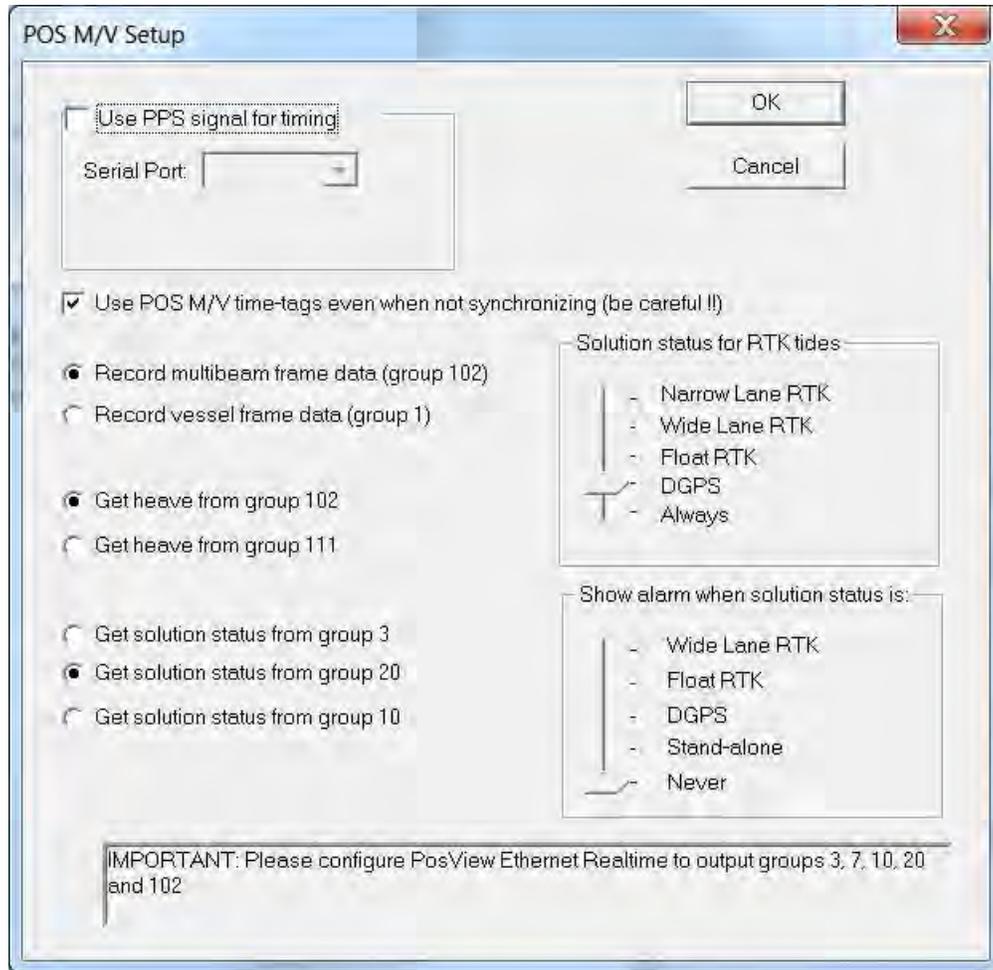


Image 5 – POS M/V Setup options

### 2.3.2 Hysweep Interface (HYSWEEP.dll)

- a. No Setup or physical connection parameters are required for this “device”. The Hysweep Interface allows Hypack to receive information from Hypack in shared memory.
- b. In the Functions box, Depth should be the only box enabled
- c. In the Options box, “Use for Matrix Update” should be enabled. This will allow real-time coverage matrices to be displayed in the main Hypack map window.

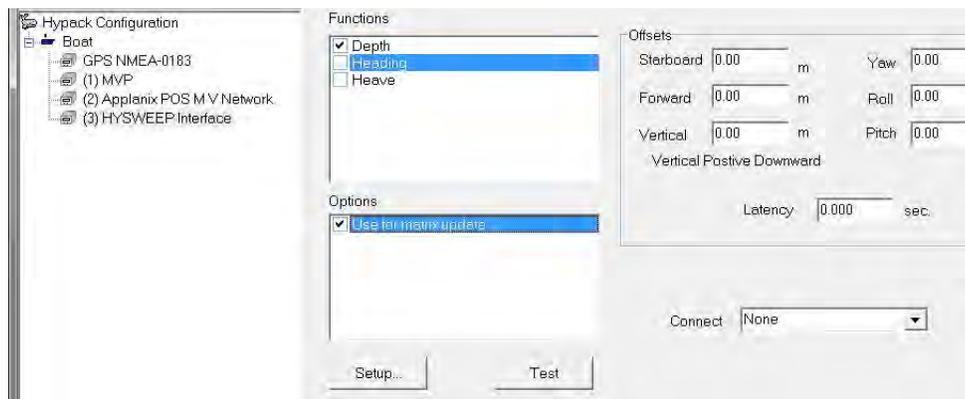


Image 6 – Hysweep Interface

### 2.3.3 AIS (ais.dll)

- a. If the survey vessel is equipped with an AIS receiver, it can be interfaced with Hypack to display vessel traffic information on the main map window,
- b. Only the physical connection parameters need to be set. This is usually via a serial connection. Example: COM#, 9600, 8, 1, None, None. The connection settings in Hypack must match the receiver output settings.

### 2.3.4 Singlebeam Echosounder

- a. All singlebeam echosounders are configured with a device in Hypack Hardware.
- b. Many devices are available, one of the most common is the device driver for the Odom MK and CV units used throughout the NOAA fleet (OdomCV\_3.dll)
- c. Odom units are setup via a UDP / Server network connection with a read port of 1600, write port of 1601. Refer to the Odom manual for details.
- d. Under Setup, the channels are setup for “bathy” or “off”. Channels 1 and 2 are used for dual frequency units. See Image 7.
- e. The Function for the echosounder should be set to Depth, and the paper annotation should be enabled.

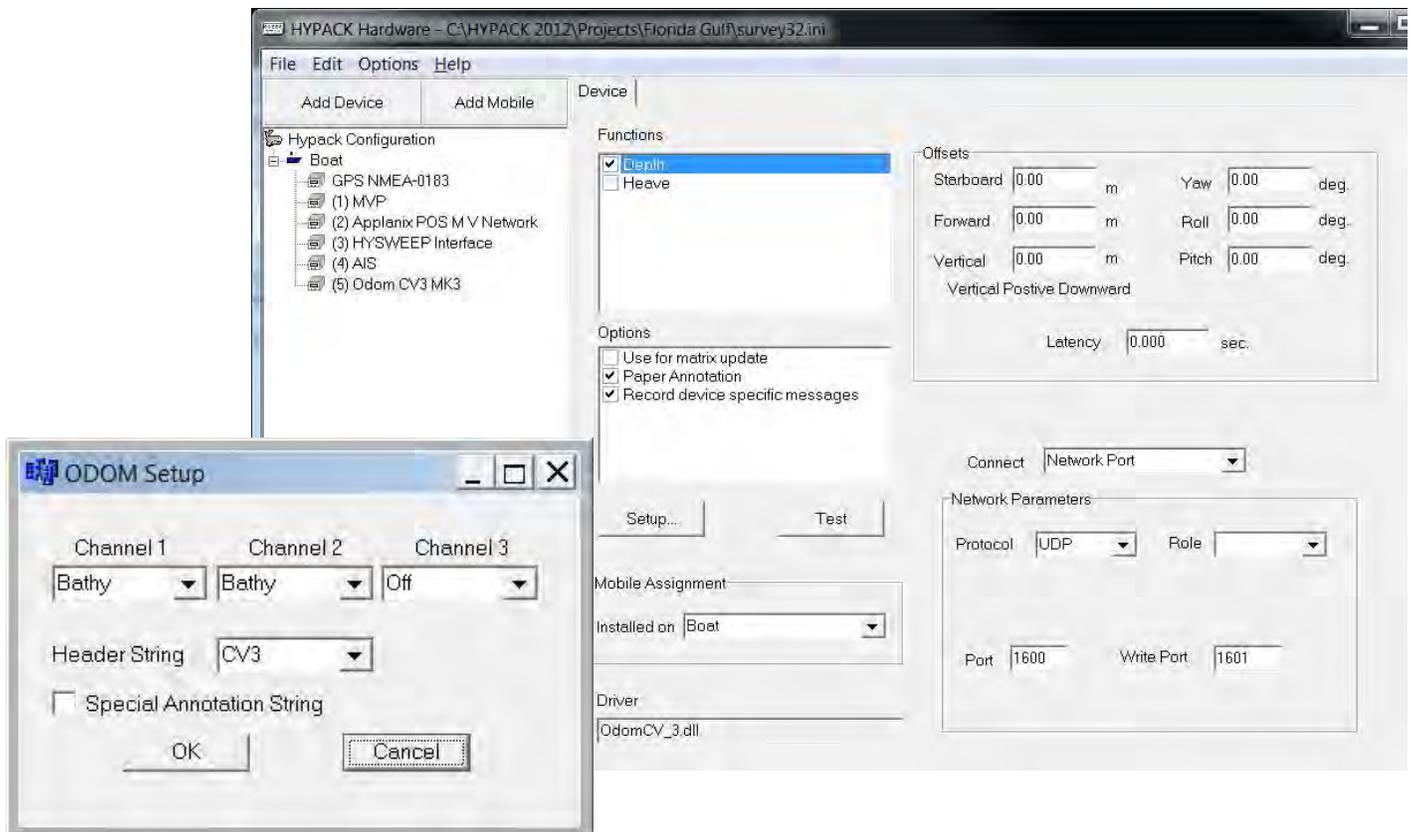
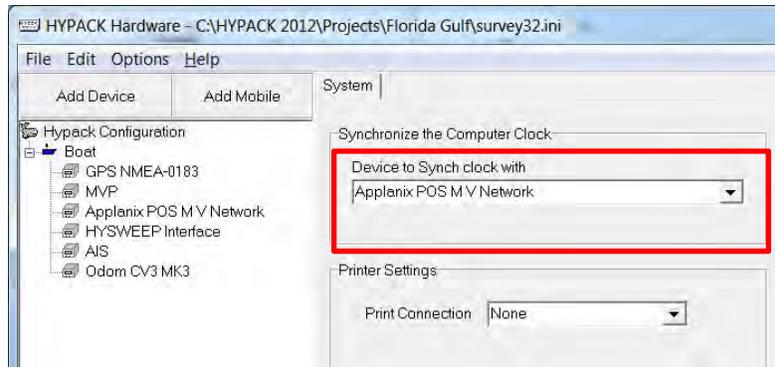


Image 7 – Odom Setup

## 2.4 Hypack Configuration – Clock Synchronization

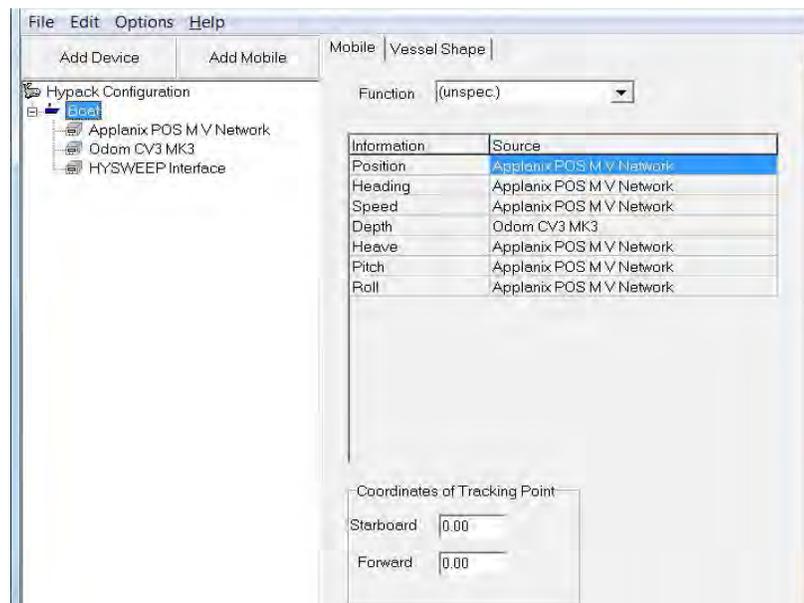
- After all the devices are setup and configured, Hypack needs to be set for clock synchronization. This action will synch the PC clock to GPS time coming from the POS M/V or other GPS device. If any device is integrated in Hypack that is not timed externally, device messages will be stamped upon arrival in the Hypack program.
- Normally the POS M/V device is used for clock synchronization. See Image 8.



*Image 8 – Setting Clock Synch*

## 2.5 Boat Configuration

- Check that the correct device (source) shows up next to each information type. This should be correct by default.
- It is on this screen that you can change the tracking point of the boat. This will add an offset to the navigational reference point so that the vessel's transducer can be steered over the survey line. This is important for real time coverage mapping on vessels with a significant X-axis distance between the RP and the transducer. See Image 9. (This offset is for display only)



*Image 9 – Boat Configuration*

## 2.6 Device Testing

- Testing of devices should be conducted periodically to make sure all sensors are communicating properly. Device testing is also commonly used as a troubleshooting tool when communication errors arise. Devices should be tested individually and together to determine any possible conflicts with other sensors.
- The most important device to check in Hypack Hardware is the Applanix POS M/V. Since this sensor provides navigation, Attitude and timing information, it is essential that Hypack is receiving all data properly.

2.6.1 Click on the Test button in the POS M/V device to access the hardware test screen.

- Ensure that all of the categories are populated, changing and seem to be correct. See image 10 below.

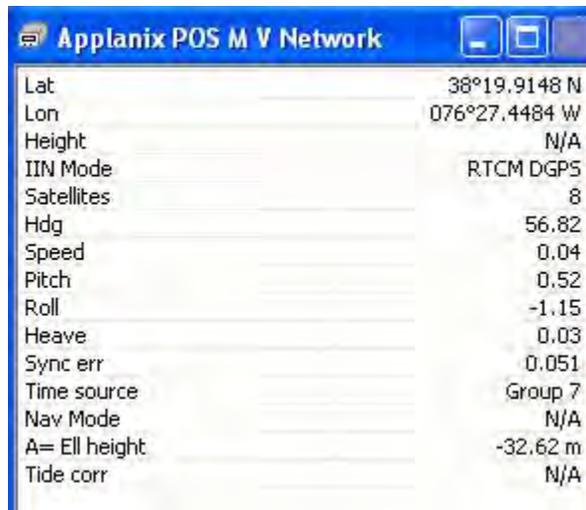


Image 10 – POS M/V device testing

- IIN Mode – The following are a list of possible codes you may see in the “IIN” section of the testing window:

0	Narrow Lane
1	Wide Lane
2	Float
3	Code DGPS
4	RTCM DGPS
5	Autonomous
6	GPS Nav
7	No Solution

RTCM DGPS is what should be populated when the system is working correctly with DGPS corrector feed into the POS M/V unit. If DGPS is not available in the survey area, RTCM may not be displayed. “No Solution” should never be displayed.

- c. Time source – **Group 7** – ensures that you have your Hypack Configuration Device to sync set correctly. The following is a list of other possible messages that may appear in Time Source:

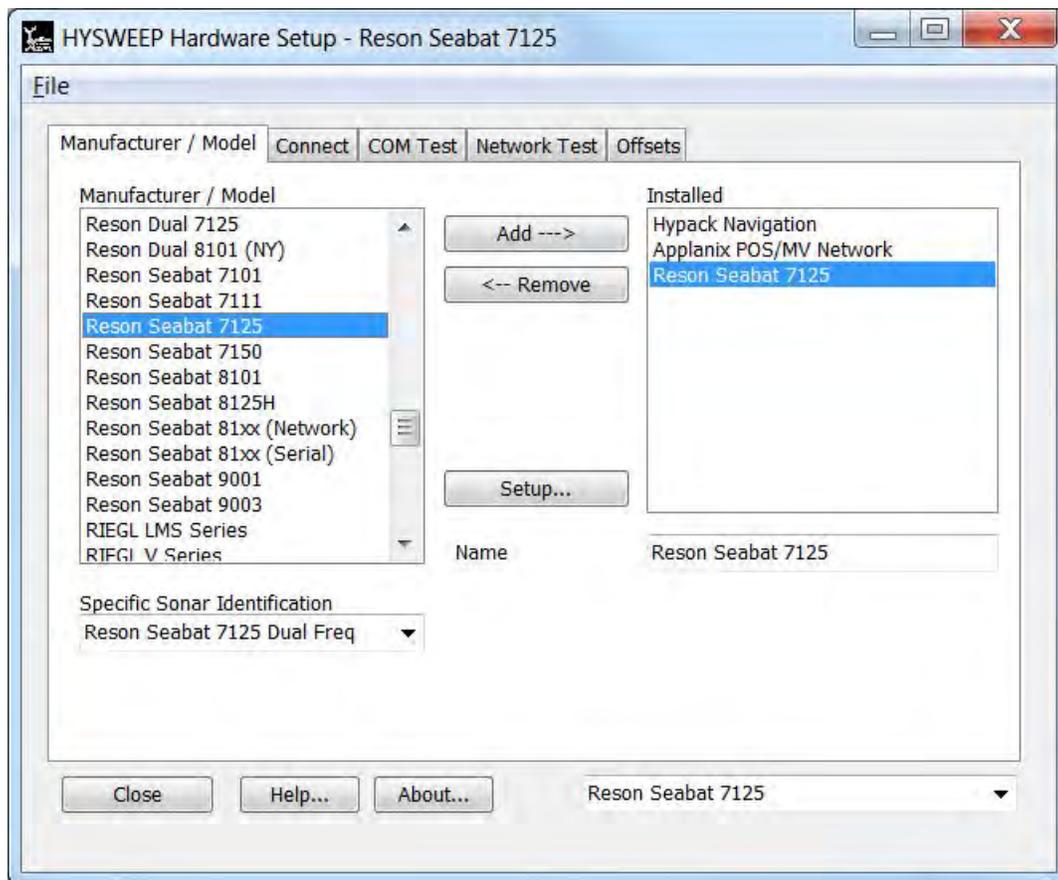
computer	Driver not synchronizing. Time tag is arrival time of each message
PPS	Driver using PPS pulse to sync computer clock to POS clock. Time tag coming from POS message.
Group 7	Driver using arrival time of message 7 to sync computer clock. Time tag coming from POS message.
POS	Driver not synchronizing but time tag is taken from POS message. This is the case where user has checked the "UTC Always" checkbox and all devices are synchronized outside HYPACK. A typical example would be a MB that receives PPS pulse from the POSMV plus the POS itself. All data is synchronized on the outside so HYPACK doesn't have to do anything.

### 3. Hysweep Survey Configuration

Hysweep has a separate set of devices that must be setup. These devices will share sensor information with the Hypack program via Shared Memory. Separate logging directories can also setup for file management. It's important to note that Windows Firewall needs to be disabled.

#### 3.1 Hysweep Hardware

To access Hysweep Hardware, click HYSWEEP→Hysweep Hardware from the main Hypack Window. Under the Manufacture / Model tab, all the available devices for Hysweep are listed. To add a device, simply highlight the correct device and click Add. Also choose the specific sonar identification from the drop-down menu. See Image 10.



*Image 10 - Hysweep Hardware setup*

- 3.1.1 Hypack Navigation – This device allows Hypack to pass navigation and other information to Hysweep in Shared Memory. There are no setup or connection parameters for this device.
- 3.1.2 Applanix POS M/V – Requires no changes in Setup. Highlight the Applanix POS M/V device and click the Connect tab. The following options should be completed:
- Enabled box should be checked
  - Port number will be 5602
  - Internet address of the POS M/V PCS unit (usually 129.100.1.231)

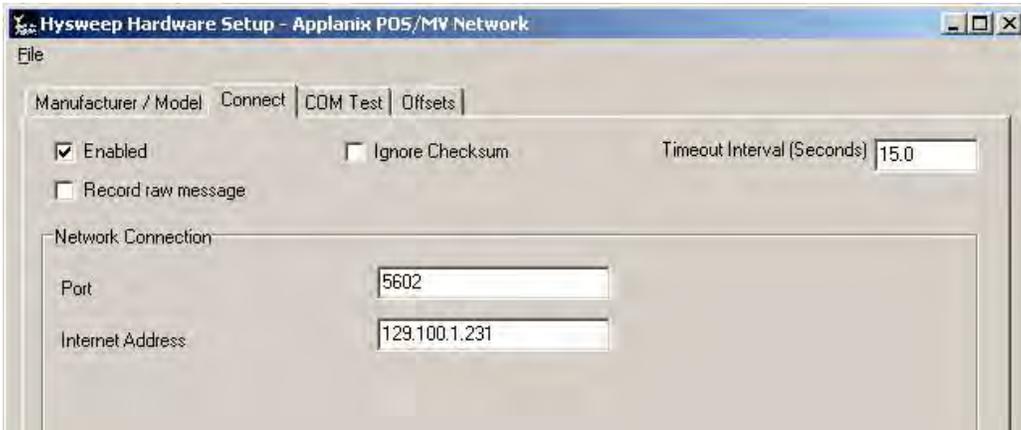


Image 11 – POS M/V connection parameters

3.1.3 Reson Seabat 7125 – Both the connection and setup tabs need to be addressed for proper setup.

- a. Under the Setup tab, the following options are available:
  - Check boxes for Side Scan Option, Use Snippets, Log Seabat Datagrams. These will be survey specific settings. Note that enabling “Log Seabat Datagrams” will record .S7K files on the Hypack PC hard drive. These may also be recorded on the 7125 topside processor.
  - 7K Drivers should be set to “Datagram Version 2”. Transmitter offsets should be zero.
  - Enabling the “Send Start and Stop Logging Commands...” checkbox will send a message to the 7125 topside processor to start recording a .S7K file every time the Hypack/Hysweep line is logged. See Image 12 below

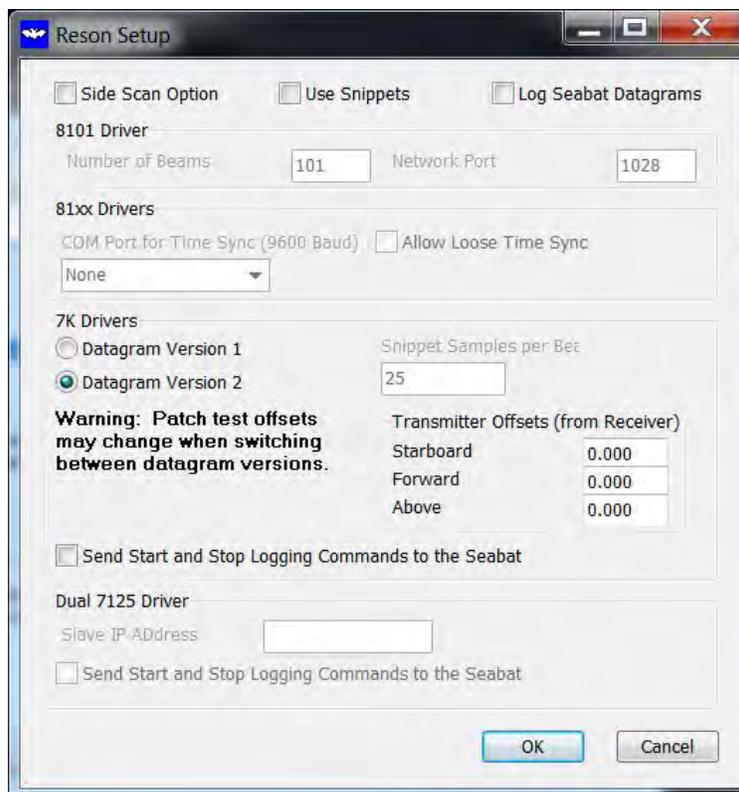
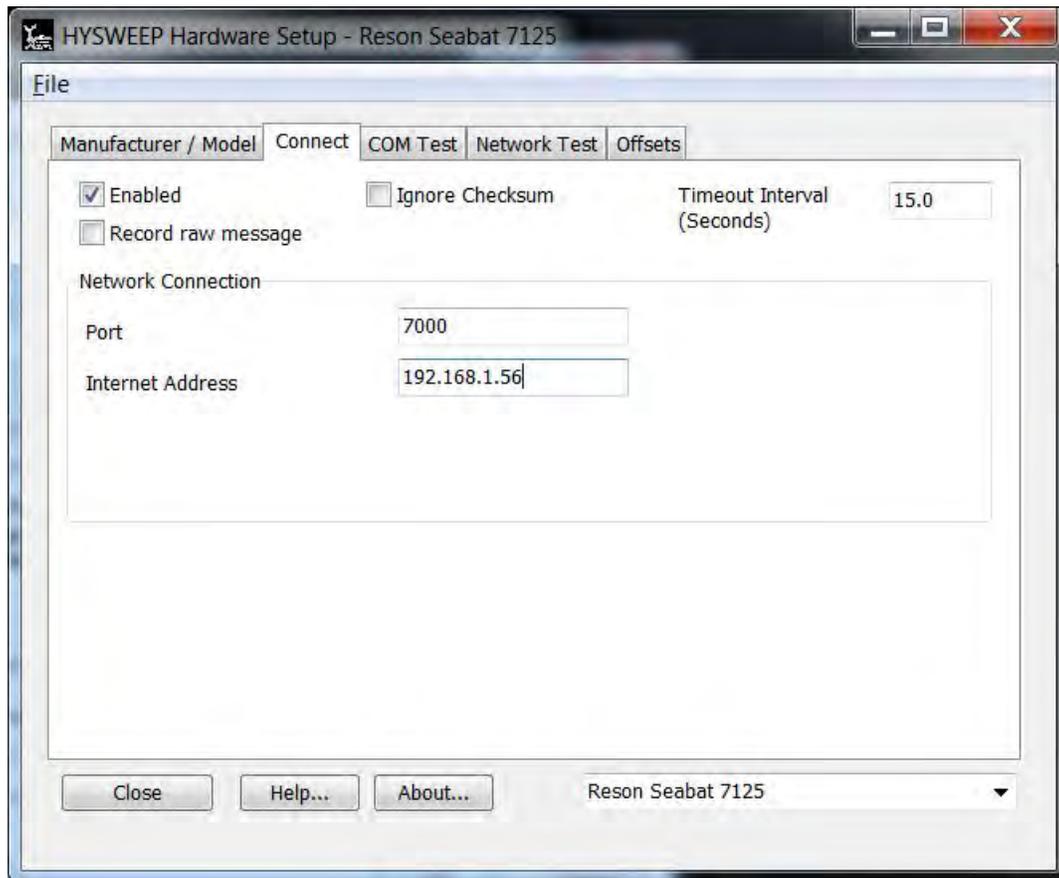


Image 12 – Reson 7125 Setup

- b. Under the Connect tab, the following options should be completed:
- Enabled box should be checked
  - Port number for the Reson 7125 is 7000
  - Internet Address of the Reson 7125 topside unit (this IP address is different for every Reson7125)
  - See Image 13 below



*Image 13 – Reson 7125 Connect Tab*

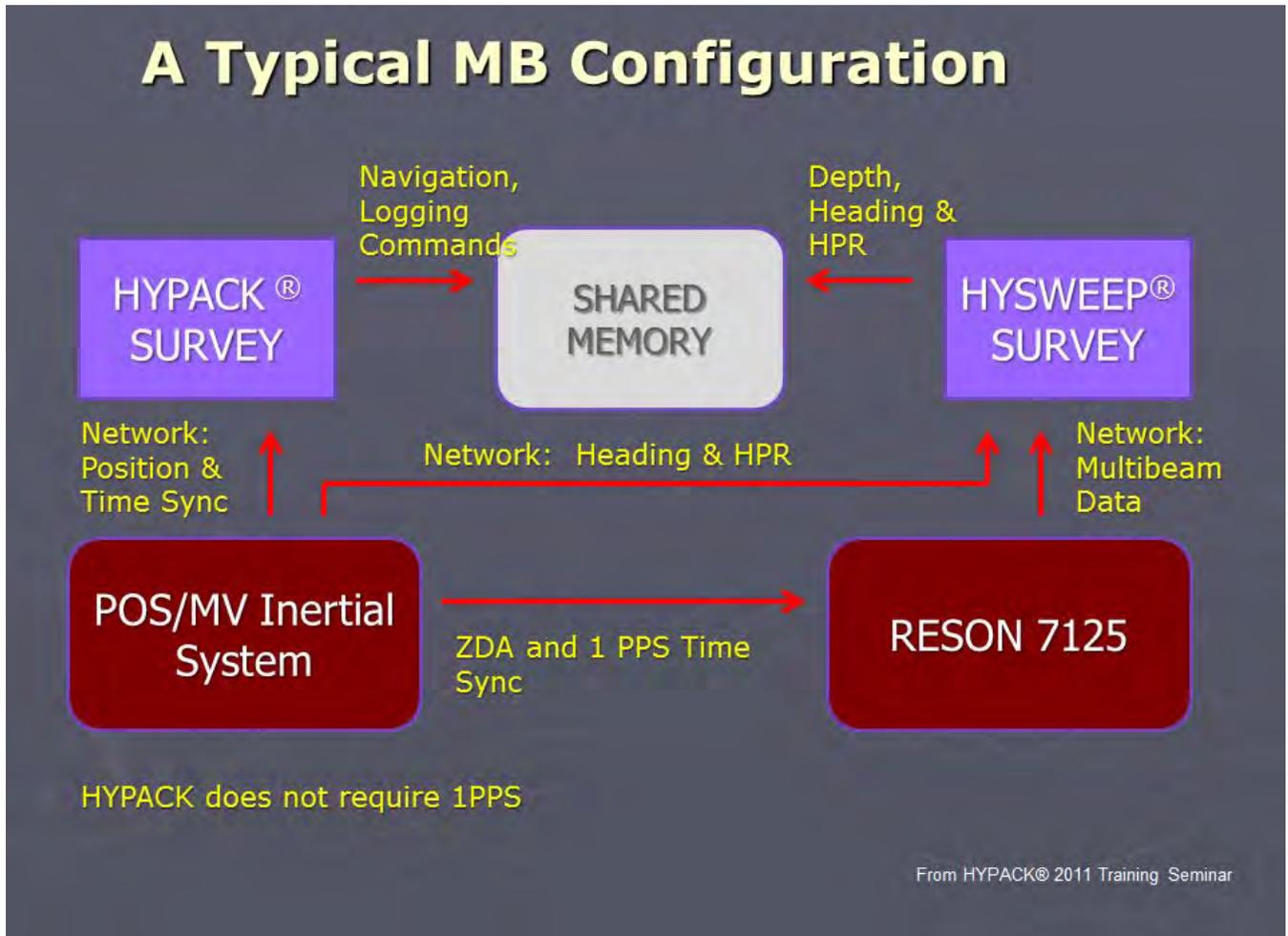


Image 14 - General Data flow concept for Reson 7125 and Hypack/Hysweep



**Standing Project Instructions  
for Coastal and Great Lakes Water Level Stations**

**Updated August 2011**

**Engineering Division  
Center for Operational Oceanographic Products and Services  
National Ocean Service  
National Oceanic and Atmospheric Administration**

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## NOTICE

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# 1 INTRODUCTION

The National Oceanic & Atmospheric Administration (NOAA) is a bureau of the U.S. Department of Commerce (DOC). The NOAA mission is to understand and predict changes in the Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs. NOAA's vision in supporting this mission is that of an informed society that uses a comprehensive understanding of the role of the oceans, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions.

The Center for Operational Oceanographic Products and Services (CO-OPS) of the National Ocean Service (NOS) is an organizational element of NOAA. We operate and maintain a network of 210 long-term water level measurement stations as part of the National Water Level Observation Network (NWLON) around the coastal United States and the Great Lakes. The NWLON supports the following four NOAA Mission Goals:

- Healthy Oceans
- Climate Adaptation and Mitigation
- Weather Ready Nation
- Resilient Coastal Communities and Economies

CO-OPS also installs and operates short-term water level stations in support of programs such as:

- Hydrographic and Photogrammetric Surveys
- Marine Boundary Determinations
- Treaty Regulation
- Harbor Dredging
- Climate Change
- Long-Term Sea Level Rise
- Habitat Restoration
- Real Time Navigation
- NOS VDatum Program

The data collected and the products derived from these water level stations are used to:

- Ensure safe, efficient, and environmentally sound maritime commerce.
- Provide data and products required by the National Weather Service to meet storm surge flood and tsunami warning responsibilities.
- Enhance navigation through a national network of Physical Oceanographic Real-Time Systems (PORTS<sup>®</sup>) in major U.S. harbors.

PORTS<sup>®</sup> is a partnering effort based on the collaboration between NOS and local maritime communities to identify and satisfy user needs for improving the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS<sup>®</sup> comes in

different sizes and configurations, each designed to meet local user requirements. PORTS<sup>®</sup> includes sensors, hardware, and associated communications systems which allow the centralized, real-time data acquisition and dissemination of water levels, currents, and other oceanographic and meteorological data. The modular design of each PORTS<sup>®</sup> installation allows the straight forward integration of additional sensors to meet user requirements.

In carrying out our mission, CO-OPS performs the following:

- Establishes the standards for the acquisition and processing of water level and current data.
- Collects and documents user requirements that serve as the foundation for all resulting program activities.
- Designs new and improved oceanographic observing systems; develops software to improve data processing capabilities.
- Maintains and operates oceanographic observing systems; performs operational data analysis and quality control.
- Produces and disseminates oceanographic products.
- Archives the resulting oceanographic data.

These Standing Project Instructions provide the recurring requirements for installation, operation, maintenance, and removal of water level stations in support of the NWLON, PORTS<sup>®</sup>, Coastal Oceanographic Applications and Services of Tides and Lakes (COASTAL) Program, hydrographic and photogrammetric survey operations, NOS VDatum and reimbursable special projects. These stations provide critical data to support the following activities:

- Ensure safe navigation
- Determine flow rates to support International treaties
- Determine tidal datums for the National Nautical Charting Program and the National Shoreline Mapping Program
- Determine the baseline from which marine boundaries are delineated
- National Weather Service tsunami and storm surge warning programs
- Coastal resource restoration and management
- Long term sea level trend analyses.

The objective of these Standing Project Instructions is to ensure that all the deployed systems and sensors are maintained in an effective and consistent manner for collecting continuous, reliable, and defect-free data.

## **1.1 General Data and Reference Datum Requirements**

The NOAA Nautical Chart Reference Datum for tidal waters is Mean Lower Low Water (MLLW) based on the latest NOAA National Tidal Datum Epoch (NTDE) of 1983-2001. The NOAA shoreline reference datums are MLLW and Mean High Water (MHW). See <http://tidesandcurrents.noaa.gov/publications/glossary2.pdf> for descriptions of all tidal datums. All tidal datum computations and water level reductions for shoreline surveys shall be referenced

to these datums.

In cases where historical sites are re-occupied, every effort shall be made to collect the new data series on the historical Station Datum (SD). In that case, data can be acquired relative to MLLW for immediate application during the survey. If the historical datum cannot be recovered, an arbitrary SD shall be assigned to the Primary Bench Mark (PBM) and the MLLW datum calculated after 30 to 60 days of water level data are collected.

In non-tidal areas, including the Great Lakes, special low water datums have been defined and are used as chart datum in these locations. For the Great Lakes, a unique Low Water Datum (LWD) for each lake based on the International Great Lakes Datum of 1985 (IGLD 85) is the reference datum. In other non-tidal coastal areas, LWD is determined by subtracting 0.5 ft from the Mean Water Level (MWL), as calculated from the water level data collected in these locations.

Leveling and GPS connections to geodetic datums are made at each water level station, as described in Section 3.6 Geodetic connections.

## 1.2 Reference Documents

The following reference documents are referred in various sections of the Standing Project Instructions.

- (1) ["NGWLMS Site Design, Preparation, and Installation Manual \(NGWLMS Manual\), January 1991"](#).
- (2) ["Xpert DCP User's Manual, October 2006"](#). (Latest updated version)
- (3) ["User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987"](#).
- (4) ["User's Guide For Electronic Levels with Translev and Windesc, Updated September 2010"](#).
- (5) ["User's Guide for Writing Bench Mark Descriptions, Updated January 2011"](#).
- (6) ["User's Guide for GPS Observations at Tide and Water Level Station Bench Marks, Updated December 2009"](#).
- (7) ["CO-OPS GPS Observations Implementation Plan, January 2003"](#).
- (8) ["CO-OPS Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations, November 2008"](#).
- (9) ["Barometer Calibration Guidelines, Updated November 2008"](#).
- (10) ["Sutron Accubar Barometer Field calibration Procedures, Updated February 2008"](#).
- (11) ["Wind Sensor Alignment Procedure for the R. M. Young Wind Sensors, October 2005"](#).

- (12) ["Guidelines for Meteorological Sensors Siting and Meteorological Sensors Height Measurements, Updated January 2011"](#).
- (13) ["CO-OPS Water level and Meteorological Site Reconnaissance Procedures, Updated May 2009"](#).
- (14) ["User's Guide for 8200 Acoustic Gauge \(Installation and Operation\), Updated August 1998"](#).
- (15) ["User's Guide for 8200 Bubbler Gauge \(Installation and Operation\), updated February 1998"](#).
- (16) ["NGWLMS GOES MESSAGE FORMATTING, Phil Libraro January 2003"](#).
- (17) ["Standards and Specifications for Geodetic Control Networks", Federal Geodetic Control Committee, September 1984"](#).
- (18) ["Spatial Data Modifications and Enhancements, FY05 Functional Requirements Document, August 2005"](#).
- (19) "Revised NGS 3 – Dimensional (3 – D) Rod Mark, National Geodetic Survey, July 1996".
- (20) ["NWLON/DMS Quality Control Software \(QC\): Functional Requirements Document"](#).
- (21) "NOS [Hydrographic Surveys Specifications and Deliverables, April 2011"](#).
- (22) ["Water Level Station Specifications and Deliverables for Shoreline Mapping Projects, Updated May 2009"](#).
- (23) ["Attachment R, Requirements for Digital Photographs of Survey Control, NGS, January 2008"](#).
- (24) "SOP-06-001 for Upgrading or Installing a New Water Level Station, Updated August 2007".
- (25) "SOP-06-004 CO-OPS Evaluation Criteria for Water Level Station Documentation, Updated October 2009".
- (26) "Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP".
- (27) ["E-Site Report Application User's Guide", December 29 2009.](#)
- (28) "SOP 3.2.3.5 E(15) E-Site Report User Access to Build, Submit, Reject, Advance, and Approve Steps".
- (29) "Engineering Bulletin 07-007 Downloading (Exporting) Data from Xpert Log Files using Xterm" October 15, 2007.
- (30) "Engineering Bulletin 08-001 Standardization of Xpert Log File Sizes" February 13, 2008.
- (31) "Engineering Bulletin 09-003 Update to Xpert Log File Sizes" November 13, 2009.
- (32) "SOP-3.2.3.5 E8 Procedures for Requesting GOES Platform ID Allocations, November 14, 2007

## **2 REQUIREMENTS FOR RECONNAISSANCE, INSTALLATION, OPERATION, MAINTENANCE, AND REMOVAL OF WATER LEVEL STATIONS**

The following sections point to the references strategic to the reconnaissance, installation, operation, maintenance, and removal of water level and/or meteorological stations.

The term Installer has been defined as a person or field party that performs any of the following tasks: reconnaissance, installation, maintenance, repair, or removal of a water level station. The installer could be CO-OPS personnel, NOAA ship personnel, Office of Coast Survey (OCS) Navigational Response Teams (NRT), other NOAA personnel, or contractors.

### **2.1 Reconnaissance**

The reconnaissance of water level and meteorological stations shall be performed in accordance with Reference 13.

### **2.2 Water Level Sensor Specifications**

The following sections provide the sensors and specifications that are used at CO-OPS water level stations.

#### **2.2.1 Primary Water Level Sensor**

The primary sensor used at a CO-OPS water level station is one of the following:

- Aquatrak™ self-calibrating air acoustic sensor
- Paroscientific pressure sensors tied into a single or dual orifice gas purged bubbler system
- BEI Motion Systems absolute shaft angle encoder (SAE)
- Design Analysis Waterlog microwave in a limited capacity

Currently, the Aquatrak™ sensor is used at the majority of tidal water level stations as the primary water level sensor. At stations where the acoustic sensor cannot be used due to the freezing of the water's surface or the lack of a suitable support structure, a single or dual Paroscientific intelligent pressure sensor(s) is incorporated into a gas purged bubbler system. In the Great Lakes, a sump with a float driven absolute shaft angle encoder is used. A microwave air gap sensor is used in selected PORTS® projects. Starting this year, a microwave sensor will be used in a limited capacity at low wave energy locations.

The sensor type will be determined after the reconnaissance of the site is completed, the final station design is performed, and CO-OPS has approved the site and the type of sensors. CO-OPS' approval of the type of water level sensor is mandatory for a project.

The sensor measurement range shall be greater than the expected range of water level and the installation shall be designed to measure the full range of extreme water level such as highest observed and lowest observed water level data (100 years, if available). The highest observed may have an additional wave allowance value added as determined by ED.

Sensors are calibrated prior to deployment, and the calibration is checked following removal. The calibration standard's accuracy is traceable to the National Institute of Standards and Technology (NIST).

For NWLON water level data, the water level sensor resolution is 1 mm or better. For hydrographic and photogrammetry surveys the required water level sensor resolution is a function of the tidal range of the area in which water level data is collected: when the tidal range is less than or equal to 5 m, the required water level sensor resolution is 1 mm or better; when the tidal range is between 5 m and 10 m, the required water level sensor resolution is 3 mm or better; and when the tidal range is greater than 10 m, the required water level sensor resolution is 5 mm or better.

Known error sources for each sensor are handled appropriately through ancillary measurements and/or correction algorithms. Examples of such errors are water density variations for pressure gauges, sound path air temperature differences for acoustic systems, and high frequency wave action and high velocity currents for all sensor types. At a number of NWLON stations, dual orifice gas purged orifices which are mounted a fixed vertical distance apart and connected to two vented Paroscientific pressure transducers are used so that a density correction can be estimated for each sample based on the pressure difference and gravity.

The orientation of the primary sensor shall be carefully documented in elevation (side) view sketches and photographs, as required. Orientation of the protective well (or sump and intake in the Great Lakes) relative to the wave or current modifiers such as nearby pilings, bulkheads, or other structures in the water shall be photographed and documented. All features in the vicinity of the protective well such as, pilings, other wells, decking, buildings (tide house), etc., which might cause uneven sun/shading of the well and resulting non-uniformity of temperature inside the well shall also be well photographed and documented.

The installer shall have all forms and figures submitted using metric units and referenced to the SD as applicable. Other references (e.g. orifice zero or tide staff zero) shall also be shown on the forms with reference to the SD.

### **2.2.2 Redundant Water Level Sensor**

The redundant sensor used at a CO-OPS water level station is one of the following:

- IMO, Druck, or KPSI pressure sensor tied into a single gas purged bubbler system
- Waterlog relative shaft angle encoder (SAE)

At tidal water level stations, the redundant water level bubbler orifices shall be secured structurally independent of the primary water level sensors (i.e. on a separate piling, etc). At Great Lakes stations, the Waterlog shaft angle encoder (SAE) shall be set to read the same as the Electric Tape Gauge (ETG) and the primary SAE.

The cable lengths of all water level and ancillary sensors shall be noted in the E-Site Report, or Xpert Site Report, or Tide Station Report to the nearest tenth of a meter (rounded up to the nearest meter value). This will assist with the efficient replacement of cables should a failure occur.

### **2.2.3 Tsunami Data Requirements**

NWLON and other water level stations installed and supporting the NOAA Tsunami Program shall have 1 minute averaged water level data available in addition to the 6 minute data. The 1 minute averaged data will be mainly coming from the primary sensor during the normal operations. In addition, 15 second data from the redundant sensor shall also be made available in the event of a tsunami, or as per the request of National Weather Service (NWS) Tsunami Warning Centers, and the Pacific Marine Environmental Laboratory of NOAA's Office of Atmospheric Research (OAR).

The RAM pack and other storage devices may be appropriate for storing the 15 second data. The sizes of the data files (minimum number of days data) for 6-minute water level data (ssp.log), 1 minute tsunami data (tsu1min.log), and system log data shall be collected according to Engineering Bulletin 09-003 dated November 13, 2009. This Bulletin is available on the ROS Wiki Page and can be made available for contractors on request, if applicable.

## **2.3 Data Collection Platform**

The primary Data Collection Platform (DCP) shall acquire and store water level measurements every 6 minutes. The water level measurements shall consist of an average of three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.). In addition to the average measurement, the standard deviation of the discrete water level samples and outliers which comprise the 6-minute measurements shall be computed and stored. The 6-minute centered average water level data and the standard deviation provide valuable data quality information regarding each measurement.

For NWLON stations, a redundant DCP shall also be installed so that in case of a failure of a primary DCP or sensor, water level data from the redundant DCP or sensor can be retrieved. The redundant DCP also shall acquire and store water level measurements every 6- minutes and the water level measurements shall consist of an average of three minutes of discrete water level samples with the period of the average centered about the six minute mark (i.e. :00, :06, :12, etc.).

The primary and redundant DCP, where applicable, shall have a capacity to store at least 30 days of 6 minute water level data and meteorological sensor data, if applicable.

## **2.4 GOES Satellite Transmissions**

The ability to monitor water level measurement system performance for near real-time quality assurance is essential for operations. Water level data transmitted via satellite in NOS format is retrieved and monitored by CO-OPS, and in the case of data gaps, sensor, or gauge problems, corrective actions are taken immediately. At all sites where access to the GOES satellite is available, and according to CO-OPS policy, the measurement system shall be equipped with a GOES transmitter to telemeter the data to NOS. This section is applicable where water level gauges are installed by CO-OPS or CO-OPS' contractors for NWLON, Tsunami, COASTAL, VDatum, Special projects, and NOAA in-house survey projects. This section is not applicable for NOAA contract hydrographic or photogrammetric projects.

The data transmissions shall use the message format detailed in Reference 16. This format is currently implemented in the Next Generation Water Level Measurement Systems (NGWLMS), assuring compatibility with the CO-OPS Data Management System (DMS).

The NOS Continuous Operational Real-Time Monitoring System (CORMS) is a 24 x 7 data monitoring operation. It monitors all water level measurement system data transmitted via GOES to assure the gauges are operating properly. Data that is not transmitted by GOES but is submitted to CO-OPS via diskette, CD-ROM, or such other electronic media, must also conform to the format specified in the above document so that data can be loaded properly into DMS.

The clock accuracy of a satellite radio system shall be adjusted with a GPS clock for NWLON gauges. For a tide gauge that does not have a GPS clock, or that transmits hourly or three hourly, the clock accuracy of a satellite radio system shall be within 5 seconds per month for short term water level gauges so that adjacent satellite channel overlapping does not occur. Non-satellite radio systems shall have a clock accuracy of better than one minute per month.

## **2.5 Data Transmission Initiation and Station Database Configuration Requirements**

The CO-OPS' Engineering Division (ED) Operational Engineering Team (OET) maintains the GOES platform ID list for all water level stations in the NWLON. For new NWLON stations, once the location, type of sensors, and DCP are selected, OET assigns the platform ID and provides the satellite configuration data for the deployment.

For other types of water level stations, such as subordinate stations installed for NOAA in-house hydrographic or photogrammetric surveys, or meteorological (met) only stations, OET also assigns platform IDs, as appropriate. This section pertains to water level stations installed by NOAA ships, CO-OPS, or CO-OPS IDIQ contractors. This section is not applicable for contract hydrographic and photogrammetry stations installed by OCS and NGS survey contractors.

OET will provide station numbers and platform ID assignments for equipment setup and testing when the location, which consists of a local name, body of water, and latitude and longitude, of the station is reported to OET. OET can be reached by telephone at 301-713-2897, fax: 301-713-

4465 or 301-713-4435, or e-mail address at [nos.coops.oetteam@noaa.gov](mailto:nos.coops.oetteam@noaa.gov). Requests for GOES platform IDs shall be submitted to OET at least 15 days before throughput testing to allow sufficient time to receive radio frequency assignments. Refer to Reference 32 for procedures on requesting a platform ID.

**Critical Information required for water level station database configuration at CO-OPS Database Management System (DMS):**

- (1) Station Number and Name
- (2) Installation Date
- (3) Latitude/longitude
- (4) Platform ID, transmit time, channel
- (5) Serial numbers of all DCPs, and sensors.
- (6) Level abstract
- (7) Sensor offset C1 (SNS) and Datum Offset C2 (DAT) as entered in the DCP for acoustic sensor; and orifice offset(s) for pressure sensors.

Prior to the installation of a station and initiation of GOES data transmissions from the field, critical information that is needed for database configuration shall be emailed or faxed to OET. See the figure at left for the critical information required for station database configuration in the CO-OPS DMS. Test transmissions monitored by the installer during the field unit installation may be conducted outside this requirement.

This station information must be configured in DMS for data to be accepted in DMS. Whenever possible, within 24 hours after reporting the above basic information and before the complete inspection package is submitted, the draft E-Site Report (or Xpert Site Report or Tide Station Report) shall be forwarded to OET. This is called the one-day draft E-Site Report submission requirement and its purpose is to:

- 1) Standardize the requirements for all of CO-OPS' field efforts;
- 2) Provide feedback by OET to the Installer while at the site, so that critical information is verified; and
- 3) Insure that timely corrective actions and required maintenance actions as described in the station specific Project Instructions can be accomplished by the Installer while at the site.

Generally, OET will respond back to the Installer or provide feedback within 24 hours or earlier during normal business hours during the work week. This requirement applies to all types of water level stations and all types of sensors for every type of maintenance - installation, regular scheduled maintenance, emergency maintenance and removal of a water level station, where CO-OPS is expected to receive and/or process the data.

CO-OPS has developed a web-based electronic site report (E-Site Report) that interacts with DMS. Refer to Reference 27 and 28 for the User's Guide and the SOP for using the E-Site report.

The effective starting date of all operational sensor data series is the date and time when the data is first received after the DMS configuration. It is the responsibility of the installer to ensure that the required documentation is provided to OET prior to the date when the operational sensor data are needed.

For the installation of the primary sensor, a leveling connection shall be made between the Primary Bench Mark (PBM) and the sensor zero for the purpose of determining the sensor zero height with respect to the SD. For the acoustic sensor, the sensor zero is the Aquatrak™ Leveling Point (AQLP), which is the top edge of the collar on which the Aquatrak sensor rests. On the ETG, the sensor zero is the ETG reading reference mark, also known as the ZETG, Zero of Electric Tape Gauge. The Paroscientific pressure sensor zero is the vertex of the V-notch in the side of the orifice, or the bottom of the top parallel plate. To make a leveling connection to this sensor zero, a rod stop called the orifice staff stop - that can be leveled as part of the leveling run - is installed at a point above the sensor zero and a calibrated steel tape measurement is made between the sensor zero and the orifice staff stop. Using the height obtained for sensor zero with respect to the SD, the datum offset (also known as Coefficient C2 or DAT), or the orifice offset shall be calculated.

The field crew shall then submit the E-Site report, Xpert site report, or Tide Station report via email or fax. Include a copy of the level abstract (and water level transfer form for Great Lakes stations) to OET in addition to a phone call to OET so that sensor parameters can be properly setup in DMS prior to the beginning of the accepted data collection.

The Installer shall contact OET (contact information is provided above at the beginning of the section) and CORMS at telephone 301-713-2540, fax 301-713-4392, or e-mail [corms@noaa.gov](mailto:corms@noaa.gov)

- a) Before performing any maintenance at a station
- b) After the maintenance is completed
- c) When a station is installed
- d) When a station is removed.

The above procedure must be followed. If this procedure is not followed in timely fashion prior to beginning of data transmission, data losses may occur. When the station sensors are properly configured in DMS, the data is accessible through the CO-OPS' web site at <http://tidesandcurrents.noaa.gov>.

Changes to the satellite platform ID, or the DCP telephone number, shall be reported to OET and the supporting Field Operations Division (FOD) office immediately via telephone, email, or fax.

The Installer/tester shall follow the appropriate throughput testing requirements as described in Reference 24.

## 2.6 Station Installation

The installation of water level station DCPs and sensors shall be accomplished according to Reference 1, Reference 2, and the manufacturer's instructions, as applicable. Nearly all of the NWLON stations have the Sutron Xpert System (Xpert DCP and Xpert Dark as redundant DCP) installed as of February 2011.

All new station installations, excepting short-term hydro/photo stations, shall undergo an engineering design review in accordance with Section 3 of the ROS. FOD and NWLON O&M contractor engineering design packages for station upgrades and installations shall be reviewed and approved by the CO-OPS Field Engineering Review Subcommittee before any work actually begins on the site. The installer shall obtain all required permits and permissions using CO-OPS approved agreement templates for the installation of the water level sensor(s), DCPs, bench marks, and utilities, as required and provide copies of signed agreements, permits, and permissions to ED and the supporting FOD office as part of the design review process. A complete reconnaissance report and station design heights shall also be submitted. The installer shall be responsible for security and/or protective measures, as required, for protecting the government furnished equipment and facility while installing, maintaining or removing a water level station.

The water level station and its various components (tide house, Data Collection Platform, all sensors, meteorological tower, bench marks, and pertinent access facilities such as railings, steps, etc., as appropriate), when designed or installed by contractors, shall be installed and maintained as prescribed by manufacturers installation manuals, appropriate local building codes, or as specified by the Contracting Officer's Technical Representative (COTR), if applicable. The water level station and all installed components shall be structurally sound for its intended application, secure, and safe to use for NOS, local partners, and general public, as appropriate.

The installer must provide CO-OPS with the GPS position, as noted below in Section 2.9, of all tide gauges and sensors installed before data collection begins, including those that were not specified in the Statement of Work. In cases where gauge location(s) needs to be different than that specified in the Statement of Work, installer shall consult with CO-OPS prior to the installation.

Digital photographs of water level station components (station, DCP, sensors, well, supporting structure, equipment, and bench marks) shall be taken and submitted. GPS photos shall be taken according to Reference 6.

A minimum of four photos for each bench mark shall be taken: close-up of the disk face; chest or waist level view of disk and setting; and horizontal views of the location of the bench mark from two different (perpendicular) cardinal directions. Photos shall also be taken of station components such as protective wells, staffs, houses, shelters, met towers, DCPs, sensors, etc. One general location photo shall be taken showing the water level station in relationship to its supporting structure and the local body of water. All digital photographs shall be submitted in JPEG format. All digital station photo files should be named such that the name of the file will

indicate the station number and the type of photo taken. For example, the acoustic sensor photo for DCP1 at Los Angeles shall be named as 94106601 sensor A1.jpg.

The station components and bench mark photographs are required when a new station is installed. The bench mark photographs shall be updated whenever any changes are noticed, such as damaged bench mark disk, or changes to settings, etc, or as requested in the station specific requirements.

All digital station bench mark photo files should be named such that the name of the file will indicate the station number, dash, PID number (if available), dash, stamping or designation, dash, photo type, dash, date, dot.jpg. For a new mark, the PID is not applicable as it is unavailable. A close-up photo showing the face and stamping of the bench mark is photo type 1, an eye level photo showing the bench mark and its setting is photo type 2, and a horizontal view of the bench mark showing nearby landmarks is photo type 3. For photo type 3 include the cardinal direction (N, NE, S, SE, etc) that the camera is pointing. If more than one type of photo is taken for a given view, then re-name them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use the designation instead of the stamping for the naming of the file. Use a maximum of 30 alpha numeric characters to the left of the dot. If you are exceeding 30 alpha numeric characters in the name, then truncate the stamping or designation so that the maximum number of characters in the name are 30 (including spaces and hyphens). For example, the bench mark E close-up photo for the Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg.

Sample file names for photo files:

Disk face photo of a new bench mark without a PID	9414290-4290A2008-1-20090101.jpg
Eye level view photo of an existing bench mark with a PID	9410660-DY2512-BM N-2-20090101.jpg
North direction photo of an existing bench mark without a PID	9447130-7130E1990-3N-20090101.jpg

In addition, place a caption on each photograph, indicating the stamping or designation of the mark, the PID, the photo type with cardinal direction, and the date of photograph taken. The Windesc program for electronic leveling has a function to assist with the photo caption.

The above naming convention for the bench mark photo files shall be applicable for all of CO-OPS' work and OCS hydrographic surveys. For NGS Shoreline mapping projects, contractors shall follow the NGS specifications for file naming of bench mark photos.

NGS Coastal Mapping Surveys require a slightly different file naming convention as described in Attachment R of the NGS Specs which is located at [http://www.ngs.noaa.gov/ContractingOpportunities/SOW\\_Main\\_Text\\_V13B\\_new.pdf](http://www.ngs.noaa.gov/ContractingOpportunities/SOW_Main_Text_V13B_new.pdf) . All photos collected for NGS Coastal Mapping Surveys for both contract and in-house projects shall be named according to NGS convention.

A completed water level measurement station installation consists of the following:

- e) The installation of the water level measurement system (water level sensor(s), primary and redundant DCP as appropriate, satellite transmitter, ancillary sensors if applicable, other equipment as necessary and its supporting structure, and a staff (if required), as specified in the Annual Station Specific Requirements, or as specified in the contract documents.
- f) The recovery and/or installation of the required minimum number of bench marks and a level connection between the bench marks, Primary Bench Mark (PBM), and the water level sensor(s), or tide staff as appropriate. The minimum number of bench marks or specific marks to be leveled will be specified in the Annual Station Specific Requirements, contract documents, or as specified in Reference 3 (See section 3.3 Levels for additional leveling requirements).
- g) The collection of GPS observations, a minimum four hour session, on one bench mark, and submission of the data through OPUS DB for publishing.
- h) Validation by CO-OPS of complete data transmissions, and proper data ingestion into DMS, as evidenced by the data display on the CO-OPS website.
- i) The preparation of all documentation and data and submission to CO-OPS (ED and supporting FOD field office) in a timely fashion (refer to Section 4 for requirements for timelines, documentation, and points of contacts).

The installer shall follow the appropriate sections of the SOP-06-001 as referenced in the Reference 24.

## **2.7 Station Maintenance Requirements**

Water level station standard annual maintenance shall be accomplished in accordance with the Appendix F of Reference 1, and the most recent version of the AI checklist, or as instructed by the Contracting Officer's Representative (COR), or by the Task Manager (TM). A PDF file or digitally scanned copy of the completed AI checklist shall be submitted for each station annual inspection. The specific maintenance requirements for each water level station will be specified in the Annual Station Specific Requirements for individual task orders for contracts.

CO-OPS shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for degraded or invalid data, when the data is disseminated via GOES telemetry using the NOS satellite message format. This includes data from CO-OPS NWLON stations, and stations supporting hydrographic and photogrammetric surveys where CO-OPS or CO-OPS contractors, Navigational Response Teams (NRT), or NOAA Ships install the subordinate water level gauges. CO-OPS shall not monitor the subordinate stations installed for NOAA contract hydrographic/photogrammetric survey projects by NOAA contractors.

This monitoring can be performed by accessing the CO-OPS web page (<http://tidesandcurrents.noaa.gov>). The data over the web are typically available for review within one to four hours after the configuration of the DCP and sensors in DMS during the normal business hours, after the installations of the DCPs and sensors in the field, and once data is reviewed and dissemination is turned on by CORMS.

During annual maintenance visits to a station that has an acoustic sensor, the Aquatrak™ sensor and matching cal tube shall be replaced. For stations where wind sensors are installed, wind sensor nose cones shall be replaced during the annual maintenance. The Ultrasonic wind sensor leads (if in question) shall be cleaned with a contact cleaner with a zero residue base. All applicable sensor serial numbers (inside the tide or gauge house) shall be verified by the installer (recorded by one person and confirmed by a second person in the field party). Safety of personnel is of utmost importance and safety gear as necessary shall be used while climbing the towers, etc, when required. Most of the serial numbers of the DCP boards and sensors are generally recorded and verified during the installation, and only when equipment is replaced during the maintenance, then the re-verification of the serial numbers is required. Necessary repairs or alterations to the stations and equipment shall be made and documented on the approved E-Site Report, Xpert Site Report, or Tide Station Report.

Repairs or alterations required by the Standing Project Instructions or the Annual Station Specific Requirements, but not completed, shall be documented, along with the reasons for the incompleteness, on the approved E-Site Report, Xpert Site Report, or Tide Station Report. Each field party crew chief shall provide a draft E-Site report, Xpert Site Report, or Tide Station Report wherever possible, within one day of completion of maintenance and leveling operations to OET.

The report(s) shall be completed by the installer before leaving each station; and reviewed by the field team leader or contractor supervisor after completion of the maintenance visit but prior to submission. The reviewed station package shall then be submitted to ED and the supporting FOD field office within 1 month after the completion of the maintenance, or as specified in the contract documents.

A minimum of 30 days of 6 minute water level data and 15 days of 1 minute tsunami water level data shall be downloaded during each maintenance trip for NWLON stations and the data shall be forwarded to OET as described in Section 4.2.2 Documentation Requirements. Engineering Bulletin # 07-007 “Downloading (Exporting) Data from the Xpert Log Files using Xterm” provides information regarding how to download the data from Xpert DCP.

Sizes of the Xpert Log Files (ssp.log, tsu1min.log, and System.log) shall be configured according to the Engineering Bulletin 09-003 “Update to Xpert Log File Sizes”.

Approved primer and anti-fouling paint shall be used on all new protective wells and all protective fiberglass/PVC components that will be in water, excluding the acoustic sensor calibration/sounding tube.

For dual orifice pressure sensor configurations, the vertical stability and elevation to the leveling points from each orifice shall be verified, including the distance between the two orifices. To do so measure the elevation of each orifice to the staff-stop using a steel tape graduated in millimeters. Two independent readings shall be taken and they should not vary more than 3 mm, then report the average of the two readings. If the two readings vary more than 3 mm, then take additional readings until two readings are obtained within 3 mm. The mounting assembly for the two orifices shall be checked for structural integrity and the orifices shall be cleaned of biofouling.

When first arriving at a station to perform annual maintenance, check and record the voltage for each battery on all DCP units. Then remove AC power to both the Primary and Redundant systems allowing them to run totally on battery power. After the units have had approximately an hour of transmit loads on the Xpert DCP and at least 2 hours for the 9000 DCP, recheck the voltage. If the battery voltage has dropped significantly (i.e. below 11.7 volts), replace it. Also write the date of installation with permanent marker on each battery, and record this date on the site report. Check all marine grade batteries to ensure that adequate water is in each cell. Use only distilled water for replacement.

A new battery shall be replaced every four years during the maintenance trip for the NWLON stations, where practical, or make arrangements to replace it at another time. The condition of a newly installed battery shall be checked using the procedure described in the above paragraph during the 2<sup>nd</sup> or 3<sup>rd</sup> year maintenance trip, and if the battery condition passes the test described above then replace the battery during the 4<sup>th</sup> year after the installation. Of course, if a battery does not pass the condition test as described above, then it shall be replaced immediately during that trip and the date of replacement shall be duly noted on the approved E-Site Report (or Xpert Site Report or Tide Station Report, if applicable).

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate approved maintenance forms (refer to Section 5 for requirements for deliverables for water level station documentation and timelines) and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date and time (GMT) of the beginning and the end of the maintenance activity; date and time of adjustments of the sensors; changes in the configuration of the DCP - such as a new datum or sensor offset, or setting the time; personnel conducting the work; parts or components replaced; component serial numbers; tests performed and test results; etc.

Proper NOAA identification emblems with an emergency phone number 1 (800)367-6622 shall be placed on all water level gauge house doors or shelters. Emblems which are unreadable should be replaced.

A completed station visit for maintenance (scheduled or emergency) consists of the following:

- a) The maintenance or repair of the water level measurement system (water level sensor(s), primary and redundant DCP as appropriate, satellite transmitter, ancillary sensors if applicable, other equipment as necessary and its supporting structure, and a staff if applicable), and as specified here in the Standing Project Instructions, the Annual Station Specific Requirements, or as specified in the contract documents.
- b) For scheduled maintenance, the recovery and/or installation of the required minimum number of bench marks and a level connection between the bench marks, PBM, and the water level sensor(s), or tide staff is required. The minimum number of bench marks or specific marks to be leveled will be specified in the Annual Station Specific Requirements, contract documents, or as specified in Reference 3 (See Section 3.3 Levels for additional leveling requirements.)

For emergency maintenance, recovery of bench marks and levels are generally not required, unless the maintenance is done which may affect the elevation of the AQLP, or orifice(s) for pressure sensor(s), in which case leveling, to the PBM and at least 2 other marks, is required.

Only for scheduled maintenance, GPS observations on one of the bench marks as specified in the Annual Station Specific Requirements, or as specified in the contract documents, may be required.

- c) CO-OPS verification of complete data transmission throughput following maintenance, from station to DMS ingestion.
- d) The preparation and submission of all documentation and data to ED and the supporting FOD field office in a timely fashion (refer to Section 4 for requirements for timelines, documentation, and points of contacts).

The maintenance party shall follow the appropriate sections of the SOP-06-001 as referenced in the Reference 24.

### **2.7.1 Additional Requirements for NOAA Sentinels**

NOAA Sentinels are water level observing stations which have been strengthened to deliver real-time storm tide data during severe coastal events. Elevated atop substantial single pile platforms, these stations are specifically designed to withstand category four hurricanes. NOAA Sentinels measure and disseminate real-time water level and meteorological observations. All of this information helps coastal authorities prepare for, mitigate, and respond to storm tides generated by severe coastal storms.

The following are the additional maintenance requirements for the NOAA Sentinel stations currently installed in the Gulf of Mexico:

**Every Year:**

- Examine the anode and the anode attachment points. Inspect the attachment points for excess corrosion and inability to remove fasteners. Provide measurements of the smallest cross sectional area of the anode. Provide underwater photos of the anode and close-ups of any excessive anode shrinkage or attachment point corrosion.

**Every 2 years:**

- Inspect all painted surfaces for rust. Document significant rust areas in the Excel or E-Site station report and provide photos of the occurrences. The repair of significant rust areas shall be added to the following year's project instructions along with procedures for coating repair.
- Inspect all galvanized surfaces for rust. Document significant rust areas in the Excel or E-Site station report and provide photos of the occurrences. Repair spot rust with a wire brush and cold galvanizing.
- Inspect all welds for rust and cracks. Provide photos and document excessive rust and cracks.
- Check all fasteners on the protective well clamps, including half moon clamps, adjustable arms, and attachment to clamp brackets. Tighten if loose.
- Check the fasteners holding the solar panel mount to the railing. Tighten if loose.
- Check all fasteners holding the enclosure to the support stand and the stand to the deck grating. Also check the bracketing system along the upper portion of the enclosure. Tighten if loose.
- Check all fasteners on the Rohn tower. Tighten if loose.
- Examine the underside of the high platform. Inspect the high platform bridge bolts for looseness and rust. Document and tighten any loose bolts.
- Examine the galvanized conduit for rust and cracks. Check also for water in the conduit entering the bottom of the enclosure.
- Examine the solar panel and Rohn tower flexible conduits for cracks and loose fitting/tubing connections.
- Grease the davit and winch. Examine for corrosion.

### **Every 5 Years:**

- Replace the battery pack in the Aid to Navigation light

### **2.7.2 Additional Requirements for Great Lakes Stations**

- The shaft angle encoders shall be inspected to insure the offset pulleys are not binding. Lift the float tape off of the offset pulley and free spin the unit. If any binding occurs, replace the bearing in the center of the gear. In addition and while the float tape is off of the encoder gear and pulley, spin the encoder shaft to represent both a 2 meter increase and a 2 meter decrease in the readings from the present reading. Then match the reading with the ETG reference and reset the tape back on the gear and pulley. After this process, remember to check the tape at the float connection to ensure that it has not kinked. This rotation procedure will ensure that the oil lubrication around the enclosed encoder bearings remains fluid. NOTE: - This test should only be performed during the time period that the DCP is not calculating the water level reading. This time period, for computing the water level reading, is 90 seconds before and after the allotted 6 minute interval. Also check to see that the float tape length has been installed such that the float neither tops out nor the counterweight bottom out before reaching its extreme limitations.
- The float shall be inspected for corrosion and leaks; replace as necessary.
- When closing off the intake valve note how many turns it takes to close off the intake as well as how many turns it takes to fully open it. This shall be reported in the remarks on the inspection sheet and on a tag placed on the valve handle. Also note the difficulty in turning the valve such that it can be predicted when the valve would become unusable and need replacement.
- A water level transfer (inside/outside check) shall be performed at each station and documented on the Site Report. The inside/outside water level must agree to within 0.006 m. The best time to perform a transfer is in the early morning or late evening when the water level is most calm. The above procedure must be followed and actions taken to correct any discrepancies.
- When diving at gauge sites measure and report the elevation of intake invert and valve invert on IGLD 85, if not previously noted. NOTE: The invert elevation is the point where the water level can no longer be measured accurately. If the intake has a gooseneck at the end this measurement should be taken at the lowest point in the curve at the top of the gooseneck, not the opening.
- Install rubber flaps over all locks on gauge shelters for protection against the weather. The locks shall be inspected and lubricated to enable easy access.

- Check gauge houses inside, outside, and around the doorframe for openings in the mortar and caulk as required. Submit a statement of work to FOD for any work recommended for completion by a contractor.
- Check gauge house structure, door, and frame for rust and paint chips. Scrape and paint as necessary.

## 2.8 Ancillary Sensor Metadata

The meteorological sensor site selection and measurement guidelines are listed in Reference 12.

Specific metadata for ancillary sensors is required as detailed below. The installer shall make note of this data in the remarks section of the Ancillary Sensor boxes on the approved Site Report or E-Site report. Metadata documentation shall be completed during the annual inspections, or emergency maintenance visits, as appropriate, for all stations with ancillary sensors. A unique Temporary Bench Mark (TBM) may be selected at each station and all the required measurements can be referenced to that TBM. The TBM must be connected via levels to the PBM. Then ED will relate the sensor elevations to SD and other datums as appropriate.

Photos shall be taken of the supporting structure and all of the ancillary sensors installed. The photos should include as many of the four cardinal compass directions as possible, with the file name indicating the direction of the view, i.e. 87617241 Met tower looking south.jpg. Photos and sensor elevations must be submitted by CO-OPS to the National Data Buoy Center (NDBC) in a timely manner before NDBC will accept the met data into its quality control process. Annual photos of the met mast and ancillary sensors are not required once the sensors have been installed. Wind sensors shall be aligned according to Reference 11.

Ancillary Sensor	Sensor Elevation Reference Point
Air temperature	Center of the sensor above the station datum and above ground to the nearest +/- 15 centimeter.
Water temperature	Center of the sensor above the station datum as derived from subtracting the distance from the leveling point to the center of the sensor from the C2 value, to the nearest centimeter.
Barometric pressure	Surface of the pressure port above MSL (see Barometer Calibration Guidelines) to the nearest +/- 15 centimeter.
Wind Speed/Direction/Gust	Center of the sensor above the station datum and above ground to the nearest +/- 15 centimeter. Note any major physical obstructions in the vicinity of the sensor.
Conductivity	Center of the loop above the station datum to the nearest centimeter.
Relative humidity	Center of the sensor above the station datum and above the pier/ground surface to the nearest centimeter.

Air gap	Sensor zero above the station datum as determined from trigonometric levels to the nearest centimeter.
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## 2.9 Obtaining and Recording Positions of Stations, DCP, Sensors, and Bench Marks Using a Hand-Held GPS Receiver

Latitude and longitude of the station, DCP, all sensors, and bench marks shall be recorded using a hand-held GPS receiver and recorded as degrees, minutes, seconds, and tenth of seconds (e.g. 45 degrees, 34 minutes, 32.6 seconds). The positions of the primary and backup DCP and all sensors that are installed in a tide house (gauge house) shall be recorded as that of a station. This position will be obtained in front of the tide house (gauge house) at the center of the front door/front wall of the tide house (gauge house). The front portion of the roof of the tide house (gauge house) may also be used as applicable if the GPS satellites are blocked from the structure. For a standalone DCP or met sensors that are 3 m (10 ft) or greater from the station, obtain positions and report appropriately on the Site Report.

For barometers which are generally installed in the tide house, report the latitude and longitude as that of the station, but report the elevation above station datum as obtained from the leveling.

For Aquatrak sensors or Paroscientific sensors that are installed 3 m (10 ft) or greater from the station location, obtain the positions of the sensors at the center of the sensor. If the Aquatrak sensor or Paroscientific sensor is installed inside a tide house (gauge house), then report the latitude and longitude as that of the station, but report the elevation above station datum.

For bench marks, obtain positions using the hand-held GPS receiver by placing the receiver on the (horizontal) bench mark. For bench marks that are installed vertically, obtain the position as close to the mark as satellite coverage will allow.

Handheld GPS units come with either patch antennas or quadrifilar antennas. The proper method for holding the GPS unit is vertically if the unit has a quadrifilar antenna, or horizontally if the unit has a patch antenna. Holding the unit otherwise will degrade the reception of the satellite signals and reduce the accuracy of the position obtained. The Garmin GPSmap 76S units used by CO-OPS have quadrifilar antennas.

Take a digital photo of the GPS unit display for each location acquired. This will insure verification of the latitude and longitude that is entered into the Excel and E-Site reports.

## 2.10 Gauge Removal

The installer shall remove a water level station, if required, and as specified in the Annual Station Specific Requirements, or as specified in the contract documents. A complete removal of the water level measurement station consists of the following:

- a) Closing levels - a level connection between the PBM and all the bench marks in the local leveling network at the station, the water level sensor(s), and/or staff, if applicable.

- b) Removal of the water level measurement system and restoration of the premises, assuming reasonable wear and tear. The property owner shall be notified prior to removal and thanked for supporting our programs.
- c) Generally, GPS observations on one bench mark are done during the installation for short term stations. If GPS observations are not done during the installation phase, and GPS observations are required, then GPS observations shall be done during the gauge removal time. Generally, GPS observations are required only one time for short term stations. For NWLON and long term stations, the frequency of the GPS observations is determined by the rate of sea level change at the station and if the GPS observations are required for a specific year, those will be listed in the station specific project instructions.
- d) The preparation of all documentation and data and submission to CO-OPS (ED and supporting FOD field office) in a timely fashion (refer to Section 4 for requirements for timelines, documentation, and points of contacts).
- e) Return of all government equipment to appropriate supporting CO-OPS' FOD field office(s) in timely fashion within 15 days of station removal.

## **3 BENCH MARKS AND LEVELS**

### **3.1 Reference Documents**

Bench marks and level operations shall be performed in accordance with Reference 3. CO-OPS electronic/barcode level operations shall be performed in accordance with Reference 31 and the Leica Manual for the DNA03 level. Help files for the TOPCON and Trimble level instruments can be found in the Windesc and Translev programs available from NGS.

Bench mark descriptions shall be written in accordance with Appendix E of Reference 4 for bench marks that are connected using the electronic levels. Descriptions for Great Lakes bench marks shall be written in accordance with the NGS Bluebook, Formats and Specifications of the National Geodetic Survey Data Base <http://www.ngs.noaa.gov/FGCS/BlueBook/>, since those marks are not published by CO-OPS.

Bench mark descriptions shall be written in accordance with Reference 5 for bench marks that are connected using the optical levels, where electronic levels are not used, or as specified in the contract documents.

### **3.2 Bench Marks**

Unless specified otherwise in the work order or contract documents, the total number of bench marks in the leveling network shall be a minimum of ten marks for the NWLON stations and a minimum of five marks for subordinate stations installed for hydrographic and photogrammetry surveys, special projects, or contract projects for U. S. Army Corps of Engineers, unless otherwise directed by ED.

Descriptions shall be checked by verifying distances with tape measurements in metric units, verifying cited landmarks and using a compass to confirm directions.

The handheld GPS coordinates of each mark shall be entered in the description file for electronic levels, or noted on the published bench mark sheet or equivalent (for optical levels). The latitude and longitude fields of the bench mark shall be reported in the following format: degrees/minutes/seconds and tenths of seconds. For example, 40 degrees, 45 minutes, 35.2 seconds.

New bench mark sketches shall use CO-OPS' standard bench mark sketch title block, or electronic equivalent. If a digital sketch is used, submit the digital file in JPG format with the leveling files and photos. If AutoCAD or AutoCAD LT is used to generate the benchmark sketch, both a JPG format and the AutoCAD DWG format shall be submitted. Submission of updated bench mark sketches are required only when necessary to document newly established marks or physical changes in the area.

CO-OPS has photos of nearly all bench mark disk faces, setting, and location shots of NWLON and active subordinate station tidal bench marks. The station specific requirements shall note any

additional photos needed to achieve a complete photo gallery of each mark.

If a bench mark is discovered disturbed or mutilated during the visit to a station, include it in the level run to determine if it is holding its elevation relative to the PBM and report it to ED and the supporting FOD field office. ED will make a decision and inform the installer via the next set of Station Specific Requirements regarding the action that needs to be taken: destroying the mark, if it is a NOS mark, or dropping the mark from the leveling network for other marks. If the PBM has been disturbed, contact ED immediately for further direction.

Before installing a new mark, perform a 1.6 kilometer (1 mile) radial search from the tide station (DCP) location at NGS web site, <http://www.ngs.noaa.gov/datasheet.html> to check if any NAVD 88 marks are available that are not part of the local leveling network. Inclusion in the local leveling network of an existing mark(s) that has a NAVD88 elevation, if it is located within a 1.6 KM (1 mile) leveling distance of the station location, is desirable and shall be preferred over installing a new mark. If the bench mark is replaced, then the stamping of the bench mark shall have a new letter designation (assigned by ED) and present year so that the new stamping is different from the original stamping of the mark, or the stamping of other marks in the local leveling network.

Digital photographs of bench marks shall be taken as described in Section 2.7 Station Installation.

### **3.3 Levels**

All leveling shall be performed with electronic/barcode systems, to either Second Order, Class I or Third Order standards, in accordance with National Geodetic Survey (NGS) standards for geodetic leveling, and CO-OPS "User's Guide for the Installation of Benchmarks and Leveling Requirements for Water Level Recording Stations, NOAA/NOS October 1987". Beginning in calendar year 2010, all CO-OPS and contractor field crews are required to use the NGS Windesc description and Translev leveling software. Refer to the "User's Guide for Electronic Levels with Translev and Windesc, Updated September 2010"

If digital bar-code leveling systems are to be used, the model should have been previously evaluated by the Federal Geodetic Control Subcommittee (FGCS). These systems include the Leica NA3003, Leica DNA03, Topcon DL101C, Trimble DiNi 12, Zeiss DiNi 10, DiNi 11, DiNi 12 and DiNi 12T. Bench mark descriptions and leveling output must be in a NGS-supported format to enable processing and adjustment of the levels by NGS. Station bench mark descriptions and recovery notes shall be submitted in computer-readable form using WinDesc software. The basic WinDesc usage instructions are built into the program. You simply go under the HELP menu when you run WinDesc. Field book and field abstract software are required and are dependent on the leveling equipment used for this project. Translev is a NGS program that facilitates the process of editing, formatting and checking digital leveling observation data and creates abstracts, bok files, and VERTOBS datasets for submission to the National Geodetic Survey (NGS). WinDesc and Translev are the two programs currently being used by CO-OPS to

submit leveling data to NGS. NGS training is available if needed. These NGS programs are available online at [http://www.ngs.noaa.gov/PC\\_PROD/pc\\_prod.shtml](http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml).

CO-OPS will provide appropriate training to contractors in the use of the Windesc and Translev software for leveling operations,

Second-order Class I leveling connections shall be made from the primary water level sensor (AQLP or pressure sensor orifice [staff stop], and in the Great Lakes the ETG RM and the Spike RM) to a minimum of 5 bench marks on an annual basis, including the primary bench mark (PBM). In the case of pressure sensors as primary sensors, the elevation of orifice zero to orifice staff stop(s) shall be measured annually using a calibrated steel tape with millimeter graduations, and elevation of the orifice staff stop(s) to PBM shall be determined using the conventional leveling equipment.

As described in the “User’s Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987” Section 3.3, Page 18, the levels are required and shall be performed for seven cases listed. Particular emphasis is placed on performing the check levels as per the specific project requirements or no later than 6 months after the establishment of a new water level station. This is required for declaring a newly installed water level station operational.

All of the bench marks in the leveling scheme shall be leveled within a two year period. This may be accomplished by leveling to the PBM and four marks one year, then to the PBM and the remaining marks the next year. In some cases, it may be practical to level to all the marks the second year to reach the furthest marks from the station. A level connection to CORS reference marks shall also be made once every two years, if those marks are within 1.6 KM (1 mile) leveling distance from the water level station. The installer shall be responsible for ensuring that every mark in the station bench mark network is leveled once every two years.

The two or three meter barcode rods for second order levels shall be used whenever possible at all stations. At stations where three/two meter level rods cannot be utilized due to airline size restrictions, justification for use of the Third Order barcode rods and levels shall be documented on the NGWLMS Site Report. For stations in AK, HI, and Pacific Island areas the Second order class I leveling requirement is waived and the Third Order levels are acceptable.

The primary water level sensor (ETG in the Great Lakes) shall be connected to the station bench marks by levels. The levels shall be run upon sensor installation, in conjunction with annual maintenance levels, if obvious sensor movement is noticed during regular/emergency maintenance, and upon sensor removal. The levels to the sensor(s) shall be spur runs from any bench mark, it is not necessary to have the spur run directly from the PBM to the sensor(s). If the leveling starts at the sensor then it is not considered a spur run.

At Great Lakes sites where a spike is unavailable for use in performing a water transfer, (see section 3.1, standing project instructions for a description of procedures to perform water transfers), the water level in the sump shall be compared to the water surface outside the sump by differential leveling and the use of the water level transfer program (h2o-tran). A difference

exceeding 0.006 meters indicates a possible restriction in flow, which must be corrected. This instruction must be recognized and initialed. Note: this procedure can best be accomplished in early morning or late evening when the water is most likely to be calm.

When abstracting the raw level data using the electronic digital level system, the PBM shall always be selected as the starting mark, and the AQLP, orifice staff stop, or ETG, as the case may be, shall always be selected as the ending mark. If the original RAW file is edited before processing, the original file (XXXXXXXo.RAW) shall be stored in a separate subdirectory named "Original RAW", and submitted with the edited RAW (XXXXXXX.RAW) file and other level files.

While using the electronic levels, any changes made to the description file (XXXXXXX.DES) require that the levels be reprocessed and submitted to ED. Dates of the DES file must be chronologically consistent with the abstract ABS and other files generated. The date of the DES file cannot be later than the date of the ABS file.

Newly installed barometric sensors shall be included in the level run as a spur. Barometric pressure sensors shall be leveled, or their height otherwise determined in relationship to station datum, during installation, or if the barometer is moved to a new location. Barometric sensors at Great Lakes stations shall be leveled, or their height otherwise determined in relationship to DYNAMIC/IGLD 85. Since small changes in elevation do not change the height correction, the original leveling requirement to the barometer every five years is not needed. The elevation of Mean Sea Level (MSL) above Station Datum in the header information for the specific annual requirements for each station is based upon the 1983-01 tidal datum epoch. The Barometer C2 shall be computed to include both the calibration corrections and height corrections. The installer shall ensure that the new elevation is also correct on the Site Report section for calculation of the barometer C2. The barometer C2s shall be updated in the DCPs during the annual inspections. The SSN for the barometric sensor shall be xx10 if it is included in the electronic leveling, where xx is the part number. At Great Lakes stations, the "Barometer Installation Worksheet – Great Lakes" shall be used to compute the Height of the Barometer above the ETG. Refer to Reference 9 for additional information.

### **3.3.1 Leveling to NOAA Sentinels and Elevated Platforms**

Leveling connections on Sentinels and other elevated platforms require a combination of steel-taped height differences between the AQLP or a TBM at deck level ("deck" TBM) and a TBM near ground level ("ground" TBM), and a standard level run between the "ground" TBM and bench mark network.

To level from the AQLP to a TBM that can be included in the standard level run a TBM shall be chosen that can be leveled to the existing bench mark network using the standard barcode rod. This "ground" TBM shall be named and described per Reference 5 so that surveyors can level to the exact same TBM in future level runs during the maintenance of the Sentinel or elevated platform. The point where the taped measurement is made is critical in this description. This TBM shall also be placed in a position where a taped measurement can be made from the TBM

to the AQLP. If this is not possible, another TBM at the deck level of the Sentinel or elevated platform shall be chosen, then named and described per Reference 5, again with care to include the point of measurement in the description. This “deck” TBM shall be connected to the AQLP using standard leveling procedures.

The steel taped distance from the “ground” TBM to the AQLP or “deck” level TBM shall be performed on a windless day. A plumb bob shall be dropped from the AQLP or “deck” TBM to insure that the steel tape is held as vertical as possible. A set of five readings each shall be made by a minimum of two people for a total of ten readings. Each reading shall have the zero of the steel tape positioned at the high point of the “ground” TBM and the elevation shall be read from the tape at the AQLP or the high point of the “deck” TBM. The steel tape shall also be moved away from the TBMs and repositioned for each reading. The ten readings shall be averaged to acquire the height between the “ground” TBM and the AQLP or “deck” TBM.

The averaged steel tape height shall be entered into the DNA03 so that it is abstracted in to the level run. This is done by manually entering a zero for the staff height on the “ground” TBM as the **Backsight**, then entering the **positive** value of the averaged steel tape height for the **Foresight** of the **Forward Run**. During the **Backward Run**, enter zero for the **Backsight**, then a **negative** value of the averaged steel tape height for the **Foresight**. This will put the height of the AQLP or “deck” TBM into the abstract when the levels are processed using Translev.

### 3.3.2 Leveling to Temporary Bench Marks (TBM)

Due to leveling to meteorological sensors and water level sensors connected to DCPs other than DCP 1, the designation for TBMs shall be changed to include the full 8 digit station number: XXX XXXXY, where XXX XXXX is the Station ID, and Y is the DCP number. For example: If the barometer is installed on DCP 1 at 8410140 Eastport, the designation shall be TBM 841 01401 Barometer. If the barometer is installed on DCP 2, the designation shall be TBM 841 01402 Barometer. This format shall be used for all **SENSOR** TBMs

In addition, there have been several new water level TBMs added that are standardized in the following table. Use the designations below to correctly identify the orifice and microwave water level leveling point at a water level station. Due to the character limitations in WinDesc and Translev, it may be also be necessary to assign an alias.

Leveling Point (LP) Designation	Leveling Point Alias	Sensor Zero Measurement Point Designation
TBM xxx xxxxx Single Orifice LP	Single Orifice LP	Single Orifice Zero
TBM xxx xxxxx Dual Orifice LP*	Dual Orifice LP	Upper Orifice Zero
		Lower Orifice Zero
TBM xxx xxxxx Upper Orifice LP**	Upper Orifice LP	Upper Orifice Zero
TBM xxx xxxxx Lower Orifice LP**	Lower Orifice LP	Lower Orifice Zero
TBM xxx xxxxx MWL LP	MWL LP	N/A

\*For Dual Paros installations sharing the orifice LP use the designation TBM xxx xxxxx Dual Orifice LP.

\*\*For Dual Paros installations with separate orifice LPs for the upper and lower orifice, use the designations TBM xxx xxxxx Upper Orifice LP and TBM xxx xxxxx Lower Orifice LP.

### **3.4 Datum Offsets and Accepted Orifice Offset**

The leveling connection to an acoustic sensor shall be done at the AQLP. The AQLP is defined as the top shoulder of the mounting plate collar on the calibration tube. In order to facilitate rod holding, a prefabricated leveling fixture may be slipped over the sounding tube to rest on the leveling point. The height of the leveling fixture, as inscribed on the fixture, shall be compensated for in the leveling record (abstract). The level abstract shall show the elevation of the leveling point only. A barcoded rule or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used in lieu of the leveling fixture by holding the rule directly on the leveling point. In cases where the leveling point is too high for a rod shot, the leveling fixture designed for a down shot shall be utilized and the readings recorded to reflect the down shot. Use of other leveling fixtures and leveling techniques must be approved in advance by ED.

The leveling connection to an ETG shall be done at the reading mark (RM). A barcoded rule (60 cm scale) or stainless steel rule, with metric graduation (mm) and the zero at the end of the rule, as appropriate, may be used by holding the rule directly on the RM.

The AQLP elevation above station datum is defined as the Datum Offset and is computed by algebraically adding the PBM elevation above SD to the acoustic sensor elevation above/below the PBM. The Datum Offset is also referred to as Coefficient C2 for the Sutron 9000 DCP and as DAT coefficient for the Sutron Xpert DCP.

The orifice zero elevation for the Paroscientific pressure sensor(s) above or below the SD is defined as the Accepted Orifice Offset and is computed by algebraically adding the PBM elevation above SD to the (sensor) orifice zero elevation above/below the PBM. The orifice zero elevation is considered to be the point of the V on the brass orifice. For dual orifice systems the orifice offsets are established for both “N1” and T1” pressure sensors.

At Great Lakes stations, the Dynamic Height of the ETG RM, plus or minus the Hydraulic Corrector, at all lake stations, defines the IGLD 85 datum offset. In the Great Lakes Rivers and Connecting Channels stations the “Dynamic Height = IGLD 85”, Hydraulic Correctors are not applied. This datum offset is applied to the Primary Water Level C2 and should only be changed by ED after reviewing the abstract and Water Level Transfer.

When using the electronic/barcode leveling system, all five decimal places shall be used to determine the Datum Offset on the approved site report. After adding or subtracting the difference between the leveling point and PBM, to the elevation of the PBM above the SD, round off the five place value of the Datum Offset to four places. Rounding shall be done to the even

number, for example: 1.53455 is rounded to 1.5346. A note shall be made to the effect that the existing Datum Offset was retained in the DCP, or the new Datum Offset was entered with date and GMT time it was entered. When new Datum Offset is entered into the DCP, additional notification is required as listed below under Section 3.5 Movement. For stations that have the Paroscientific pressure sensor(s) as primary sensor(s), the change of accepted orifice offsets shall be documented on the Site Report with GMT date and time, and additional notification is required as listed below under Section 3.5 Movement.

If optical leveling equipment is used, then all elevations shall be recorded to the tenth of a millimeter level (e.g. 12.3457 m) on the leveling abstract.

After documenting the dynamic elevation for the ETG and SPIKE at Great Lakes stations, round to four places and apply these elevations to the "Water Level Transfer" program. Then apply the Hydraulic Corrector utilizing the sign, negative or positive in the program. This elevation is now the hydraulically corrected reference elevation, Zero Electric Tape Gauge (ZETG) and is then rounded to three places and entered in the DCP as Primary Water Level C2. C2 will not be changed unless the elevation differs by greater than  $\pm 0.003$  meters and only then after notification and review by ED.

When setting up the encoder offset at Great Lakes stations, the C2 in the Xpert DCP (sensor 14, coefficient 2 in the 9000 DCP) will need to be zeroed (0.000). The encoder gear will then be turned to reference 6.000 M on the display. Then an ETG reading will be obtained and subtracted from the 6.000 M reference. This difference, called the initial C2, is then stored in the Xpert DCP (sensor 14 coefficient 2 in the 9000 DCP). All ETG/Display readings have to be within 0.003 m. If not, the set up procedure must be performed again. NOTE: This procedure can best be accomplished in early morning or late evening when the water is most likely to be calm or by closing off the valve.

The accepted PBM elevation above IGLD85 in meters shall be used as the starting elevation on the level abstract at Great Lakes stations. This method results in all bench mark elevations referenced directly to IGLD85.

At coastal sea level stations, the accepted PBM elevation above the SD in meters shall be used as the starting elevation on the level abstract. This method results in all bench mark elevations referenced directly to the SD. "Old" (before sensor swap) and "new" (after sensor swap) AQLP connections, if required, shall be treated as spurs. Regardless of whether the acoustic sensor head is swapped or not, the leveling shall be done only once after the sounding tube has been cleaned and everything is put in place. For stations that have acoustic sensors installed, upon initial inspection of the station, if the installer suspects a movement of the well or that of the AQLP, then leveling shall be done twice, once before disturbing the well or sounding tube for cleaning and then after repairing the well or cleaning the sounding tube. For stations that have pressure sensor(s) installed, upon initial inspection of the station, if the installer suspects a movement of the orifice(s), then leveling shall be done twice, once before disturbing the orifice(s) and then after repositioning/securing of the orifice(s).

### 3.5 Movement

The movement of an entity, such as (a) AQLP, (b) pressure orifice zero, or (c) bench mark is defined as change in elevation of the entity in excess of 0.0060 m (0.020 foot) as obtained by comparing the current difference in elevation of the entity with PBM, with the previous difference in elevation of the entity with PBM. For acoustic sensors this difference shall be compared to what is stored in the DCP and appropriate action shall be taken as described below. For pressure sensor orifices this difference shall be compared with the accepted orifice offset as listed on the site report (and stored in DMS) because the accepted orifice offset is not stored in the DCP and appropriate action as described below shall be taken.

The movement shall be noted in the remarks box of the leveling section of the approved site report. If the Datum Offset determined from the latest level run indicates a deviation exceeding 0.0060 meter from the value presently stored in the field unit, and the PBM has remained stable, the new Datum Offset shall be entered into the field unit (no verification levels required) after consultation with ED. If the PBM is determined to be unstable, and other bench mark differences remain within the 0.0060 m allowable, the Datum Offset in the field unit shall not be changed. The suspected movement of the PBM shall be specifically noted, as instructed above, for further action by ED. At Great Lakes stations, if the Primary Water Level Coefficient 2 (C2) determined from the latest levels indicates a deviation exceeding 0.003 meter from the value presently stored in the field unit, and the PBM has remained stable, contact ED within 24 hours and provide the leveling abstract and Water Level Transfer.

ED and the supporting FOD field office shall be notified by phone or email immediately when the Datum Offset is changed in the DCP, or the accepted orifice offset has changed more than +/- 0.0060 m. An email ([nos.coops.oetteam@noaa.gov](mailto:nos.coops.oetteam@noaa.gov)), fax copy of the level abstract (fax 301-713-4465), and a phone call (telephone 301-713-2897) if possible, must be received by ED and supporting FOD field office within 24 hours of the change. Contact information for FOD field offices are listed in Section 4.2.3.

### 3.6 Geodetic Connections

Water level datums are local vertical datums which may vary considerably within a geographical area. A geodetic datum is a reference surface relative to which heights are determined. The North American Vertical Datum of 1988 (NAVD 88) is the accepted vertical datum of the National Spatial Reference System (NSRS) for the conterminous United States and Alaska and is officially supported by NGS. The relationships of tidal datums to geodetic datums such as NAVD 88 and to ellipsoid heights (above GRS 80 ellipsoid) support many hydrographic, coastal mapping, and engineering applications including monitoring of sea level changes, the deployment of GPS Electronic Chart Display and Information Systems (ECDIS), and the NOS Vertical Datum (VDatum) transformation tool.

Existing Geodetic Bench Marks (GBM) in the vicinity (up to 1.6 km (1 mile) leveling distance) of a water level station (primary and subordinate) shall be searched for and recovered. If a mark

is either not recovered or not used in the survey/project, a separate report shall be made using the NGS on-line Mark Recovery Entry Form at [http://www.ngs.noaa.gov/ngs-cgi-bin/recvy\\_entry\\_www.prl](http://www.ngs.noaa.gov/ngs-cgi-bin/recvy_entry_www.prl)

The connection to geodetic datums involves the following three leveling ties:

- 1) NAVD88 Level Tie
- 2) NAD 83 GPS Tie
- 3) NAVD88 GPS Tie

An orthometric level connection and ellipsoidal GPS tie are required at each water level station (primary and subordinate) which has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station).

The required “NAVD 88 Level Tie” is described in this document and the required “NAD 83 GPS Tie” and “NAVD GPS Tie” are described in Reference 6.

### **3.6.1 NAVD 88 Level Tie**

There are two parts for this requirement as described below in A and B.

(A) NAVD 88 Level Tie: At all water level stations, a valid level tie to at least two GBM is required on each set of levels, where appropriate GBM marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet. At many NWLON stations, the Primary Bench Mark (PBM) is a GBM. At the majority of NWLON stations, there are two or more tidal bench marks that are also GBM, thus increasing the chance that the geodetic level tie would be valid.

Make a Second-Order, Class 1 level tie to NAVD88 for all NWLON stations in the conterminous United States and Caribbean Islands. A Third-Order tie is used for all NWLON stations in Alaska, Hawaii, and Pacific Island areas.

At stations supporting hydrographic or shoreline mapping surveys, or other special projects, the tie shall be consistent with the accuracy of the levels required for the project (e. g. 2<sup>nd</sup> order class 1 or 3<sup>rd</sup> order levels, etc.).

The Translev leveling program includes a check function that will tell the user if a two mark tie to NAVD88 has been successful. Information on performing a valid level tie is also provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website:

[http://www.ngs.noaa.gov/FGCS/tech\\_pub/1984-stds-specs-geodetic-control-networks.htm#3.5](http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5)

Also, *Section 3.4 of “User’s Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987”* provides the same information regarding

how to perform a valid level tie. The information in User's Guide is easier to follow as it is written in layman's terms.

The Second-Order, Class 1 tie is a requirement for digital levels to be accepted into the NGS database. Short level runs to the sensor, PBM, and two marks are excluded from this requirement since they are usually meant to verify sensor stability only. Since a level connection to GBMs with dynamic heights defines the International Great Lakes Datum of 1985 (IGLD 85) datum offset at each station in the Great Lakes, a valid connection to at least two GBMs (within a mile of station location) is required at each site.

A note shall be made in the remarks of the leveling section of the Site Report that a valid tie was achieved or not achieved. If a valid tie is not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If a successful NAVD 88 level tie is performed, then NAVD 88 elevations for all the bench marks in the local leveling network (10 for NWLON and 5 for subordinate stations) can be determined for the NOS Vertical Datum transformation (VDatum) program.

If the water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the NAVD 88 level tie requirement is waived.

(B) NAVD 88 Level connection: An orthometric level connection is required at each water level station (primary and subordinate) which has at least one GBM located within 1.6 km (1 mi) leveling distance of a water level station. If the water level station has two or more GBM within 1.6 km (1 mi) of radial distance of the station location, then perform a NAVD 88 Level Tie (as described above in A) which fulfills the requirement for NAVD 88 level connection.

A successful NAVD 88 level connection to a GBM will help determine the approximate NAVD 88 elevations for the all the bench marks in the local leveling network (10 for NWLON and 5 for subordinate stations) for the NOS VDatum program.

If there are no GBM within 1.6 km (1 mi) leveling distance of the station location, then the requirement for NAVD 88 level connection requirement is waived.

### **3.6.2 Leveling at CORS**

For any NGS Continuously Operating Reference System (CORS) reference bench mark that is located within 1.6 km (1 mi) leveling distance of a water level station DCP, a leveling connection shall be made to the tidal bench marks in the water level station network every two years.

Information about NGS CORS stations can be obtained at <http://www.ngs.noaa.gov/CORS/>.

As of 2010, there are a limited number of water level stations in this category, but NGS and CO-OPS are attempting to secure funding to establish additional co-located sites to support long-term sea level trends monitoring.

### **3.6.3 GPS Connections**

An orthometric level connection and ellipsoidal GPS tie are required at each water level station (primary and subordinate) which has at least one GBM located nearby (within 1.6 km (1 mi) leveling distance of a water level station).

GPS connections involve the following two ties:

- 1) NAD 83 GPS Tie
- 2) NAVD88 GPS Tie

The required “NAD 83 GPS Tie” and “NAVD GPS Tie” are described in Reference 6.

## **4 SCHEDULE, REPORTS, AND DELIVERABLES**

### **4.1 Schedule and Reports**

Operations schedules are prepared for all water level stations each September for the upcoming fiscal year. Schedules for FOD and contractor operations are combined to produce one composite plan for CO-OPS. Overall accomplishments are compared to the plan on a monthly basis and reported to CO-OPS management.

Contractors shall provide ED and the supporting FOD field office a proposed annual schedule for accomplishing the indicated work in the station specific annual project instructions, or task orders, at the beginning of the task order with updates on a monthly basis, or as specified in the contract documents. Changes to the schedule must be requested in advance and approved by the Contracting Officer's Representative (COR) or CO-OPS.

Operations related to the indicated work in the station specific annual project instructions, or task orders, shall be discussed in a monthly activities report, or as specified in the contract documents.

### **4.2 Deliverables – Timelines, Documentation, and Points of Contacts**

#### **4.2.1 Timeline Requirements**

Wherever communications allow, the one-day draft E-Site Report (or Xpert Site Report or Tide Station Report) along with level abstract shall be forwarded to OET within 24 hours after the following maintenance activities:

- a) Installation of a water level station;
- b) Completion of regular scheduled annual maintenance;
- c) Completion of emergency maintenance;
- d) Completion of check levels; or
- e) Removal of a water level station.

The purpose of the one-day draft E-Site Report submission requirement is to:

- 1) Standardize the requirements for all of CO-OPS' field efforts;
- 2) Provide feedback by OET to the Installer while at the site, so that critical information is verified; and
- 3) Insure that timely corrective actions and required maintenance actions as described in the station specific Project Instructions can be accomplished by the Installer while at the site.

Generally, OET will respond back to the Installer or provide feedback within 24 hours or earlier during normal business hours during the work week. This requirement applies to all types of water level stations and all types of sensors for every type of maintenance - installation, regular

scheduled maintenance, emergency maintenance and removal of a water level station, where CO-OPS is expected to receive and/or process the data.

CO-OPS has developed a web-based electronic site report (E-Site Report) that interacts with DMS. Refer to Reference 28 and 29 for Users Guide and SOP for use of E-Site report. The Installer shall follow the SOP for using the E-Site report as described in reference 29.

The installer is required to submit the required documentation as described below in Section 4.2.2 to CO-OPS ED and the supporting FOD field office or the Task Manager within 30 calendar days of completion of water level station installation, maintenance, repair, removal, GPS observations, or as specified in the contract documents, whichever is earlier.

All data and documentation submitted to CO-OPS shall be retained by the installer for a period of not less than three years or as stipulated in the contract, whichever is longer.

#### **4.2.2 Documentation Requirements**

The standard water level station documentation package includes the following:

- 1) Transmittal letter (PDF format)
- 2) E-Site Report, or Water Level Station Xpert Site Report, or Tide Station Report (E-Site report in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format)
- 3) Google map image, or NOAA Chart image showing the station location including the standard title block with NOAA chart number. (PDF format)
- 4) Name of the U.S. Geological Survey quadrangle map (7.5 seconds interval) indicating the exact location of the station, with map name and scale shown (PDF format)
- 5) Sensor test worksheet (PDF format)
- 6) Sensor elevation drawing (PDF format) showing sea floor, pier elevation, and sensor elevation if the sensor is mounted vertically.
- 7) Water level transfer form (for Great Lakes stations only - PDF format)
- 8) Barometer Installation Worksheet (for Great Lakes stations only - PDF format)
- 9) Bench mark sketch (PDF format) – Large-scale bench mark location sketch of the station site showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The bench mark sketch shall include an arrow indicating north direction, a title block, and latitude and longitude (obtained from hand-held GPS receiver) of the gauge.
- 10) Bench mark descriptions with handheld GPS coordinates (d/m/s.s format), and “Station to Reach” statement in Microsoft Word format (See Reference 5).
- 11) Digital photographs of each bench mark disk (four views), station, DCP, equipment, underwater components, and vicinity (JPEG format).
- 12) Levels (electronic files) including leveling equipment information and field notes of precise leveling, if applicable.
- 13) Abstract of precise leveling (electronic format).
- 14) Datum offset computation worksheet or Staff/Gauge difference work sheet as appropriate showing how sensor “zero” measurement point is referenced to the bench

- marks.
- 15) Staff to gauge observations, if applicable (Microsoft Excel format)
  - 16) Calibration certificates for Invar leveling rods, if applicable (PDF format)
  - 17) Calibration records for sensors, if applicable (PDF format)
  - 18) Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (PDF format)
  - 19) Other information as appropriate, or as specified in the contract (PDF format)
  - 20) Water level data download in specified format
  - 21) GPS Deliverables - the OPUS published datasheet and 4 photos of the GPSBM in electronic format for each observation session as described in the User's Guide for GPS Observations at Tide and Water Level Bench Marks.
  - 22) Annual Inspection (AI) checklist (Applicable for all CO-OPS' NWLON AI)

The station documentation shall be submitted in digital format only. All GPS data and documentation shall be published to NGS OPUS.

Water level data downloaded for NWLON, PORTS, Tsunami, COASTAL, or in-house projects shall be in accordance with Reference 26 "*Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP*". Water level data downloaded for contract hydrographic and photogrammetry survey projects and submitted to CO-OPS for validation shall be in accordance with Reference 27 "*NOS Hydrographic Surveys Specifications and Deliverables*" Latest update.

Generally, for established NWLON stations or long term water level stations (more than 1 year), the bench mark sketch, chartlet, and "To Reach" statement need only be submitted if these items have been revised during the station maintenance or removal, because these items are required and are generally submitted with the installation station package.

When using the electronic/barcode system, all digital files created using the Windesc and Translev programs shall be submitted. At stations where the automated or manual levels are used, Precise Leveling sheets of actual runs (NOAA Form 75-29) and Abstract of Precise Levels (NOAA Form 76-183) shall be completed and submitted.

For submission in electronic format, the station documentation shall be organized by various folders under the main station number folder, and then pertinent information shall be placed in the various folders and submitted on a digital media, such as DVD/CD-ROM, FTP sites, etc.

Here is an example of submission of the electronic folders for San Francisco tide station:

- 9414290 San Francisco 2010 Annual Inspection
- /Transmittal letter
- /Calibration records for sensors, if applicable
- /Site Report or tide station report
- /Station Chartlet
- /Sensor test worksheet
- /Sensor elevation drawing
- /Bench mark sketch

- /Bench mark descriptions and “Station to Reach” statement
- /Photographs of bench marks, station, DCP, equipment, and vicinity in digital format
- /Levels (raw) (electronic files) and field notes of precise leveling
- /Abstract of precise leveling
- /Staff to gauge observations, if applicable
- /Datum offset computation worksheet or Staff/Gauge difference work sheet (elevation of sensor zero measurement point referenced to bench marks)
- /Calibration certificates for Invar leveling rods, if applicable
- /Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable
- /Other information as appropriate, or as specified in the contract
- /Water level data (6-minute, hourly heights, high/low, monthly means, station datum)
- /GPS deliverables, as applicable
- /Diving Documents

Submit required GPS deliverables, including the OPUS published datasheet, and 4 photos of GPSBM on a separate digital media, such as DVD/CD-ROM, FTP sites, etc. For example, GPS submission for San Francisco tide station will be as follows:

- 9414290 San Francisco 2010 Annual Inspection
- /OPUS Published Datasheet
- /Photos of GPSBM

#### **4.2.3 Points of Contact for Deliverables**

All required deliverables listed in Section 4.2.2 above shall be submitted to the proper point of contact as listed in the project instructions, contract documents, if applicable; or to NGS or CO-OPS (see below) within 15 business days of the GPS observations, installation, maintenance, or a removal of a water level station, or as specified in the Statement of Work or contract, whichever is earlier. All GPS data and documentation shall be published to NGS OPUS.

(A) For all work done by NOAA (FOD, NOAA ships, NRT, other NOAA personnel) submit one copy of all the documentation including the GPS deliverable in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Chief, Engineering Division  
CO-OPS, N/OPS1, SSMC 4, Station 6531  
1305 East-West Highway  
Silver Spring, MD 20910-3233  
Tel: 301-713-2897 x 145

(B) For all CO-OPS’ IDIQ contract work deliverables, submit two copies of all the documentation including the GPS submission in digital media, such as DVD/CD-ROM, FTP sites, etc. Submit one copy in digital media to:

Marty Welch  
Contracting Officer’s Representative  
NOAA/NOS/CO-OPS

SSMC 4, Station # 6544  
1305 East-West Highway  
Silver Spring, MD 20910-3281  
Tel # 301-713- 2897 X 129

Submit the other copy of the completed station package to the Task Manager, or appropriate supporting FOD field office.

For East Coast task orders, submit to:  
Task XXX Manager, Field Operations Division Atlantic Regional Office  
808 Principal Court  
Chesapeake, VA 23320  
Tel: 757-436-0200

For West Coast task orders, submit to:  
Task XXX Manager, Field Operations Division Pacific Regional Office  
7600 Sand Point Way, NE  
Bin C15700  
Seattle, WA 98115  
Tel: 206-526-6360

(C) For OCS contract hydrographic survey projects, submit one copy of all the deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Chief, Engineering and Development Branch  
CO-OPS, N/OPS1, SSMC 4  
1305 East-West Highway, Station 6507  
Silver Spring, MD 20910-3233  
Tel: 301-713-2897 x 190

(D) For NGS contract shoreline mapping survey projects, submit one copy of all the deliverables (water level data, station documentation, and GPS deliverable) in digital media, such as DVD/CD-ROM, FTP sites, etc., to:

Mr. Greg Stinner  
Contracting Officers Representative  
NOAA/NOS/National Geodetic Survey  
SSMC 3, Station # 8609  
1315 East-West Highway  
Silver Spring, MD 20910-3281  
Tel # 301-713- 3167



# **USER'S GUIDE FOR GPS OBSERVATIONS**

**Updated March 2007**

**Requirements and Development Division  
Center for Operational Oceanographic Products and Services  
National Ocean Service  
National Oceanic and Atmospheric Administration**

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# USER'S GUIDE FOR GPS OBSERVATIONS

## 1.0 Introduction

This User's Guide for Global Positioning System (GPS) Observations for the tidal and water level station bench marks is prepared to support the Center for Operational Oceanographic Products and Services (CO-OPS) GPS Implementation Plan. The field observation procedures are developed in collaboration with the National Ocean Service (NOS), National Geodetic Survey (NGS), and consist of slight modifications of NOAA Technical Memorandum NOS NGS-58, Version 4.3, as described below, to obtain relative accuracy in connecting water level stations to the International Terrestrial Reference Frame (ITRF) and the North American Datum of 1983 (NAD 83) coordinate systems. Modifications made to NOAA Technical Memorandum NOS NGS-58 guidelines and requirements involve the length of the GPS observations required, in this document. This Guide must be used in conjunction with NGS-58 for collecting the GPS data at water level stations.

It is assumed that the field personnel are familiar with the basic operating principles of the GPS equipment, the cable connections and the antenna/tripod setup procedures. A detailed discussion of GPS processing software and processing procedures is outside the scope of this Guide. GPS data collected by CO-OPS or CO-OPS' contractors for the National Water Level Observation Network (NWLON), for hydrographic and photogrammetric surveys either by NOS Office of Coast Survey (OCS) and NGS field parties will be submitted to NGS for data processing – “blue-booking” is a term used to describe this processing according to the Input Formats and Specifications of the National Geodetic Survey Database, Appendix L – Guidelines for Submitting GPS Relative Positioning Data.

All GPS data must be collected as per NGS specifications and as described later in this document and processed first using NGS Online Positioning User Service (OPUS). All GPS data and documentation shall be submitted to CO-OPS, which will then be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

### 1.1. Reference Documents

The following reference documents are referred in various sections of this document.

- (1) “CO-OPS GPS Observations Implementation Plan, January 2003”.
- (2) “NOAA Technical Memorandum “NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3”.
- (3) “User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987”.
- (4) “Standards and Specifications for Geodetic Control Networks”, Federal Geodetic Control

Committee, September 1984.

(5) “Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005”

## **2.0. Equipment and Setup**

High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites. A choke ring antenna is preferred; however, any geodetic quality ground plane antenna may be used. More important than antenna type, i.e. choke ring or ground plane, is that the same antennas or identical antennas models should be used during the entire observing sessions. If not, a correction for the difference in antenna phase patterns (modeled phase patterns) must be applied. This is extremely critical for obtaining precise vertical results. The antenna cable length between the antenna and receiver should be kept to a minimum when possible; 10 meters is the typical antenna cable length. If a longer antenna cable is required, the cable must be fabricated from low loss coaxial cable (RG233 for up to 30 meters and RG214 over 30 meters).

A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, 2 meter pole with three adjustable legs, a bulls-eye bubble to plumb the antenna, and a magnetic compass to align the antenna to North. These fixed height tripods reduce the chance of introducing a Height of Instrument (HI) “blunder” during the post-processing of the data. There are situations where it may be necessary to use the adjustable precise GPS antenna tripod, such as when a bench mark is elevated above ground level or when using air transportation. The center pole is adjustable on this tripod; therefore, if not fully extended to the 2 meter position, the antenna height is measured with a steel tape (several times) and entered into the receiver and onto the GPS Observation Log Sheet. In fact, even in the 2 meter position, it is recommended that the adjustable tripod be measured to verify the length. There is a screw-on point at the bottom of the center pole of both - the fixed and adjustable tripods - that must be inspected each time the tripod is setup to ensure that the point is tight and not bent. The tripod must be stable during observations; therefore, the tripod legs must be secured, preferably with sand bags.

Antenna set-up is critical to the success of the project. Plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbness is determined. Plumbing bubbles must be shaded for at least 3 minutes before checking and/or re-plumbing.

The manufacturer, model, and complete serial numbers of all receivers and antennas must be included for each occupation on each station/bench mark observation log sheet as shown in Figure 3.

### **3.0 Geodetic connections and datums relationship**

Water level datums are local vertical datums which may change considerably within a geographical area. A geodetic datum is a reference surface relative to which heights are determined. The North American Vertical Datum of 1988 (NAVD 88) is the accepted vertical datum of the National Spatial Reference System (NSRS) for the conterminous United States and Alaska and is officially supported by NGS. The relationship of tidal datums to NAVD 88 has many hydrographic, coastal mapping and engineering applications including monitoring sea level change and the deployment of GPS electronic chart display and information systems, etc.

Existing geodetic marks in the vicinity of a subordinate tidal station shall be searched for and recovered. A search routine is available at <http://www.ngs.noaa.gov>. An orthometric level connection and ellipsoidal GPS tie is required at a subordinate tide station which has at least one geodetic bench mark located nearby as stated below for Sections “NAVD 88 Level Tie” and “NAD 83 GPS Tie” requirements. NAVD 88 heights for published bench marks are given in Helmert orthometric height units by NGS. The GPS ellipsoid network height accuracies are classified as conforming to 2 cm or 5 cm standards accuracies (Refer to NOAA Technical Memorandum NOS NGS-58). At the present time, GPS ellipsoid heights conforming to the 2 cm accuracy standards are required for all GPS survey projects.

A connection to the geodetic datums at a water level station enhances the value of the tidal data, allowing comparison with other data sets. The geodetic network essentially serves as a global reference datum to which all tidal datums can be referenced.

The connection to geodetic datums involves the following three ties:

- (1) NAVD88 Level Tie
- (2) NAD 83 GPS Tie
- (3) NAVD88 GPS Tie

#### **3.1. Level Connections**

##### **3.1.1. NAVD88 Level Tie**

At all water level stations, a valid level tie to at least two Geodetic Bench Marks (GBM) is required on each set of levels, where appropriate marks are available within 1.6 KM (1 mi) leveling distance of the station location. A GBM is defined as a bench mark that exists, is useable, is available in the NGS database, has a Permanent ID (PID), and has a NAVD 88 elevation published on the datasheet. At many NWLON stations, the Primary Bench Mark (PBM) is a GBM. At the majority of NWLON stations, there are two or more tidal bench marks that are also GBM, thus increasing the chance that the geodetic level tie will be valid.

Make a Second-Order, Class I tie for all NWLON stations in the conterminous United States and Caribbean Islands. A Third-Order tie is used for all NWLON stations in Alaska, Hawaii, and Pacific Island areas.

At stations supporting hydro or other special projects, the tie shall be consistent with the accuracy of the levels required for the project.

Information on performing a valid level tie is provided in the Federal Geodetic Control Committee (FGCC) Standards and Specifications for Geodetic Control Networks, listed at the following website:

[http://www.ngs.noaa.gov/FGCS/tech\\_pub/1984-stds-specs-geodetic-control-networks.htm#3.5](http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm#3.5)

Also, *Section 3.4 of “User’s Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, October 1987”* provides information regarding how to perform a valid level tie.

The Second-Order, Class I tie is a requirement for digital levels to be accepted into the NGS database. Short level runs to the sensor, PBM, and two marks are excluded from this requirement since they are usually meant to verify sensor stability only. Since a level connection to GBMs with dynamic heights defines the International Great Lakes Datum of 1985 (IGLD 85) datum offset at each station in the Great Lakes, a valid connection to at least two GBMs is required at each site.

A note shall be made in the remarks of the leveling section of the Site Report that a valid tie was achieved or not achieved. If a valid tie is not achieved, an explanation shall be provided and/or recommendations made for making a valid tie in the future.

If the NWLON water level station does not have two or more GBMs within 1.6 km (1 mi) leveling distance of the station location, then the level tie requirement is waived.

### 3.1.2. Leveling at Continuously Operating Reference Stations (CORS)

For any NGS CORS reference bench mark that is located within 1.6 km (1 mi) leveling distance of a water level station Data Collection Platform (DCP), a leveling connection shall be made to the tidal bench marks in the water level station network every two years.

Information about NGS CORS can be obtained at <http://www.ngs.noaa.gov/CORS/>.

As of 2007, there are a limited number of water level stations in this category, but NGS and CO-OPS are attempting to secure funding to establish additional co-located sites to support long-term sea level trends monitoring.

## 3.2. GPS Connections

### 3.2.1. References

Static GPS observations shall be performed at water level stations in accordance with “NOAA Technical Memorandum “NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3”. These guidelines are written for establishing GPS derived ellipsoid height accuracy standards of 2 cm for all NWLON, PORTS®, hydrographic/Photogrammetry survey projects, COASTAL projects, and special project applications.

### 3.2.2. GPS Observations - Goals and Planning

Precise positioning of NWLON stations in a global geocentric reference framework is needed to support NOS marine safe navigation and height modernization projects, in addition to monitoring vertical crustal motions for absolute sea level and global climate change studies.

CO-OPS shall initiate a program of making periodic GPS observations at water level stations, as resources permit. CO-OPS activities shall be coordinated with NGS activities for best use of available resources.

GPS technology and procedures shall be implemented in the operational plan:

- (1) To support the development of a seamless, geocentric reference system for the acquisition, management, and archiving of NOS water level data. This will provide a national and global digital database, which will comply with the minimum geo-spatial metadata standards of the National Spatial Data Infrastructure (NSDI) and connect the NOS water level datums to the NGS NSRS;
- (2) To establish transformation functions between NOS chart datum Mean Lower Low Water (MLLW) or Low Water Datum (LWD) in the Great Lakes, and the geocentric reference system to support NOS 3-dimensional hydrographic surveys, the implementation of Electronic Chart Display and Information Systems (ECDIS), and the NOS Vertical Datum transformation (VDatum tool) and tidal datum models. Integration of GPS procedures will support the development of tidally-controlled Digital Elevation Maps and Models for use in programs such as marsh restoration.
- (3) To support water level datum transfers by using GPS derived orthometric heights.
- (4) To monitor crustal motions (horizontal and vertical) to support global climate change investigations.

The GPS surveys should be scheduled during routine annual maintenance trips to NWLON or PORTS® stations and during the installation of secondary and tertiary water level stations to support the survey projects, U.S. Army Corps of Engineers (USACE) projects, COASTAL project stations, tsunami stations, and special purpose surveys. CO-OPS shall continue to coordinate the GPS occupation of water level network bench marks with NGS, USACE, and the National Geospatial-Intelligence Agency (NGA), as appropriate.

GPS-derived orthometric heights can be accurately determined and used for water level datum transfers according to the following criteria: (a) use the established guidelines for 3-D precise relative positioning to measure ellipsoid heights; (b) properly connect to several NAVD 88 bench marks; and (c) use the latest high-resolution modeled geoid heights for the area of interest. In many remote locations, the use of GPS-derived orthometric heights for datum transfer will be more efficient (timely) and more cost-effective than the use of conventional differential surveying techniques and may, under certain circumstances, preclude the installation of additional water level stations to establish a datum.

As specified in the Annual Project Instructions, Annual Station Specific Requirements, or in the contract documents, installer shall be required to perform GPS observations at each water level station at specified intervals over time, depending on the rate of sea level rise in that water area of the coast.

As of March 2007, 20 NWLON stations have been identified where annual GPS observations are required because of the sea level rise in those areas. These 20 NWLON stations – 8 in Alaska and 12 in the Gulf of Mexico – will be identified in the annual Project Instructions. The rest of the NWLON stations require GPS observations every five years. These guidelines will be updated as GPS technology improves and the policy or regulations change in the future.

### 3.2.3. Static Surveys

Static GPS surveys shall be conducted on a minimum of one bench mark at each water level station, according to the priority levels below. Generally, one mark at each station is designated as the GPS mark and observations shall be made to that mark (as per the required GPS observation frequency) unless otherwise specified in the Station Specific Requirements.

1. National Water Level Observation Network (NWLON), PORTS®, and tsunami stations.
2. Long term operating secondary water level stations.
3. New tertiary survey, COASTAL stations, and special project stations.
4. Historical subordinate water level stations with an accepted MLLW value on the current official tidal datum epoch

Static GPS surveys shall be conducted at water level stations periodically over time to establish a history of relationship between the tidal or water level datums, and the ellipsoid.

### 3.2.4. Criteria for Bench Mark Selection for GPS Observations

The GPS Water Level Station Bench Mark (GPSBM) shall be selected based on the following criteria: (a) permanence or stability; (b) historic GPS use; (c) satellite visibility; and (d) safety and convenience.

#### (a) Permanence or Stability of Bench Marks

NGS has defined the following monumentation quality codes, also called the stability codes, for various bench mark settings.

Stability code A – monuments of the most reliable nature which may be expected to hold their elevations very well; e.g. Class A rod marks, or marks installed on large boulders/rock outcrop.

Stability code B – monuments which probably hold their elevations well; e.g. Class B rod marks, or marks installed on large concrete footings/foundations.

Stability code C – monuments which may hold their elevations but which are commonly subject to surface ground movements; e.g. pavement or concrete monuments.

Stability code D – movements of questionable or unknown reliability.

The station bench mark selected for GPS observations shall be of stability code A or B. GPS observations on the PBM are preferred if the PBM is either stability code A or B, and is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations, unless NGS has previously made GPS observations on those marks.

#### (b) Historic GPS Use

In many states, CO-OPS has provided NGS with lists of selected marks suitable for GPS observations at water level stations, and NGS has completed observations on these marks. Some tidal marks designated as Federal Base Network (FBN) or Cooperative Base Network (CBN) marks may be of stability code C. Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. If leveling reveals instability of the mark over time, select another mark.

Priority shall be given to a GBM for GPS observations because the GBM already has a NSRS height (NAVD 88). The GBM considered here is one of the 10 tidal or water level bench marks at a NWLON water level station, or one of the 5 bench marks for survey or special projects.

### (c) Satellite Visibility

The most desirable bench mark for GPS observations should have 360 degrees clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have these clearances, if at all possible. If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new 3-D rod mark shall be established. This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. A note shall be made, either in the APP field of the electronic leveling HA file or on a copy of the published bench mark sheet, stating the suitability of GPS observations for each mark. The GPS visibility obstruction diagram as shown in Figure 5 under Section 6 GPS Project Documentation shall also be completed for each mark observed.

### (d) Safety and Convenience

The location of the GPS bench mark should be safe, secure, and convenient. Bench mark locations which allow unattended GPS data collection are desirable as the field crew can multi-task at the same time as collecting the GPS data. The safety of the GPS equipment (vandalism proof) should be considered in the mark selection process.

The bench mark selected for GPS observations should be located on public property rather than on private property, as permissions from private owners may be required in the future to access the bench mark and for collecting the GPS data. The distance from the station DCP should also be convenient.

### 3.2.5. Planning, Position, and Photograph of the GPS Bench Mark

Regarding suitability of a mark for GPS observations, a review should be made first of the historical bench mark information in the station files and level records, if access to that information via database is available, or if the information is available. Stable marks from the level records are identified and copies of the descriptions and sketches are made. Descriptions and sketches are examined and marks are eliminated that have obvious obstructions, such as vertical marks, marks set several meters from medium to large structures, etc. Do not eliminate marks that are near poles, fences or about 20 meters from small structures at this time during the preliminary planning. If no other mark is available or found suitable, and time does not permit the installation of a new (GPS) mark, it may be necessary to use one of these marks. In selecting a GPS mark, priority should be given to the NWLON PBM or an NGS, NSRS, mark with a First or Second-Order NAVD 88 height on a NGS datasheet.

If time permits, conduct a site reconnaissance survey prior to starting the GPS sessions, to select the proper mark(s) to occupy with GPS. A site survey consists of preparing an obstruction diagram for each useable mark using an inclinometer and placing a GPS unit (hand-held or better) over the bench mark to determine how many satellites can be tracked at that location. Determine the location of a suitable weather proof location, if any, for the GPS receiver. Measure the distance from the mark to this location to determine the antenna cable length required. Ideal marks should have approximately 360 degree unobstructed visibility above the 10 degree elevation mask. However, satellite geometry changes with time, so for 4-hour tracking sessions some obstructions, particularly those to the north of the mark, may not degrade the precision or accuracy of the final solution.

GPS (horizontal) positions (latitude and longitude) of each bench mark installed or recovered shall be listed on the HA files for laser levels, if used, or on the bench mark descriptions sheet for optical leveling, as applicable, at each subordinate water level station occupied for all projects.

Digital photographs shall be taken of all station bench mark disks in accordance with Reference 5 - *Attachment R, Requirements for Digital Photographs of Survey Control, NGS, July 2005*". A minimum of three photos shall be taken: close-up of the disk face; waist or chest level view of disk and setting; and horizontal view of location and direction of view. All digital station photo files should be named such that the name of the file will indicate the station number and the type of photo taken. For example, the bench mark A face photo for San Francisco water level station shall be named as 94142901 BM A face photo .jpg.

A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 7. If a digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 6. A digital photo of the stamping is preferred over rubbing of the mark.

### 3.2.6. Data Collection and setup

Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites.

Always collect a little bit of extra data if time and schedule permit, so that blunders or invalid data, if any, can be removed during processing still leaving required minimum number of hours of valid data for one GPS session.

It is recommended that after each session is complete, two independent downloads be done from the GPS receiver to the laptop computer, so that if one downloaded file gets corrupted, the other file may have good data. Since two downloads of the GPS observation file is a requirement, do not make copy of the downloaded file twice to the laptop instead, as both the files will have the same problem, if there exists a problem. Send both copies of digital GPS data so that one copy of the data can be forwarded to NGS and other copy will be kept for record in CO-OPS' Requirements and Development Division's Operational Engineering Team (RDD/OET).

Data should be compressed and copied to a CD-ROM, diskette, and/or zip disk, as appropriate, at the end of each GPS day for transporting data from the field to the office, or hotel as the case may be, for processing. If data are logged to a PCMCIA card (flash card) in the receiver, consult the receiver User Reference Guide about re-formatting the card prior to beginning observations.

Data should be collected during periods when the Vertical Dilution of Precision (VDOP) is less than 6 for at least 90% of each 30-minute or longer GPS observations, if VDOP maps or data are available for the site.

### 3.2.7. North American Datum 1983 (NAD83) GPS Tie

At each NWLON station, GPS observations shall be performed as listed in the Annual Project Instructions, Annual Station Specific Requirements, and contract documents. The frequency of repeated observations on the GPSSBM shall be determined based upon the rate of sea level rise and general stability of bench marks in the local leveling network.

The NGS OPUS is now used extensively for quick and convenient processing of the GPS raw data for a variety of applications. The position solution provided by OPUS is considered preliminary data and is not retained by NGS. Further information on using OPUS is provided later in this document.

The expected ellipsoid height accuracy for a 4 hour OPUS solution is 1.8 cm, (at the 67% confidence level), and that is desirable, practical, and achievable with the requirements as specified in reference #2, NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3.

The length of GPS observation sessions depends upon the length of time the field crew has available for GPS observations, security of the equipment, number of satellites available at a site, number of GPS receivers available for GPS observations, etc.

For all water level stations, collect a minimum of 4 hours of GPS data on the GPSBM. Extra care shall be taken to ensure that the antenna height is precisely recorded, and that the antenna setup is stable. A continuous long session (at least 4 hours long but less than 24 hours) repeated annually is preferred to two or more shorter sessions (of less than 4 hours each) repeated on the same visit, providing better data for OPUS and more independent observations.

After the data collection session is complete, two independent downloads are required from the GPS receiver to the laptop computer. If one downloaded file gets corrupted, the other file may have good data. Do not make a copy of the downloaded file, as both the files will have the same problem, if there is a problem. Follow the NGS guidelines for naming these files. Submit both copies of the digital GPS data along with the necessary documentation as specified below.

### 3.2.8. GPS Data Processing Using OPUS

Field parties shall use OPUS for processing the raw GPS observations. OPUS provides an easily accessible, rapid method for submitting GPS data and receiving an almost instantaneous solution response from NGS via email.

The NGS OPUS web page can be obtained at <http://www.ngs.noaa.gov/OPUS/>. The following information is found on the OPUS web page but is also presented here for convenience of the reader.

OPUS allows users to submit their GPS data files to NGS, where the data will be processed to determine a position using NGS computers and software. Each data file that is submitted will be processed with respect to three CORS sites. The sites selected may not be the nearest to your site but are selected by distance, number of observations, site stability, etc. The position for your data will be reported back to you via email in both - [ITRF and NAD 83 coordinates](#) as well as Universal Transverse Mercator (UTM), U. S. National Grid (USNG) and State Plane Coordinates (SPC) northing and easting.

OPUS is completely automatic and requires only a minimal amount of information from the user, such as:

- (a) The email address where you want the results sent
- (b) The data file that you want to process (which you may select using the browse feature; raw or RINEX accepted)
- (c) The [antenna type](#) used to collect this data file (selected from a list of calibrated GPS antennas)
- (d) The [height of the Antenna Reference Point \(ARP\)](#) above the monument or mark that you are positioning.

Once this information is complete, you then click the Upload button to send your data to NGS.

Your results will be emailed to you, usually within a few minutes. You may upload multiple data files in a zip archive if you wish. However, be careful, the options that you choose will be applied to all of the data files in that archive (i.e. the same antenna type, ARP height will be used for all of the files in the zip file).

The following are some simple guidelines for analyzing the OPUS solutions.

- (a) Make sure the [antenna type](#) and the [ARP height](#) are correct.
- (b) Review the solution statistics:
  - (I) A good quality OPUS run should typically use 90% or more of your observations.
  - (II) OPUS should have fixed at least 80% of the ambiguities
  - (III) The overall RMS should seldom exceed 3 cm.
  - (IV) The maximum peak to peak errors should be less than 2 cm for horizontal and 4 cm for vertical (This depends, of course, on the accuracy you are trying to achieve.)

NGS needs to receive orbit data from IGS in order to obtain a solution. If the data is submitted too quickly (before NGS gets the orbit data from IGS), the submitter may need to re-submit the data at a later time. For best results, submit the GPS data to OPUS at least 17 hours after the first midnight (in Greenwich Mean Time) following the time when the observations were recorded. Compare the resultant solution to the last previous solution made at the station, if available, to ensure that you do not have a blunder in the antenna setup. This will be revealed by a noticeable discrepancy in the ellipsoid height. Include a copy of the solution in the station inspection documentation package submitted to RDD/OET, as well as to NGS GPS data sets.

### 3.2.9. OPUS DB Preliminary information

Pending NGS support, OPUS DB will be released by NGS in the near future. This advanced version of OPUS will submit solutions directly to the NGS database for publication as part of NSRS if all required documentation is provided by the submitter. Further guidance will be provided once OPUS DB is released and this document will be updated as appropriate. Any data sets submitted to OPUS will be subsequently re-submitted by RDD/OET to OPUS DB to ensure the data is published by NGS, provided all the proper and required GPS data and documentation (as listed below under data submission section) has been submitted to CO-OPS.

Height modernization guidelines are listed at the following url:

<http://www.ngs.noaa.gov/heightmod/guidelines.shtml>

The Opus DB datasheet concept is fully listed at the following NGS web site:

<http://www.ngs.noaa.gov/PROJECTS/draft/OPUS/OPUS-DB-concept.htm>

The following tables identify the required data elements and optional data elements for OPUS DB respectively.

**REQUIRED DATA ELEMENTS (15 each):**

ELEMENT	RATIONALE
e-mail	For identification & correspondence.
Filename	Necessary to compute position.
Antenna	Necessary to compute position.
antenna height	Necessary to compute position.
name of submitting agency	Identifies the observer.
permanent identifier (PID)	Identifies the station.
Designation	Identifies the station.
descriptive text	Aids in station recovery.
Rod/pipe depth & units	Describes monumentation quality.
sleeve depth & units	Describes monumentation quality.
setting code & specific setting text	Describes monumentation quality.
photograph (of marker)	Aids in station recovery.

**OPTIONAL DATA ELEMENTS (11 each):**

ELEMENT	RATIONALE
photographs (of equipment, horizon)	Equipment photos describe antenna height and equipment used. Horizon photos aid in station recovery and could explain visibility or multipath problems.
vertical stability code	Useful for stability assessment.
magnetic property code	Aids in station recovery.
antenna s/n	Useful in identifying equipment-specific problems.
receiver	Useful in identifying equipment-specific problems.
receiver s/n	Useful in identifying equipment-specific problems.
receiver firmware	Useful in identifying firmware-specific problems.
stamping	Aids in station identification.
condition code	Useful for stability assessment.
special application codes	Identifies the station type (tidal station, Public Land Survey corner, etc.)
remarks	Allows user to record observation comments.

This information regarding the Required Data Elements and Optional Data Elements is for reference only and not required at the present time. These requirements will be active once OPUS DB is designated operational by NGS. Out of the 15 Required Data Elements, 13 are applicable to all the marks and the remaining two - rod/pipe depth & units and sleeve depth & units – are applicable only to rod marks.

#### 3.2.10. NAVD 88 GPS Tie

The NAVD 88 GPS Tie involves simultaneous GPS observations at the GPSBM and one or more GBMs located up to 10 KM (6.26 mi) from the GPSBM. This “Height Mod” tie is deferred until such time as NGS enables user-friendly blue-booking of campaign data (OPUS projects).

### 4.0 GPS Project Documentation and Data Submission

The following information in addition to the results obtained from OPUS shall be submitted to CO-OPS at the end of the project (see the time frames for submission of GPS data later in Section 4.1) so that proper information can be forwarded to NGS for blue-booking purposes.

This documentation is important because most of the information is used to submit the GPS data to NGS. In addition to the log, data must comply with the “Data Submission to NGS Section” of NGS-58 (Reference 2) and the “Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base” (Reference 4) to become part of the NSRS.

GPS data collected by contractors or NOAA Ships for hydrographic survey support, or special projects shall be processed by the parties, and final data product - Receiver Independent Exchange Format (RINEX) data and appropriate forms - shall be submitted to CO-OPS which will be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

GPS forms in PDF format can be found at the following NGS Federal Base Network (FBN) web site:

<http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm>

Refer to Figures 1 through 7 for GPS projects submission checklist and sample package contents.

- (a) Project report (Refer to Figure 1):  
One project report per GPS project is required.
- (b) Station (bench mark) description or recovery notes (Refer to Figure 2)  
One per bench mark, for which GPS observations are submitted, is required.
- (c) Observation log sheets (Refer to Figure 3 and 4)  
One per each GPS observation session is required.

- (d) Station/bench mark visibility diagrams (Refer to Figure 5)  
One per each bench mark, for which GPS observations are submitted, is required.
- (e) Photographs or rubbings of station (bench) marks (Refer to Figure 6 and 7)  
One per each bench mark, for which GPS observations are submitted, is required.
- (f) Raw GPS data
- (g) Rinex GPS data
- (h) OPUS results

#### **4.1. Data Submission**

All required GPS data and documentation shall be submitted to CO-OPS within 15 business days of the GPS observations or the removal of the gauge whichever is earlier.

All GPS data and documentation shall be submitted in paper format and in digital format such as CD-ROM in duplicate, so that one copy stays with CO-OPS and other copy is forwarded to NGS. For GPS data that are collected according to the contracts, there may be additional requirements for submission, please check with the appropriate Contracting Officer's Representatives.

Submit all GPS project data and documentation to:

Chief, Requirements and Development Division  
CO-OPS, N/OPS1, SSMC 4  
1305 East-West Highway, Station 6531  
Silver Spring, MD 20910-3233  
Tel: 301-713-2897

## Figure 1      GPS PROJECT SUBMISSION CHECKLIST

Project Title : \_\_\_\_\_

Submitting Agency: \_\_\_\_\_

Observing Agency: \_\_\_\_\_

Receiver Type: \_\_\_\_\_

Antenna Type: \_\_\_\_\_

### PACKAGE CONTENTS

- Project Report
- Station Description or Recovery notes
- Observations Log Sheets  
*Data which must be filled out:* Station Designation, Date (UTC), General Location, Day of Year, Project Name, Session ID, Observation Session Times, Agency Full Name, Operator Full Name, Phone Number, GPS Receiver, GPS Antenna, Antenna Height, Data File Name
- Antenna height measurements
- Station Visibility Diagrams
- Photographs or Rubbings of Station Marks
- Raw GPS data
- Rinex GPS Data - See below
- OPUS Results
- Other

## DATA REFORMATTING

Convert the raw GPS data to RINEX2 format with your manufacturer's software. The software should require you to enter the raw data filename, the output filenames, your name, the observer's name and agency, and the antenna type used.

The NGS-standard data filenames are as follows:

Raw GPS input files: aaaaddds.xxx

Where: aaaa = Alphanumeric 4-character station identifier,

ddd = Julian day of the year,

s = session, yy = year of observations,

and xxx is the receiver-dependent file extension (e.g., .DAT, .EPH, .ION, .MES, etc.)

RINEX2 navigation and observation files shall be named as follows.

RINEX2 Navigation File: aaaaddds.yyn

RINEX2 Observation File: aaaaddds.yyo

For example, RINEX2 filenames for navigation and observation from station BALD 2 on session A of 12/31/06 are BALD365A.06o and BALD365A.06n

Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch diskettes or CD ROM.

**Figure 2: Station (Bench mark) Description/ Recovery Form**

--> Click here to clear the sample data <--

**NATIONAL GEODETIC SURVEY  
STATION DESCRIPTION / RECOVERY FORM**

PID: QE2736      Designation & Alias: BALD 2 RESET  
 Country: USA / USA      State: OR      County: LINCOLN  
 Latitude: N 44 49 49.17802 "      Longitude: W 124 08 56.23447 "      Elevation: 17.0 (meter / ft)

Original Description (check one):		Recovery Description (check one):	
<input type="checkbox"/> P	Preliminary (mark has not been set yet)	<input type="checkbox"/> F	Full description of a station <u>not</u> in the database
<input type="checkbox"/> D	A newly set mark	<input checked="" type="checkbox"/> T	Full description of a station <u>in</u> the database
<input checked="" type="checkbox"/> R	A recovered mark	<input type="checkbox"/> M	<u>Partial</u> description of a station in the database
Established by: (NGS / CGS / Other) <u>Oregon DOT</u>		Recovered by: (NGS / Other:) <u>Oregon DOT</u>	
Date:      Chief of Party (initials): <u>???</u>		Date:      Chief of Party (initials): <u>CFS</u>	

Monument Stability (check one):		Recovery Condition (check one):	
<input checked="" type="checkbox"/> A	Of the most reliable nature; expected to hold well	<input checked="" type="checkbox"/> G	Recovered in good condition
<input type="checkbox"/> B	Will probably hold position and elevation well	<input type="checkbox"/> N	Not recovered or not found
<input type="checkbox"/> C	May hold well, but subject to ground movement	<input type="checkbox"/> P	Poor, disturbed, or mutilated
<input type="checkbox"/> D	Of questionable or unknown reliability	<input type="checkbox"/> X	Surface mark known destroyed

Setting Information:		Stamping:	
Marker Type: (Rod / <del>Disk</del> / Other)		<u>BALD 2 1991</u>	
Setting Type: ( <del>Block</del> / Concrete / Other:)		Agency Inscription: (NGS / CGS / Other:) <u>Oregon DOT</u>	
<input checked="" type="checkbox"/> / N / ?      Monument contains magnetic material?		Rod Depth:      (meter/ft), Sleeve Depth:      (meter/ft)	
		Monument is: ( <del>flush</del> / projecting / recessed)      (cm/inch)	

Special Type (check all applicable):		Transportation (check one):	
<input type="checkbox"/> F	Fault monitoring site	<input checked="" type="checkbox"/> C	Car
<input type="checkbox"/> T	Tidal Station	<input type="checkbox"/> P	Light truck (pickup, carry-all, etc.)
<input checked="" type="checkbox"/> -	Control Station: ( FBN / <del>CBN</del> / Bench <del>mark</del> )	<input type="checkbox"/> X	Four-Wheel Drive Vehicle
<input type="checkbox"/> -	Airport Control Station: ( PACS / SACS )	<input type="checkbox"/> _	Other (SnowCat, Plane, Boat; describe)
<input checked="" type="checkbox"/> N	Mark is suitable for GPS use?	<input checked="" type="checkbox"/> N	Pack Time (hike) to mark? (hh:mm): <u>00:03</u>

**See Back of Form to add Text Description**

**General Station Location:** The station is located in about 10 km south from Lincoln Bay, 13 km north from Depoe Bay, and at the US101 Boiler Bay wayside rest area.

(Describe general location; include airline distances to three towns or mapped features.)

**Ownership:** The station is on the property of Oregon State Department of Parks and Recreation.

(name, address, phone of landowner)

**To Reach Narrative:** To reach the station from the intersection of US routes 5 and 101 in Depoe Bay, go north on US 101 for 1 km to the south entrance of the Boiler Bay wayside. Bear left on entrance road for 0.4 km to the parking area on the left. Park northwest inside fence for about 90 meters to end of fence and the station on the right.

(Leg-by-leg distances and directions from major road intersection to mark)

**Monument Description and Measurements:** The station is set into drill hole in bedrock, 7.6 m south from the north fence corner, 8.8 m east from the west fence corner, and 3.6 m southeast from the northwest end of the outcrop.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

**NOTE: - Include a pencil rubbing, sketch, or photographs of mark.**

Described by: John Q. Surveyor Phone: (301)713-3194 e-mail: jqs@ordot.gov

Figure 3: GPS Station Observation Log

--> Click here to clear the sample data <--

	Station Designation: (check applicable: FBN / <input checked="" type="checkbox"/> BN / PAC / SAC / <input checked="" type="checkbox"/> M) <b>BALD 2 RESET</b>		Station PID, if any: <b>QE2736</b>	Date (UTC): <b>31-Dec-98</b>				
	General Location: <b>Boiler Bay Wayside</b>		Station 4-Character ID: <b>BALD</b>	Day of Year: <b>365</b>				
Project Name: <b>Sample GPS, 1998</b>		Project Number: <b>GPS- 1234</b>	Station Serial # (SSN):	Session ID:(A,B,C etc) <b>A</b>				
NAD83 Latitude <b>44 49 49.17802</b>	NAD83 Longitude <b>124 03 56.23447</b>	NAD83 Ellipsoidal Height <b>-6.44</b> meters	Agency Full Name: <b>Oregon DOT</b>					
Observation Session Times (UTC): Sched. Start <b>12:00</b> Stop <b>17:30</b>		Epoch Interval= <b>15</b> Seconds	Operator Full Name: <b>John Q. Surveyor</b>					
Actual Start <b>11:55</b> Stop <b>17:32</b>		Elevation Mask = <b>10</b> Degrees	Phone #: ( ) <b>(301) 713-3194</b>					
GPS Receiver: Manufacturer & Model: <b>Leica SR530</b>		GPS Antenna: Manufacturer & Model: <b>Trimble Choke Ring</b>	Antenna plumb before session? <input checked="" type="checkbox"/> (Y/N) Circle Antenna plumb after session? <input checked="" type="checkbox"/> (Y/N) Yes or No Antenna oriented to true North? <input checked="" type="checkbox"/> (Y/N) -If no, explain Weather observed at antenna height? <input checked="" type="checkbox"/> (Y/N) Antenna ground plane used? <input checked="" type="checkbox"/> (Y/N)					
P/N: <b>p/n 667122</b>		P/N: <b>p/n 29659-00</b>	Antenna radome used? (Y/N) <input checked="" type="checkbox"/> If yes, describe.					
S/N: <b>s/n 0030354</b>		S/N: <b>s/n 02200-63591</b>	Eccentric occupation (>0.5 mm)? (Y/N) <input checked="" type="checkbox"/> describe.					
Firmware Version: <b>Version 3.0</b>		Cable Length, meters: <b>30 meters</b>	Any obstructions above 10°? (Y/N) <input checked="" type="checkbox"/> Use					
<input checked="" type="checkbox"/> CamCorder Battery, <input type="checkbox"/> 12V DC, <input type="checkbox"/> 110V AC, <input type="checkbox"/> Other		Vehicle is Parked <b>25</b> meters <b>N</b> (direction) from antenna.	Radio interference source nearby (Y/N) <input checked="" type="checkbox"/> Vis. form					
Tripod or Ant. Mount: Check one: <input checked="" type="checkbox"/> Fixed-Height Tripod, <input type="checkbox"/> Slip-Leg Tripod, <input type="checkbox"/> Fixed Mount		<b>** ANTENNA HEIGHT **</b> (see back of form for measurement illustration)						
Manufacturer & Model: <b>SECO</b>		Before Session Begins: measure and record both Meters AND Feet						
P/N: <b>none.</b>		After Session Ends: measure and record both Meters AND Feet						
S/N: <b>97-G</b>		A= Datum point to Top of Tripod (Tripod Height) <b>2.000</b> <b>2.000</b>						
Last Calibration date: <b>1998-11-01</b>		B= Additional offset to ARP if any (Tribrach/Spacer) <b>-0.003</b> <b>-0.003</b>						
Tribrach: Check one: <input checked="" type="checkbox"/> None, <input type="checkbox"/> Wild GDF 22, <input type="checkbox"/> Topcon, <input type="checkbox"/> Other (describe)		H= Antenna Height = A + B						
Last Calibration date:		= Datum Point to Antenna Reference Point (ARP)						
		Note: Meters = Feet X (0.3048) Height Entered Into Receiver = <b>2.000</b> meters. Please note &/or sketch ANY unusual conditions. Be Very Explicit as to where and how Measured!						
Barometer: Manufacturer & Model: <b>pretel altipus A2</b>		Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit Celsius	WetBulb Temp Fahrenheit Celsius	Rel. % Humidity	Atn. Pressure inches Hg millibar	Weather Codes *
P/N: <b>none.</b>		Before	12:00	74.0	68.0	74	29.4	00000
S/N: <b>J.Q.S.</b>		Middle	14:45	77.0	72.5	81	29.6	00001
Last Calibration or check Date: <b>11-Sep-01</b>		After	17:30	82.5	78.0	82	29.7	00102
Psychrometer: Manufacturer & Model: <b>Psychrodyne</b>		Average of Readings		<b>Calculate</b>		* See back of form for codes		
S/N: <b>J.Q.S.</b>								
Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:								
1. Winds, calm at start, gradually increased to 20 knots by end of session.								
2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment.								
3. Center pole of tripod projected 3 mm into dimple of disk. Antenna height was therefore 2 m - 3 mm = 1.997 m								
Note: Entries are required in all Unshaded areas.								
Data File Name(s): <b>BALD365A.dat</b>			Updated Station Description: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier			LOG CHECKED BY:		
(Standard NGS Format = aaaaaddds xxx) where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension			Visibility Obstruction Form: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier			BY: <b>JGE</b>		
			Photographs of Station: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier					
			Pencil Rubbing of Mark: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier					

**Figure 4: GPS Antenna Height Measurements**

**ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:**

**I. Instructions for Fixed-Height Tripods:**

Measure & record the fixed-height tripod length (A) and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) (B)

**Antenna Height =  $H = A + B$**

**II. Instructions for Slip-Leg Tripods:**

**1. Measure the Slant Height (S)**

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm	223.40	223.30	223.30	
Before, inch	87.95	87.94	87.93	
After, cm	223.40	223.40	223.30	
After, inch	87.97	87.96	87.95	
Note: cm= inch x (2.54)	Overall average, cm			

S = \_\_\_\_\_ cm

**2. Record the Antenna Radius (R) and the Antenna Constant (C)**

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

R = 19.05 cm

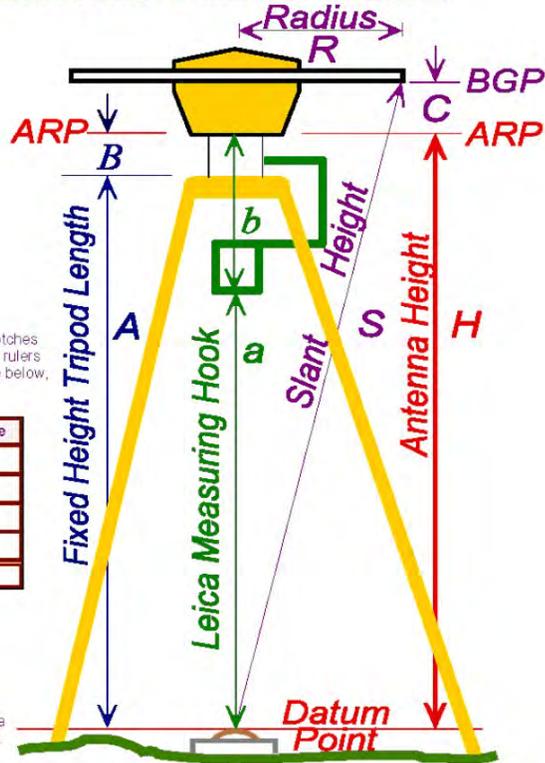
C = 3.50 cm

**3. Compute Antenna Height (H)**

Use the following Pythagorean equation:

**Antenna Height =  $H = ((S^2 - R^2) - C)$**

**Antenna Height =  $H = a + b$**



**III. Instructions for using the Leica Brand Measuring Hook:**

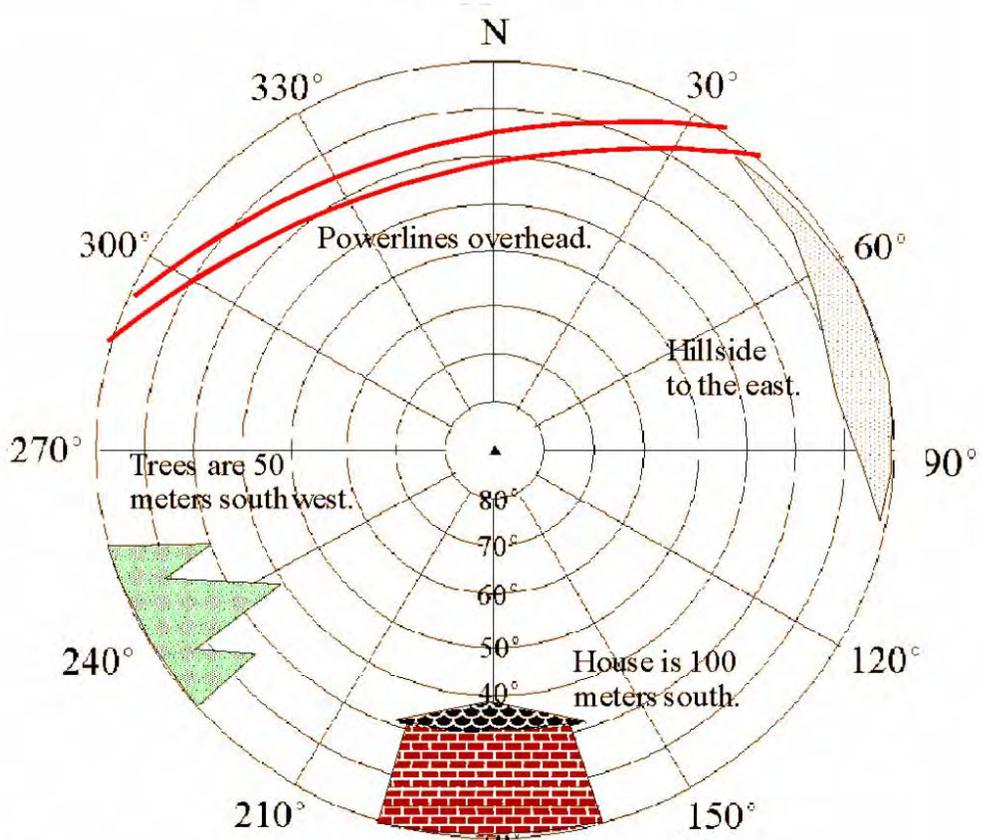
Follow the Leica operating instructions, being sure to reduce the height to the Antenna Reference Point (ARP), NOT the L1 Phase Center.

Table of Weather Codes -- for entry into Weather Data Table on front of form:					
CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80° F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80° F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over 15mph (24km/h)
Examples: Code 00000 = 0 - No problems, 0 - good visibility, 0 - normal temperature, 0 - clear sky, 0 - calm wind Code 12121 = 1 - Problems, 2 - poor visibility, 1 - hot temperature, 2 - overcast, 1 - moderate wind					

**Figure 5: Visibility Obstruction Diagram**

--> Click here to clear the sample data <--

**NATIONAL GEODETIC SURVEY  
VISIBILITY OBSTRUCTION DIAGRAM**



**INST**

Identify obstructions by azimuth (magnetic) and elevation angle (above horizon) as seen from station mark. Indicate distance and direction to nearby structures and reflective surfaces (potential multipath sources).

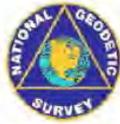
Designation: BALD 2 RESET PID: QE2736

Location: Boiler Bay Wayside County: LINCOLN

Reconnaissance By: John Q. Surveyor Height above mark: 2 Meters

Agency/Company: Oregon DOT Phone: ( 301 ) 713-3194 Date: 1998-12-31

**Figure 6: Station Pencil Rubbing Form**



## Station Pencil Rubbing Form

--> Click here to clear the sample data <--

Location / Airport Name and ID _____ Boiler Bay Wayside _____		Project _____ Sample GPS, 1998 _____	
Station Designation _____ BALD 2 RESET _____		PID _____ QE2736 _____ Date _____ 1998-12-31 _____	
Circle all applicable: FACS _____ SACS <input checked="" type="checkbox"/> FBN <input checked="" type="checkbox"/> OTHER _____		Observer & Organization _____ John Q. Surveyor, ORDOT _____	
<b>Station Pencil Rubbing</b>			
<p><u>Instructions:</u> Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.</p>			
Remarks: This disk is reset into the same drill hole as the original station BALD 1962.		Monument Type _____ Brass Disk _____  Inscribed Agency _____ Oregon DOT _____  Stamping _____ BALD 2 1991 _____	

**Figure 7: Digital Photograph of a Stamping of a Bench Mark**



GUIDELINES FOR ESTABLISHING GPS-DERIVED ELLIPSOID HEIGHTS  
(STANDARDS: 2 CM AND 5 CM)  
VERSION 4.3

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Joseph D. D'Onofrio  
Stephen J. Frakes

Silver Spring, MD

November 1997

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Preface

Introduction

Observations

Vector processing

Data submission to NGS

Appendix A. Definitions

Appendix B. GPS ellipsoid height hierarchy and basic requirements for 2-cm standard

Appendix C. ITRF to NAD 83 transformation parameters

GUIDELINES FOR ESTABLISHING GPS-DERIVED ELLIPSOID HEIGHTS  
[Standards: 2 cm and 5 cm]  
Version 4.3

Preface:

The following guidelines were developed by the National Geodetic Survey (NGS) for performing Global Positioning System (GPS) surveys that are intended to achieve ellipsoid height network accuracies of 5 cm at the 95 percent confidence level, as well as ellipsoid height local accuracies of 2 cm and 5 cm, also at the 95 percent confidence level. See Appendix A for information about local and relative accuracies. These guidelines were developed in a partnership with Federal, state, and local government agencies, academia, and private surveyors and are the result of processing various test data sets and having extensive discussions with various GPS users groups.

We are confident that these guidelines, if followed, will result in achieving the intended accuracy. Additional tests may show that some of these guidelines can be relaxed. These guidelines are intended for establishing geometric vertical control networks.

These guidelines will be expanded in the future to include the establishment of GPS-derived orthometric heights that approach these same accuracies, 2 cm and 5 cm. The slight differences between the accuracies of GPS-derived ellipsoid heights and GPS-derived orthometric heights will be generally due to the accuracy of the geoid model and published orthometric heights used to evaluate the differences between the three height systems, i.e., ellipsoid, geoid, and orthometric heights.

Note: these guidelines assume that for the survey project area in question, NGS has completed the establishment of a high accuracy reference network at 100-kilometer spacing or that a state-wide High Accuracy Reference Network (HARN) has been established, i.e., there are A- or B-order stations distributed throughout the state at an approximate spacing of 50 km or else there are Federal HARN stations or GPS Continuously Operating Reference Station (CORS) sites located within 75 km of the project area.

An effort should be made to connect to stations which were previously determined using these guidelines (or equivalent).

## Introduction:

Accurate connections to the control stations cited in the Observations section on the next page must be made in the International Terrestrial Reference Frame (ITRF) coordinate system. (See Appendix C for more information on ITRF.) This is accomplished by simultaneous observations between selected A-order (5 mm + 1:10,000,000 accuracy standards) stations of the International GPS Service for Geodynamics (IGS) and/or NGS CORS or NGS-approved CORS within about 75 km of the project. NGS-approved CORS are those which NGS has positioned or approved with respect to the ITRF/NAD 83 coordinate systems. If there are none available, B-order (8 mm + 1:1,000,000 accuracy standards) stations within about 75 km of the project may be substituted. However, it must be noted that the use of some of the B-order stations may mean that the network accuracy of +/- 5 cm will not be achieved.

These IGS stations and CORS sites are located throughout the United States. The IGS stations or CORS sites located closest to the project must be used. The following commands are used to access the NGS CORS system:

```
Ftp cors.ngs.noaa.gov
login: anonymous
Password: your complete e-mail address
```

The same files are accessible with Web browsers (i.e., Mosaic, Netscape, Internet Explorer). The NGS home page is at <http://www.ngs.noaa.gov>

"Information about A- and B-order stations is given on five sets of CD-ROMs covering the United States." The particular CD-ROM that covers the project area in question can be obtained by contacting NGS' Information Services Branch, 1315 East-West Highway, Silver Spring, Maryland 20910, (301) 713-3242 (voice), (301) 713-4172 (Fax). A limited amount of this information, i.e., the 100 closest stations of any type, can be retrieved from the NGS world wide web site. The electronic bulletin board system and/or web site usually contain new stations that have been added after the CD-ROM was produced.

Analysis of the quality of project data shall be based on repeatability of measurements, adjustment residuals, and analysis of loop misclosures. Please be aware that repeatability and loop misclosures do not disclose all problems.

## Observations:

The following requirements are for both 2-centimeter and 5-centimeter standards, unless otherwise stated.

1. Dual-frequency, full-wavelength GPS receivers are required for base lines greater than 10 km and are the preferred type of GPS receiver for all observations, regardless of base-line distance. Geodetic-quality antennas with ground planes are required. Whenever possible, antennas used during a project should be identical; otherwise corrections must be made for antenna phase patterns. Different makes and models of antennas have different antenna phase patterns. If antenna phase patterns are not accounted for, mixing different antennas in a project can cause vertical discrepancies of as much as 10 cm. Some manufacturers are including software packages which correct for the use of different antennas. (It should be noted that choke ring antennas help reduce the effect of multipath and are highly recommended.)

The manufacturer, model, and complete serial numbers of all receivers and antennas must be included on each station Session Observation Log.

2. The survey shall be referenced to at least three existing National Spatial Reference System A- or B-order three-dimensional control stations near the project area. The survey will also consist of at least three primary base stations that are referenced to the three control stations and interspersed throughout the project. The survey will also include secondary base stations and local network stations to meet the spacing requirements in item 5., below. Primary and secondary base stations can be newly established stations in this project.

A sample project with observing scheme is depicted in figure 1 located at the end of the section. A summary of the guidelines is provided in table 1 located at the end of the vector processing section. See Appendix A for more information about control, base, and local network stations.

3. For control stations and primary base stations, receivers shall collect data continuously and simultaneously for at least three, 5-hour sessions on 3 different days during the project.

4. Observation periods for stations other than control stations and primary base stations are as follows:

a. For the 2-Centimeter Standard: Each base line (adjacent station pair) must be occupied for a minimum of 30 minutes per session.

b. For the 5-Centimeter Standard: Observations between primary and secondary base stations must be for a minimum of 30 minutes per session. While there is no minimum observation time for local network stations, each base line (adjacent station pair) must be occupied long enough in each session to ensure that all integers are fixed and the RMS for the base line solution does not exceed 1.5 cm.

5. The observing scheme is based on the GPS survey of marks spaced as indicated below for 2- and 5-centimeter standards. Stations in the scheme

are noted as either control, primary base station, secondary base station, or local network stations. (The observing scheme chosen for a sample project is depicted in figure 1, page 7.)

For the 2-Centimeter Standard: Spacing between local network stations cannot exceed 10 km; the average spacing must be less than or equal to 7 km. Spacing between primary base stations cannot exceed 40 km and spacing between primary and secondary base stations cannot exceed 15 km.

For the 5-Centimeter Standard: Spacing between local network stations cannot exceed 20 km; the average spacing must be less than or equal to 10 km. Spacing between primary base stations cannot exceed 50 km and spacing between primary and secondary base stations cannot exceed 20 km. (Note that secondary base stations may not be required in projects of small areal extent. See Item 2. above.)

6. The observing scheme for all primary base stations requires that each primary base station must be connected to at least its nearest primary base station neighbor and nearest control station according to the observing procedures stated in item 3., above. Primary base stations must be traceable back to two control stations along independent paths.

In addition to this requirement for primary base stations, the observing scheme for all base stations (primary and secondary) requires that each base station be connected with at least its two nearest primary or secondary base station neighbors according to observing procedures stated in item 4., above. For secondary base stations, one of these connections must be to its nearest primary base station neighbor. Secondary base stations must be traceable back to two primary base stations along independent paths.

Local network stations must be traceable back to two base stations along independent paths.

The observing scheme for all stations requires that all adjacent stations (base lines) be observed at least twice on 2 different days and at two different times of the day according to observing procedures shown in item 4. on the previous page. The purpose is to ensure different atmospheric conditions (different days) and significantly different satellite geometry (different times) for the two base line measurements.

Observations on the second day should be completed between 27 and 33 hours after the completion of the first day's observations if the first day's observations were begun prior to 12:00 noon. Or, the observations should be completed between 15 and 21 hours after the completion of the first day's observations if the first day's observations were begun after 12:00 noon. This is necessary since the satellite constellation geometry repeats itself every 12 hours.

Examples:	First-day observations	Second-day observations
	Begun during:	Completed anytime between:
	8:00 a.m. to 8:30 a.m.	11:30 a.m. and 5:30 p.m.
	10:30 a.m. to 11:00 a.m.	2:00 p.m. and 8:00 p.m.
	1:00 p.m. to 1:30 p.m.	4:30 a.m. and 10:00 a.m.
	3:30 p.m. to 4:00 p.m.	7:00 a.m. and 12:30 p.m.

(Note that the second day of observations does not need to follow immediately after the first day. Satellite geometry moves ahead, or precesses, 4 minutes per day. If the second observations are not performed within 1 week of the first, this daily 4-minute change must be accounted for when meeting the different satellite geometry requirement.)

7. Selection of primary and secondary base stations in order of most-to-least- preferred are: 1. High Precision Geodetic Network (HPGN)/HARN (either Federal Base Network (FBN) or Cooperative Base Network (CBN) stations which have level ties to bench marks of A- or B-stability quality during this project; 2. bench marks of A- or B-stability quality or HPGN/HARN stations which were previously tied to bench marks of A- or B-stability quality; 3. User Densification Network (UDN) stations which have level ties made during this project; or 4. bench marks of C stability quality. In areas of known or suspected subsidence or uplift, special guidelines may need to be followed.

8. Data should be collected during periods when the Vertical Dilution of Precision (VDOP) is less than 6 for at least 90 percent of each 30-minute, or longer, observing period. For shorter observing periods, as in some projects where the 5-centimeter standard is the goal, a VDOP greater than 6 should be avoided entirely. Travel between stations could be scheduled during large VDOP periods.

9. For sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. For sessions less than 30 minutes, collect data at 5-second intervals.

10. Track satellites down to at least a 10-degree elevation angle. (Note that tracking below 15 degrees may be helpful during processing when collecting data for less than 30 minutes.)

11. If possible, coordinate observations with local, existing CORS which are collecting phase data with dual-frequency receivers.

12. Meteorological data must be collected at the control stations and primary and secondary base stations. Weather data consist of wet- and dry-bulb temperatures (or dry-bulb temperature and relative humidity) and atmospheric pressure. For sessions greater than 2 hours, record weather data at the beginning, middle, and end of each session. For sessions that are less than 2 hours in length, but more than 30 minutes, record weather data at the beginning and end of each session. For sessions that are less than 30 minutes in length, collect data at the mid-point of the session. Meteorological data shall also be collected immediately after an obvious weather front passes during a session and also immediately before it passes, if possible. Atmospheric pressure measurements must be made at approximately the same height as the GPS antenna phase center. Record on the observing log the time and where the weather data were gathered, and any abnormal weather conditions.

(Note that even though all of these data may not used in the vector processing, they may be helpful during the analysis of the results and in future reprocessing with more robust software.)

Before taking weather observations, the meteorological instruments should be allowed ample time (approximately 10 minutes) to stabilize to ambient conditions. Observations of wet- and dry-bulb temperatures must be observed and recorded to at least the nearest 1 degree Celsius. Barometric readings must be observed and recorded to at least the nearest 1 millibar. Meteorological data should be collected at or near the antenna phase center. All equipment must be checked for proper calibration.

13. Antenna set-up is critical to the success of the project. Plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbing is performed. Plumbing bubbles must be shaded for at least 3 minutes before checking and/or re-plumbing. The perpendicularity of the poles must be checked at the beginning of the project and any other time there is suspicion of a problem.

For the 2-Centimeter Standard: Fixed-height tripods are required for all receivers.

For the 5-Centimeter Standard: Fixed-height tripods are preferred for all receivers. When a fixed-height tripod is not used, the height of the antenna must be carefully measured to prevent station set-up blunders. Tribrachs used for these set-ups must be checked and adjusted when necessary. Totally independent measurements of the antenna height above mark in both metric units and English units must be made before and after each session. Someone other than the observer must check the measurement computations by carefully comparing measurements and then entering his/her initials on the log.

14. A rubbing of the mark must be made at each occupation of a station. When not feasible to make the required rubbing, a plan sketch of the mark must be substituted, accurately recording all markings.

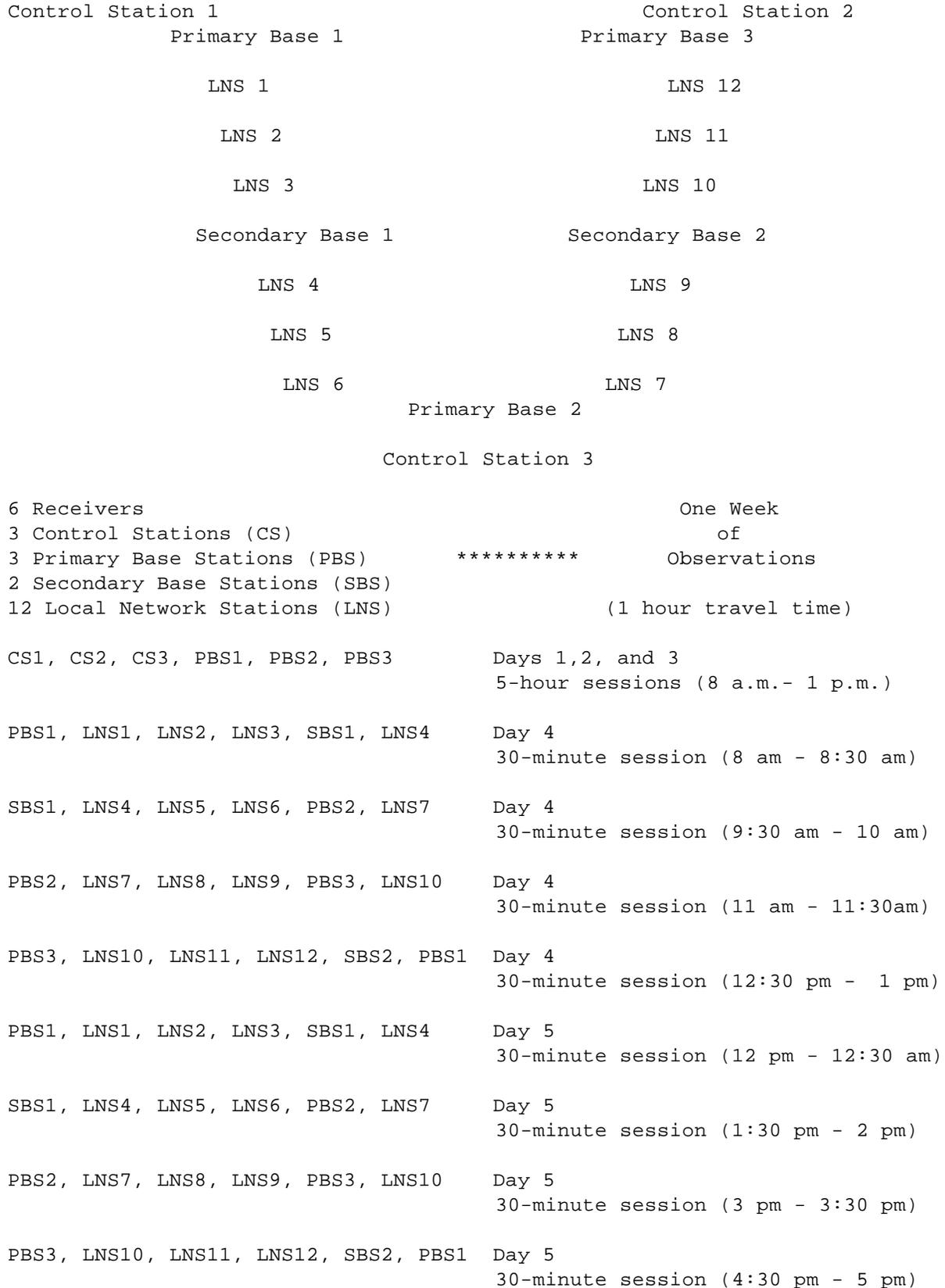


Figure 1.--Sample project observing scheme.

## Vector Processing:

The following requirements are for both 2-centimeter and 5-centimeter standards unless otherwise stated. A summary of the guidelines is listed in table 1 at the end of this section.

1. Final vector processing and quality review of collected data shall be accomplished using NGS' program OMNI or other interactive, graphics-producing software which produces results equivalent to OMNI. The vector between adjacent GPS-occupied stations shall be processed using the multi-station processing technique which includes double-difference phase correlations (or equivalent) with a selection of a reference station that minimizes vector lengths.
2. Use precise ephemerides. NGS' precise ephemerides are available from the U.S. Coast Guard Bulletin Board System or the NGS world wide web site. The Coast Guard Bulletin Board System number is (703)313-5910 and the NGS web site address is <http://www.ngs.noaa.gov> The USCG web site address is <http://www.navcen.uscg.mil/navcen.htm>
3. For sessions greater than 30 minutes, process data using 30-second epoch intervals. (Note that using a smaller epoch interval may improve ease of data processing.) For sessions less than 30 minutes, process data using 5-second epoch intervals.
4. For sessions greater than 30 minutes, use only satellite data tracked above the 15-degree elevation angle. For sessions less than 30 minutes, use satellite data tracked above the 15-degree elevation angle; data collected below the 15 degree elevation angle should only be used if required to derive a successful solution.
5. Final processing shall consist of fixing all integers for each vector for all sessions except to some control sites. For short base lines, under 10 km, the L1 fixed solution may be the best choice. For vectors greater than 40 km to control sites, a session may consist of a set of partially or completely fixed vectors and in the worst possible scenario may also include float solutions where no integers could be fixed.

A model to account for tropospheric effects must be used. The project report must state which model was used. Measured meteorological data should be used only when it has been determined that the instruments have been properly calibrated and the measurements accurately represent the current atmospheric conditions at the station. If standard meteorological data are used instead of actual measured values, the processing software must account for changes in standard default values due to the station's location and height above the vertical datum. For base lines greater than 15 kilometers or with "large" height differences, a relative tropospheric scale parameter should be solved for, along with the base line vector components.

6. The quality of collected data shall be determined from the double-difference residual plots and RMS values. Final coordinates and their quality assessment shall be determined by using least-squares adjustment software and by analysis of repeated vectors and free-adjustment residuals and loop misclosures (most loops consisting of repeated vectors).

7. RMS values for each computed base line (adjacent station pairs) must not exceed 1.5 cm.

8. Reobservation criteria:

For the 2-Centimeter Standard: For local network requirements, must reobserve any base line (adjacent station pair) where the difference in ellipsoid height between the repeat observations exceeds 2.0 cm. For station pairs involving control stations, must reobserve any control station base line where the ellipsoid height difference between the repeat observations exceeds 5.0 cm.

For the 5-Centimeter Standard: Must reobserve any base line (adjacent station pair) or control station pair where the ellipsoid height difference between the repeat observations exceeds 5.0 cm.

When reobserving base lines that exceed tolerance values, the new observation must agree with an old base line which was observed using the criteria in number 6. of the Observations section above, i.e., the two base line measurements must contain significantly different satellite geometry.

Table 1. -- Summary of Guidelines.

	Control 2 and 5 cm	Primary Base 2 cm	Primary Base 5 cm	Secondary Base 2 cm	Secondary Base 5 cm	Local Network 2 cm	Local Network 5 cm
Dual Frequency Required	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km	Yes, if base line is greater than 10 km
Geodetic Quality Antenna with Ground Plane	Yes						
Min. Number of Stations	3	3	3	No Minimum	No Minimum	No Minimum	No Minimum
Occupation Time	5 Hours	5 Hours	5 Hours	30 Minutes 1	30 Minutes 1	30 Minutes 1	No Minimum 1
Number of Days Station is Occupied	3	3	3	2 2	2 2	2 2	2 2
Max. Distance Between Same or Higher-Order Stations	75 km	40 km	50 km	15 km	20 km	10 km	20 km
Average Distance Between Stations	No Maximum	No Maximum	No Maximum	No Maximum	No Maximum	7 km	10 km
Repeat	YES 3						
"Base Line"							
Collect Met Data	Yes	Yes	Yes	Yes	Yes	No	No
Fixed Height Pole	Yes	Yes	No	Yes	No	Yes	No
Rubbing of Mark	Yes						
Precise Ephemerides	Yes						
Fix Integers	Yes 4	Yes 5	Yes 5	Yes	Yes	Yes	Yes

Notes for Table of Summary of Guidelines:

1 Analyses have indicated that when following all guidelines in this document, 30 minutes of observations over base lines that are typically less than 10 kilometers will meet the standards. For base lines greater than 10 km, but less than 15 km, 1 hour sessions should meet the standards. For observing sessions greater than 30 minutes, collect data at 15-second epoch interval. For sessions less than 30 minutes, collect data at 5-second epoch interval. Track satellites down to at least 10-degree elevation cut-off.

2 Base lines must be reobserved on different days with significantly different satellite geometry.

3 The observing scheme requires that all adjacent stations have base lines observed at least twice on two different days with significantly different geometry.

4 If base line is greater than 40 kilometers, a partially fixed or float solution is permitted.

Data Submission to NGS:

1. The project accession number is of the form GPS-xxx. (The project accession number will be assigned by NGS when draft project plans are submitted to NGS for evaluation prior to the start of the project.)

2. A project report and the data elements listed in Appendix L of "Input Formats and Specifications of the NGS Data Base" must be transmitted to NGS. Quality checks for conformance to NGS format standards shall be performed using software programs COMPGB and OBSDES.

3. Latitude, longitude, and ellipsoid heights, as well as X, Y, and Z coordinates shall be provided in both NAD 83 and ITRF coordinate systems. See Appendix C for more information on transformation parameters and related information.

Guideline Updates:

These Guidelines will be updated as the results of future projects and other procedures are reviewed. There are other procedures that will also achieve the standards. The user should note which procedures in this document were not followed and note how errors and systematic biases were detected, reduced, or eliminated by the new procedure. NGS welcomes the opportunity to examine alternate procedures and supporting data that demonstrate the ability to achieve the accuracy standards stated in this document. If you have such data or would like to comment, please contact Dave Zilkoski or Steve Frakes, telephone 301-713-3191, or write:

National Geodetic Survey, N/NGS2  
NOAA, 1315 East-West Highway  
Silver Spring, Maryland 20910-3282  
email: davez@ngs.noaa.gov or  
steve@ngs.noaa.gov

## Appendix A. -- Definitions

### Accuracy

Local Accuracy - The local accuracy of a control point is a value expressed in cm that represents the uncertainty in the coordinates of the control point relative to the coordinates of the other directly connected, adjacent control points at the 95 percent confidence level. The reported local accuracy is an approximate average of the individual local accuracy values between this control point and other observed control points used to establish the coordinates of the control point.

Network Accuracy - The network accuracy of a control point is a value expressed in cm that represents the uncertainty in the coordinates of the control point with respect to the geodetic datum at the 95 percent confidence level. For National Spatial Reference System (NSRS) network accuracy classification, the datum is considered to be best supported by NGS. By this definition, the local and network accuracy values at CORS sites are considered to be infinitesimal, i.e., to approach zero.

### Stations

#### Base Stations

Primary - Stations evenly distributed that surround the local network. These stations relate the local network to NSRS to the 5-cm, or better, standard through simultaneous observations with control stations. They can be newly established stations and be part of the local network.

Secondary - Stations evenly distributed throughout the local network that ensure that the local network does not contain a significant medium wavelength (20-30 km) ellipsoid height error through simultaneous observations with primary base stations. These stations may be newly established stations and are part of the local network. They are located between Primary Base Stations.

#### Control Stations

A- or B-order three-dimensional stations that surround the project area in at least three different quadrants. These stations relate the local network to the National Spatial Reference System through simultaneous observations with primary base stations. They must be referenced to NSRS and they provide the network accuracy. They may be newly established stations in the survey project if A- or B-order specifications and procedures are used to establish them. These procedures are not covered in this document, please contact NGS for additional information.

#### Local Network Stations

These stations include all other stations that are not base (primary or secondary) or control stations. They are part of the local network. They provide the local accuracy standard through simultaneous observations between adjacent stations.

Appendix B. -- GPS Ellipsoid Height Hierarchy and Basic Requirements for  
2-cm standard

HARN/Control Stations

(75 km)

Primary Base

(40 km)

Secondary Base

(15 km)

Local Network Stations

(7 to 10 km)

HARN/Control Stations

O CS1

O CS2 <-----75 km-----> O CS3

Primary Base Stations

O CS1

PB1

PB2 <-----40 km----->PB3

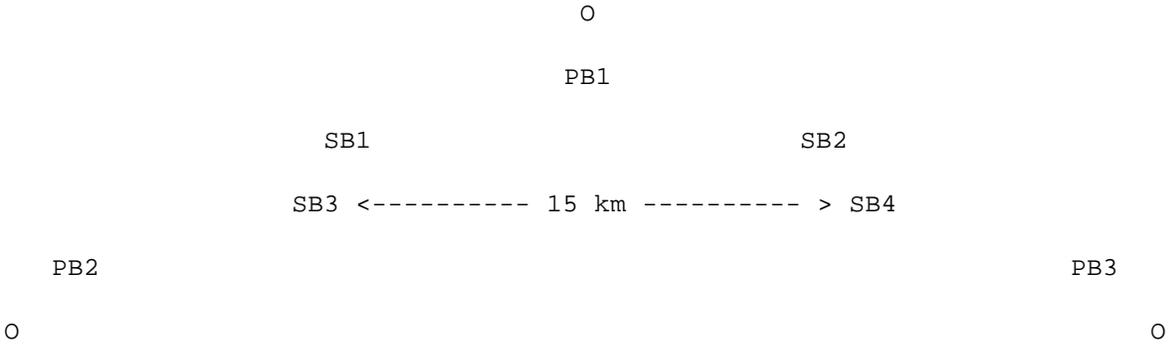
O CS2

CS3 O

Basic Requirements

- o 5 Hour Sessions / 3 Days
- o Spacing between primary base stations cannot exceed 40 km.
- o Each primary base station must be connected to at least its nearest primary base station neighbor and nearest control station.
- o Primary base stations must be traceable back to 2 control stations along independent paths; i.e, base lines PB1 - CS1 and PB1 - PB2 plus PB2 -CS2, or PB1 - CS1 and PB1 - PB3 plus PB3 - CS3.

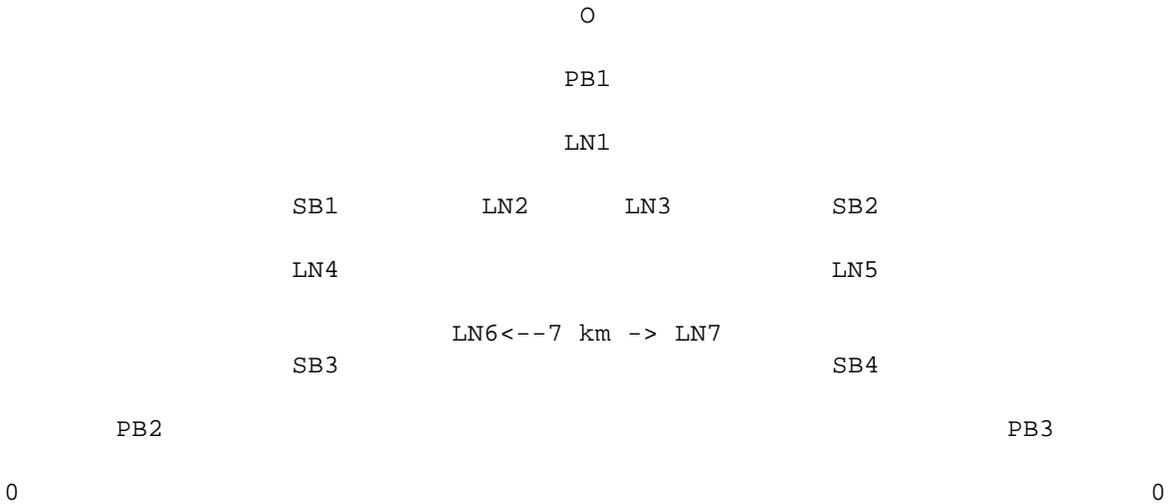
## Secondary Base Stations



### Basic Requirements

- o 30 Minute Sessions / 2 Days / Different times of the day
- o Spacing between secondary base stations (or between primary and secondary base stations) cannot exceed 15 km.
- o All base stations (primary and secondary) must be connected to at least its two nearest primary or secondary base station neighbors.
- o Secondary base stations must be traceable back to 2 primary base stations along independent paths; i.e., SB1- PB1 and SB1- SB3 plus SB3 - PB2, or SB1 - PB1 and SB1 - SB4 plus SB4 - PB3.
- o Secondary base stations need not be established in surveys of small areal extent.

## Local Network Stations



### Basic Requirements

- o 30 Minute Sessions / 2 Days / Different times of the day
- o Spacing between local network stations (or between base stations and local network stations) cannot exceed 10 km.
- o All local network stations must be connected to at least its two nearest neighbors.
- o Local network stations must be traceable back to 2 primary base stations along independent paths; i.e., LN1 - PB1 and LN1 - LN2, plus LN2 - SB1, plus SB1 - SB3 plus SB3 - PB2, or LN1 - PB1 and LN1 - LN3, plus LN3 - SB2 plus SB2 - SB4 plus SB4 - PB3.

## APPENDIX C.--ITRF TO NAD 83 TRANSFORMATION PARAMETERS

### Introduction

The International Earth Rotation Service Terrestrial Reference Frame (ITRF) has become an important coordinate system for users of Global Positioning System (GPS) technology. Both GPS and ITRF are global, geocentric coordinate systems. The ITRF coordinate system supports GPS orbit computations and provides a basis for more precise GPS data reduction computations. Also, for many applications it is necessary to use a coordinate system such as ITRF to account for the motions of the Earth's crust. Published ITRF solutions provide not only coordinate values at a particular epoch in time, but station velocities as well. Thus, up-to-date ITRF station coordinate values can be computed for future epochs in time after the original solution.

The North American Datum of 1983 (NAD 83), on the other hand, has the advantage of being fixed and stable relative to the North American tectonic plate. Additionally, NAD 83 has been officially adopted by the Federal government as the coordinate system for mapping and charting in the United States. Therefore, the relationship of ITRF to regional or continental datums like NAD 83 is of utmost importance to GPS users.

The following background information on NAD 83 should help understanding the differences, systematic and otherwise, between ITRF and NAD 83.

### NAD 83 Datum Definition

The NAD 83 adjustment combined terrestrial data (distances, azimuths, and direction observations) with space-based data, such as 3-D positions derived from satellite Doppler observations and 3-D inter-station vectors obtained from Very Long Baseline Interferometry (VLBI).

Along with these data, and equally important, was a set of implied constraints that defined the scale and orientation of NAD 83. Also included in the NAD 83 adjustment was a set of global parameters that allowed the implied constraints to have complete influence. An example would be that of a distance observation which has implied scale, but if a global scale parameter is included in its observation equation, it allows the scale to be determined elsewhere. Table 1 shows the global parameters for the NAD 83 adjustment:

Table 1.--Global parameters - NAD 83  
adjustment.

Parameter	Terrestrial	Doppler	VLBI
X Shift		F	
Y Shift		F	
Z Shift		F	
X Rotation		F	A
Y Rotation		F	A
Z Rotation	F	A	A
Scale	A	F	A

F=fixed  
parameter  
A=estimated  
parameter

The above table shows that the 3-D positions derived from Doppler observations defined the geocentricity, scale, and the major part of the orientation of the NAD 83 datum.

The VLBI vectors are very important for several reasons. To begin with, the VLBI vectors are extremely precise. These vectors span the continent and are found to be internally consistent at the 2-3 cm level. Second, the VLBI stations and data are an integral part of the ITRF solutions and thus provide a link between NAD 83 and ITRF. Third, although the VLBI vectors were not used to help define the NAD 83 scale and orientation, the adjusted values for global parameters associated with the VLBI vectors tell how they were changed. This provides a quantitative measure of the systematic difference between NAD 83 and coordinate systems based on VLBI.

Table 2.--Adjusted values for VLBI global parameters.

Parameter	Value
X Rotation	0.022 arc seconds
Y Rotation	0.026 arc seconds
Z Rotation*	0.010 arc seconds*
Scale Change	-0.075 ppm

\*The actual adjusted value of the Z rotation was 0.375 arc seconds, however there was a post-adjustment correction of 0.365 arc seconds applied, resulting in the 0.010 arc seconds shown above. In effect the coordinate system was rotated to be more consistent with the VLBI observations.

#### NAD 83 Upgrade Surveys

In 1988, the National Geodetic Survey (NGS) began to upgrade the NAD 83 coordinates by performing high accuracy reference network (HARN) GPS surveys. This is being done on a state-by-state basis. The strategy for determining the control for these upgrades follows. First consider the following (X, Y, Z) transformation, designated equation 1:

$$\begin{aligned}X_n &= T_x + (1 + S)X_i + R_z Y_i - R_y Z_i \\Y_n &= T_y - R_z X_i + (1 + S)Y_i + R_x Z_i \\Z_n &= T_z + R_y X_i - R_x Y_i + (1 + S)Z_i\end{aligned}$$

This equation defines a seven-parameter transformation from ITRF to NAD 83, where  $(X_i, Y_i, Z_i)$  denote geocentric cartesian coordinates in ITRF and  $(X_n, Y_n, Z_n)$  denote geocentric cartesian coordinates in NAD 83.

In order to establish control stations for the new HARN GPS surveys, NGS completed the following:

1. NGS used a set of 12 VLBI stations located in North America to determine a seven-parameter transformation (equation 1) from ITRF89 (epoch 1988.0) to NAD 83 (see table 3).
2. NGS decided to accept the scale of ITRF89 as being closer to the true value.
3. The derived transformation parameters, translations, and rotations, but NOT scale, were applied to the complete set of ITRF89 positions to get NAD 83 values with corrected scale. A comparison with the original NAD 83 coordinates showed a change in ellipsoid height of 0.6 meters, which was caused by scale differences.

Table 3.--Transformation  
parameters, ITRF89 (Epoch 1988.0)  
to NAD 83.

Parameter	Value
Tx = X Shift	0.9191 meters
Ty = Y Shift	-2.0182 meters
Tz = Z Shift	-0.4835 meters
Rx = X Rotation	0.0275 arc seconds
Ry = Y Rotation	0.0155 arc seconds
Rz = Z Rotation	0.0107 arc seconds
S = Scale Change	-0.0871 ppm [See item 3) above.

Apparent in Table 3 is the similarity of the values for the rotations and scale with those in Table 2. This indicates that the coordinate system of the original VLBI vectors is very similar to ITRF.

#### Computations of GPS Data in ITRF

Several other solutions of ITRF have been computed by the International Earth Rotation Service since the publication of ITRF89. As more and more data have been collected and included in the ITRF solutions, the resulting coordinates and velocities have increased in accuracy. Confidence in ITRF has grown to the point that most geodetic organizations throughout the world now use ITRF as a basis for GPS orbit computations.

An important concept for the GPS user community to understand is that since GPS precise orbits are referred to ITRF, fixed orbit solutions of GPS produce vectors that are oriented in the ITRF coordinate system. However, most of the user community is working in NAD 83. The systematic differences between ITRF and NAD 83 must be accounted for, if high accuracy is to be maintained.

Since we are dealing with inter-station vector components, instead of positional coordinates, we need not worry about X, Y, Z shifts. Also, recall that the scale of NAD 83 was corrected when the high accuracy GPS survey began. But the X, Y, Z rotations between ITRF and NAD 83 must be accounted for. NGS adjustment software ADJUST does just that. ADJUST accepts GPS vectors expressed in ITRF as well as other coordinate systems as input, then, internal to the program, applies the X, Y, Z rotations to convert to NAD 83.

Table 4 describes transformation parameters between NAD 83 and some more recent solutions of ITRF.

Table 4.--Transformation parameters: ITRF solutions to NAD 83.

Parameter	ITRF93 (Epoch 1995.0)	ITRF94 (Epoch = E, in years)
Tx = X Shift	0.9769	0.9738 meters
Ty = Y Shift	-1.9392	-1.9353 meters
Tz = Z Shift	-0.5461	-0.5486 meters
Rx = X Rotation	0.0264	0.02755 + 0.00009(E-1996.0) arc sec
Ry = Y Rotation	0.0101	0.01005 - 0.00077(E-1996.0) arc sec
Rz = Z Rotation	0.0103	0.01136 + 0.00002(E-1996.0) arc sec
S = Scale Change	0.0	0.0 ppm

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# Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of  
Coast Survey

2014

## Chapter 4 Appendices:

Additional Attribution Guidance

Pydro Flags

Attributing and Flagging for Automated Feature Reports

Backscatter Acquisition SOP v2.6

Backscatter Processing SOP v2.6

CARIS HVF Uncertainty Values

Combined Surface Grid Requirements

Customized Attribute Equivalencies

Ellipsoidally Referenced Equivalencies

FileVerifier++ SOP v1.1

Standard Shorthand for Features

TCARI for Notebook Features SOP

TVU\_QC\_SOP

SSS Contacts to \$CSYMB\_SOP

CARIS Compute TPU Dialog menu

### Please Note:

The Standard Operating Procedure's (SOP's) within the FPM Appendices are in the process of being transferred to the "Documents" section of the Hydroforum and the SOP's will reside in both places for the remainder of the 2014 field season.

## Additional Attribution Guidance

### Additional Pydro Flags

The following is a list of additional flags in Pydro to support data processing and analysis:

<b>Pydro Flag</b>	<b>Description</b>
<b>Submitted</b>	Denotes that items flagged as Primary+Chart+DTON have been exported from Pydro to a DTON report for submission to MCD. Once marked Submitted, these items will not be re-exported during creation of subsequent DTON reports unless the “Submitted” flag is manually cleared prior to generating the report.
<b>Office QC</b>	Denotes that AHB/PHB examination and verification have been completed for an item. The Pydro PSS for a completed survey to be submitted to HSD or otherwise archived shall not contain any Primary items that are not flagged Office QC. This is a Processing Branch tool only.
<b>Rejected</b>	Identifies any item that the hydrographer does not want included in the survey. Any pertinent information explaining why the feature has been rejected should be included under the Remarks tab of the Editor’s Notebook. Rejecting an imagery feature in Pydro will flag the corresponding SIPS contact as rejected, but will not delete the contact. Rejecting a bathymetry feature in Pydro will clear the Outstanding flag in HIPS, but will not reject the corresponding sounding data.
<b>Significant</b>	Identifies features which meet the NOAA significant contact height criteria set forth in the HSSD (see section 5.2.2 and 6.2.1), or some other priority condition determined by the field unit, and warrant further investigation and/or development. If applied to a Primary feature, the Significant flag will automatically be applied to all correlating Secondary features.
<b>Tgt Exported</b>	Denotes that an item was flagged Investigate and has been exported to MapInfo MIF/MID and HYPACK TGT format, typically for some subsequent investigation procedure. This flag will be set automatically when “Export Investigation Items” function in Pydro is performed. Once marked Tgt Exported, these items will not be re-exported unless the Tgt Exported flag is manually cleared prior to performing the export.

<b>In Bathy</b>	Forces a feature's least depth to be explicitly included in the PSS database of shoal-biased binned line (PVDL) data for plotting in Pydro, MapInfo (via Hydro_MI's "Draw PSS" function), or otherwise exported from Pydro. A sounding must first be classified as a bathymetric feature to be designated In Bathy. Once flagged In Bathy, that depth will take priority over other PVDL bathymetry data and other feature depths in the PSS during over-plot removal.
<b>Designated</b>	This flag is used to force a feature's least depth to be explicitly included in the two PSS bathymetry databases (as applicable) for display/analysis in Pydro (both over-plot removed Depths and ZSurfaces), plotting in MapInfo (via Hydro_MI's "Draw Pydro Data" Post Survey tool), or otherwise exported from Pydro: (i) HIPS BASE/Weighted Grid data and (ii) shoal-biased binned line (PVDL) data. During bathymetry layer over-plot removal (aka "excessing") in Pydro, feature depths may suppress other (deeper) feature depths; however, non-feature depths do not suppress feature depths, regardless of magnitude (i.e., all feature depths are regarded as being shoaler than all other depth nodes in the grid). In CARIS, the Designated flag should be used when a single least depth measurement is preferred over the weighted-mean depth calculation for BASE surface grid nodes. Designated soundings often equate to navigational significance and, hence, the desire for a symbolized feature to be rendered on the chart—and why HIPS Designated soundings are read into Pydro as candidate features (items from bathymetry). However, this is not always the case. For example, if the area of least depth has been adequately surveyed, yet contains a small number of soundings, the Designated flag should be used. Also, if a feature's least depth was determined by DLDG, the Designated flagging mechanism must be used to accurately represent the (single) measurement in the BASE surface. Designated soundings are applied to the BASE surface during the Finalize step in CARIS by checking the "Apply designated soundings" option.
<b>Outstanding</b>	Flagging a sounding Outstanding can only be accomplished in HIPS, but this action correlates to creating a bathymetry feature in Pydro. In other words, a sounding flagged Outstanding in the HDCS data will automatically be a bathymetry feature in the PSS. Likewise, creating a bathymetry feature in Pydro will write an Outstanding flag back to that sounding in the HDCS data.

## Attributing and Flagging for Automated Feature Reports

### Special Feature Types

The following attributes and flags shall be used to distinguish features for HCell compilation and the Feature Report. See section 8.2 of the HSSD for the official attribution table.

**Note:** There are several logic paths for some of the items in Pydro

<b>Special Feature Types:</b>	<b>CARIS &amp; HYPACK</b>	<b>Pydro</b>
<b>DTONs</b>	[sftype = 3 DTON]	Accepted (i.e., not flagged Rejected) + Chart + DTON
<b>AWOIS</b>	[sftype = 2 AWOIS]	<ul style="list-style-type: none"><li>• Report + [Keyword == "AWOIS"]</li><li>• Report + Accepted + Non-DTONs + Secondary AWOIS</li></ul>
<b>Maritime Boundary</b>	[sftype = 2 Maritime Boundary]	<ul style="list-style-type: none"><li>• Report + [Keyword == "Maritime Boundary"]</li><li>• Report + Accepted + Non-DTONs + Secondary Maritime Boundary</li></ul>

**New and Charted Features**

<b>New &amp; Charted Features:</b>	<b>CARIS &amp; HYPACK</b>	<b>Pydro</b>
<b>New</b>	[descr = 1 New]	<ul style="list-style-type: none"> <li>• Report + Accepted + Non-DTONs (with no Secondary from Chart GP or AWOIS)</li> <li>• Report + [Keyword=="DR_UnCharted"] + [Chart = New]</li> </ul>
<b>Updated</b>	[descr = 2 Updates]	<ul style="list-style-type: none"> <li>• Report + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS)</li> <li>• Report + [Keyword=="DR_Charted"] + [Chart = Update]</li> </ul>
<b>Disproval</b>	[descr = 3 Delete]	<ul style="list-style-type: none"> <li>• Report + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS)</li> <li>• Report + [Keyword=="DR_Charted"] + [Chart = Delete]</li> </ul>
<b>Retain</b>	[descr = 4 Retain]	<ul style="list-style-type: none"> <li>• Report + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS)</li> <li>• Report + [Keyword=="DR_Charted"] + [Chart = Retain]</li> </ul>
<b>Not Addressed</b>	[descr = 5 Not Addressed]	<ul style="list-style-type: none"> <li>• Report + Accepted + Non-DTONs (i.e., not flagged DTON) + Secondary ChartGP (but no Secondary from AWOIS)</li> <li>• Report + [Keyword=="DR_Charted"] + [Chart = Not Addr]</li> </ul>

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PROCESS OWNER
<p>This Process is owned by the NOAA IOCM Center</p> <p>SOP Custodian: Glen Rice</p>

REVISION HISTORY			
REV	Description of Change	Author	Effective Date
0	Initial release	Glen Rice	5/5/12
1	Updated with comments and corrections	Glen Rice	6/14/12
2	Updated with new data import plugin	Glen Rice	10/16/12
3	Updated for FMGT 7.3.4, which works with Hypack datagram version 2.	Glen Rice	4/1/2013

REFERENCE DOCUMENTS	
Document Number	Document Title
HSSDM 2013	Hydrographic Survey Specifications and Deliverables Manual 2013
FPM 2013	Field Procedures Manual 2013

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### 1. Purpose

The purpose of this document is to provide guidance to NOAA hydrographic offices and vessels for processing backscatter data and creating ready to use backscatter files and a mosaic for archival.

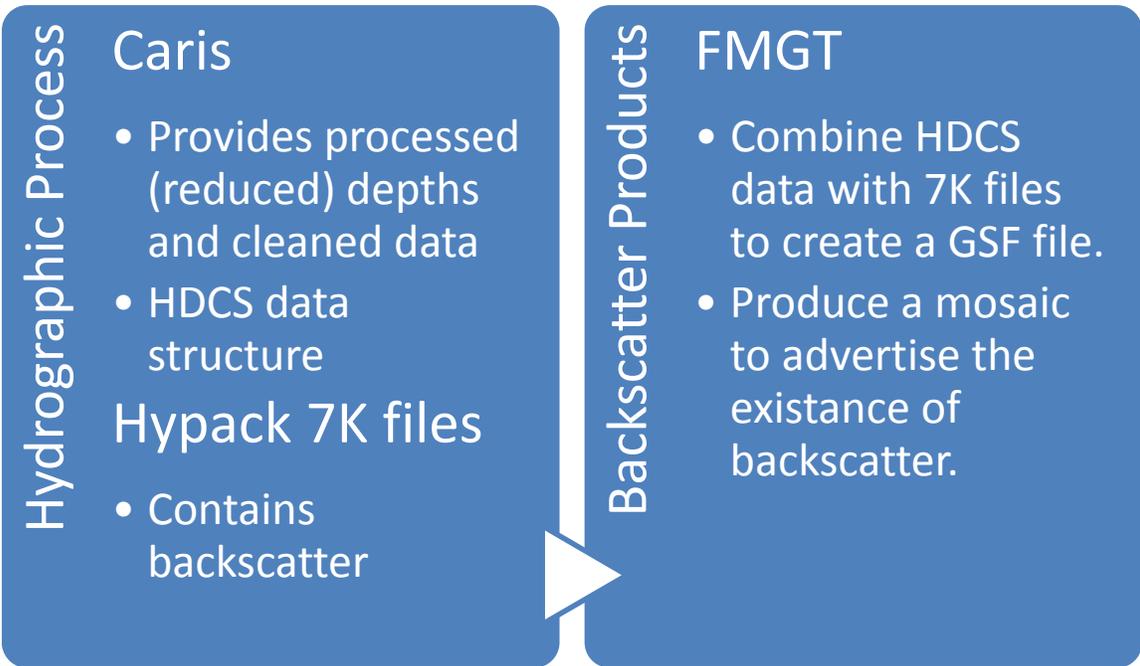
### 2. Scope

This guidance is directed towards processing Reson 7125 and 7111 sonar data from HYPACK/HYSWEEP 2013 acquisition software, and Kongsberg ALL files, in the Fledermaus Geocoder Toolbox environment.

### 3. Definitions and Acronyms

- FMGT            Fledermaus Geocoder Toolbox
- PVDL           Project/Vessel/Day/ Line, NOAA’s standard folder hierarchy
- NAD 83        North American Datum of 1983
- GSF            File format, Generic Sensor Format
- ALL or \*.all   Kongsberg file format

### 4. Flowchart



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## 5. Responsibilities

### 5.1 Hydrographic Vessel or Processing Branch Personnel

- Perform processing tasks to convert raw data into formats usable by the backscatter mosaicing application.
- Create backscatter mosaic.
- Perform QC on mosaic.
- Deliver to appropriate agency or contact if applicable.

## 6. Procedure

### 6.0 Introduction

This SOP outlines the use of Fledermaus Geocoder Tool Box (FMGT) to QC backscatter data and/or create backscatter products for submission to NGDC. The products that will be archived at NGDC are Generic Sensor Files (GSF) or ALL files, which can be used for further backscatter processing by other interested parties, and a backscatter mosaic, which advertises the data and can be used to reveal general differences in bottom composition. The GSF files and ALL files are the most straightforward point for further processing because they contain both backscatter and processed bathymetry.

### 6.1 Software

The latest version of FMGT can be downloaded on the Hydrossoft website. It is recommended to work on a 64bit machine when possible.

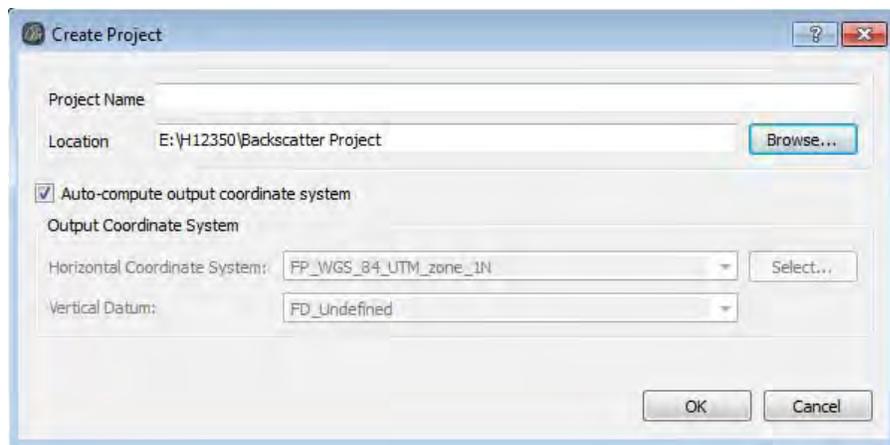
	<h1>Hydrographic Survey Review</h1>	Document #: <p style="text-align: center;">N/A</p>	Rev.: <p style="text-align: center;">3</p>
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## 6.2 Create an FMGT Project

Section 6.3.1 of the Fledermaus Reference Manual clearly outlines the steps to import data into FMGT. This manual can be found in Start > All Programs > Fledermaus - v7 > Manuals. In addition an FMGT training video (129MB) which provides an overview of FMGT can be downloaded from the Hydrosoft website under the documents link. **This video should not be shared outside of NOAA.**

Currently one FMGT project and one mosaic is produced per vessel per survey sheet.

1. Create a Project where there is enough space (approximately  $\frac{3}{4}$  of the backscatter file size): File > Create Project...



- a. Direct FMGT to the project folder with the Browse button
- b. Name the Project
- c. Make sure “Auto-compute output coordinate system” is checked

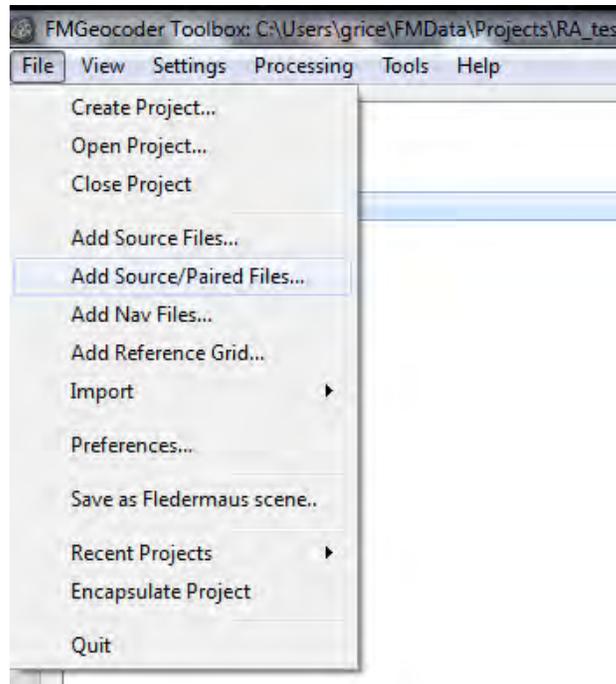
**Note: Geocoder works in projected coordinates.**

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### 6.3 Import lines into FMGT Project

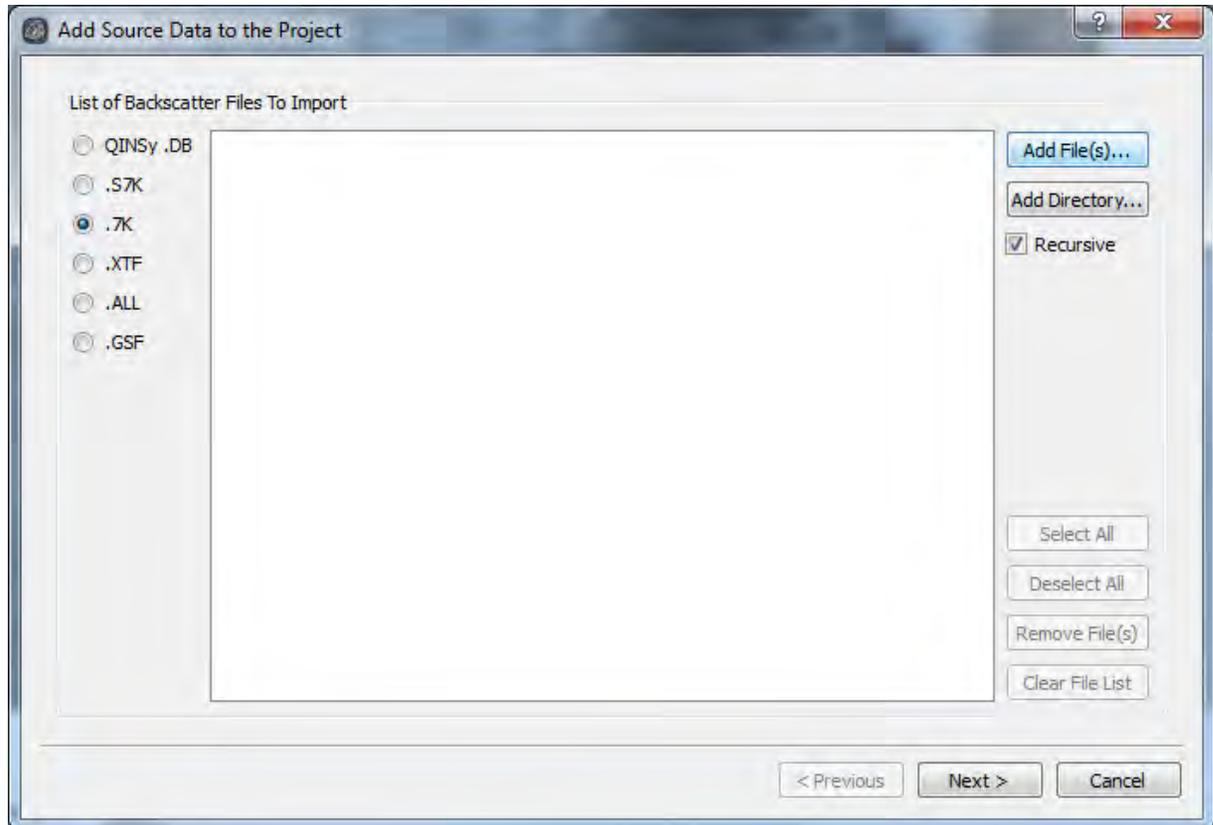
The GSF files are created by combining backscatter files and the processed depth files. Backscatter and bathy data from NOAA vessels are typically \*.all files (Kongsberg with SIS) or HSX / 7K pairs (HYPACK with Reson systems), or \*.sdf files (Klien Side scan with Sonarpro). The ALL files can be imported directly into FMGT because they contain the backscatter and processed depth information. HSX (bathy) files are processed in CARIS, which creates a CARIS HDCS data structure containing the ProcessedDepths file. FMGT combines pairs of 7K files with the HDCS lines based on the files names. SDF files are not currently supported, but are expected to be importable in the future.

1. Select File > Import > Backscatter Files



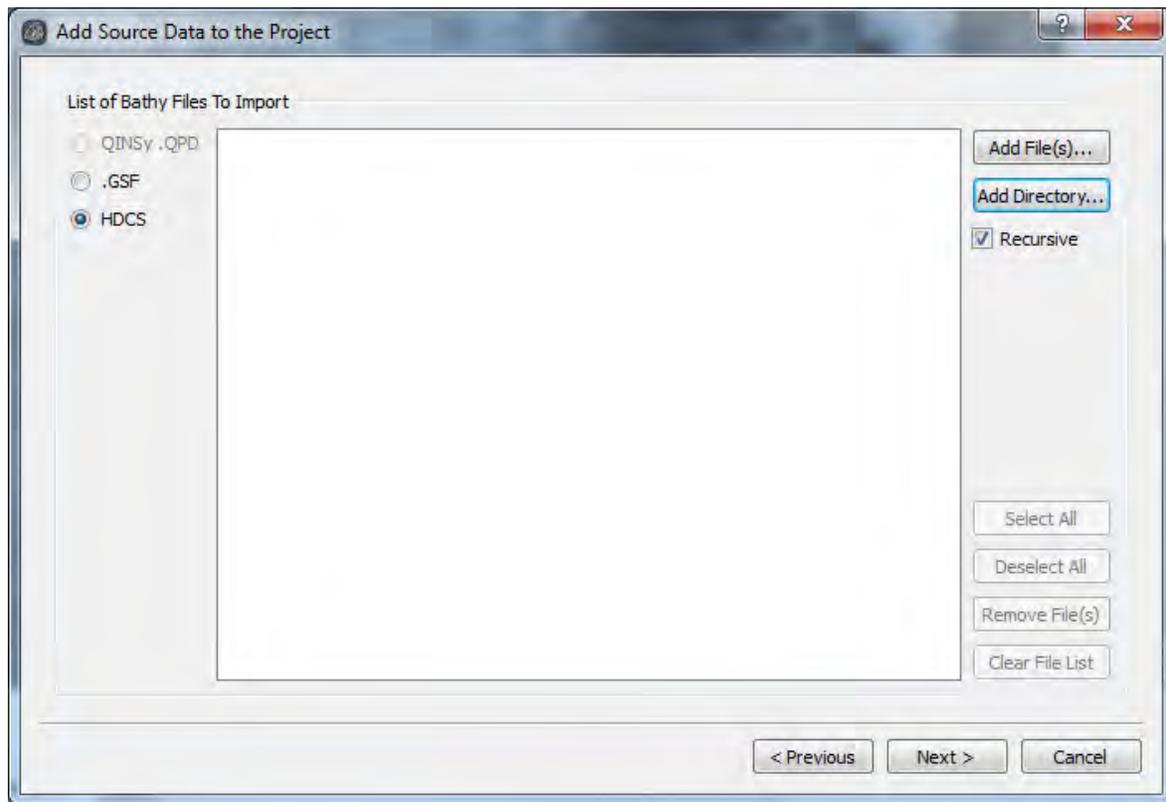
	<h1>Hydrographic Survey Review</h1>	Document #: <p style="text-align: center; font-size: 1.2em;">N/A</p>	Rev.: <p style="text-align: center; font-size: 1.2em;">3</p>
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2. Select “Add File(s)...” or “Add Directory...” to select the 7K files for processing. If the “Recursive” box is checked, subdirectories will be searched too.

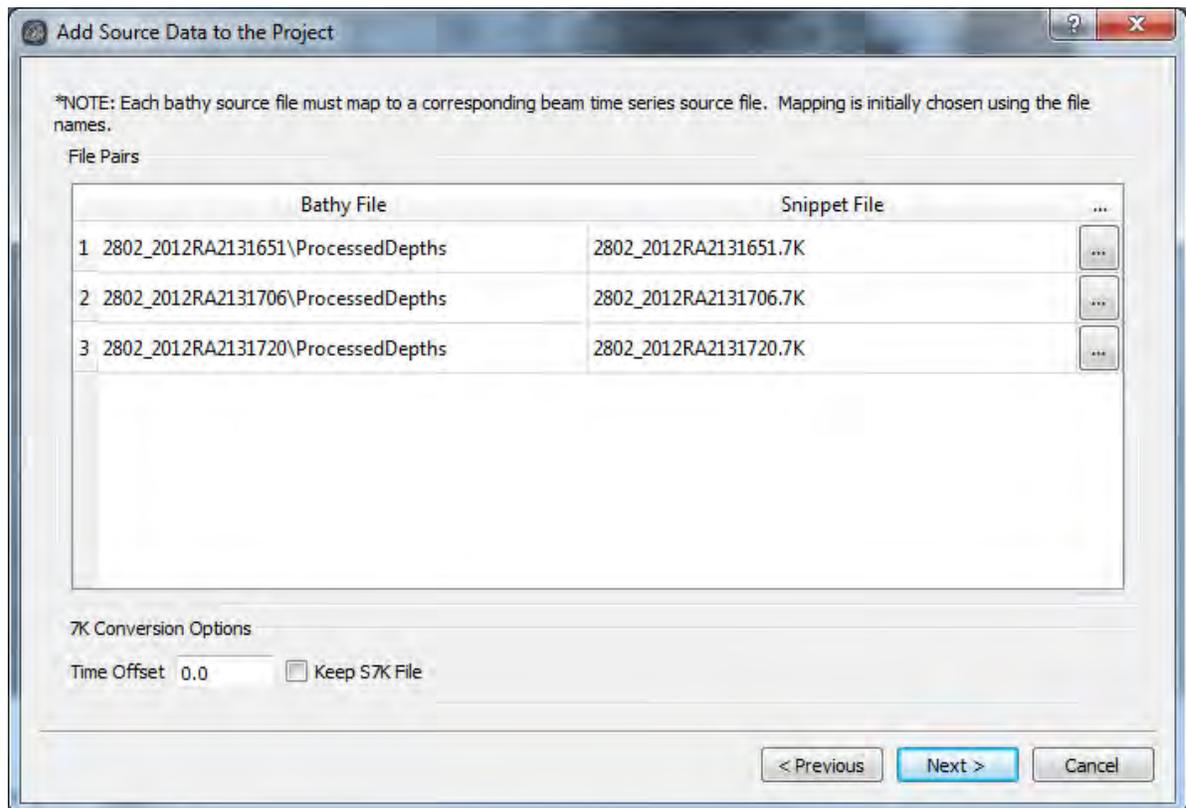


	<h2>Hydrographic Survey Review</h2>	Document #: <p style="text-align: center; font-size: 1.2em;">N/A</p>	Rev.: <p style="text-align: center; font-size: 1.2em;">3</p>
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3. Select “Add Directory...” and select the directory containing the corresponding HDCS lines. You can also select specific lines, but this method is more cumbersome because you need to select the ProcessedDepths file from each line folder. Since FMGT is matching files, it is okay to select a directory that contains more files than the 7k file previously selected. Leave the “Recursive” box checked.



- The files as paired are now displayed. Ensure correct pairing by scrolling through the files. A time offset between the HDCS and 7K files can be provided. This should be “0.0”, but at times the HDCS data appear to have an offset so “-1.0” should be entered instead. There is not currently a way to determine if this offset is needed before processing. If there is a roll artifact in the mosaic, the offset is needed.

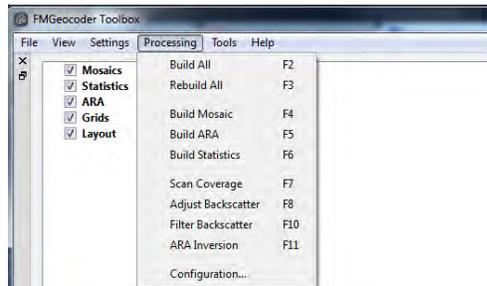


- Select FG\_NAD83 for the Horizontal Coordinate system for the incoming lines, and leave the Vertical Datum as FD\_Undefined.

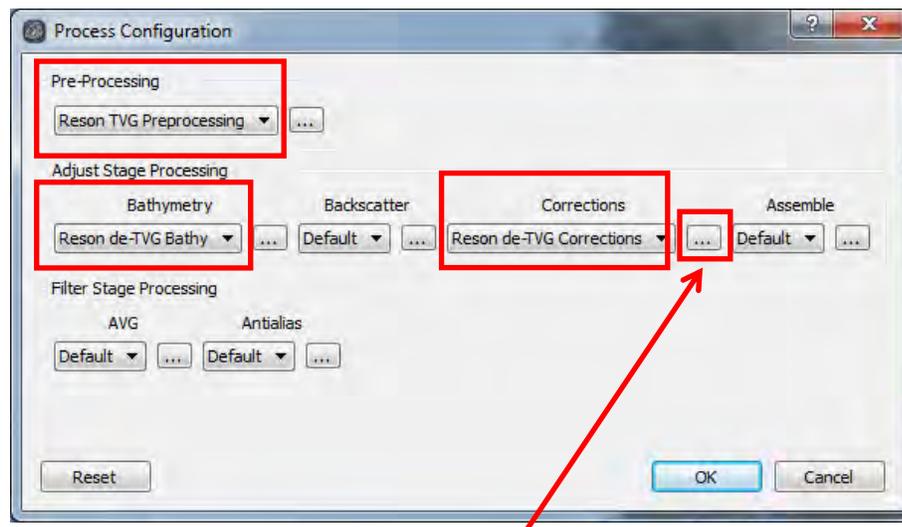
#### 6.4 FMGT Configuration

The FMGT Configuration parameters must be adjusted if processing RESON data because the RESON TVG curve is not correctly implemented in Geocoder. (If processing Kongsberg data skip to step 6.5.) If the user forgets to set the Configuration parameters to the TVG plugin the backscatter may be outside of the calibrated sonar filter range.

1. Select Processing > Configuration...



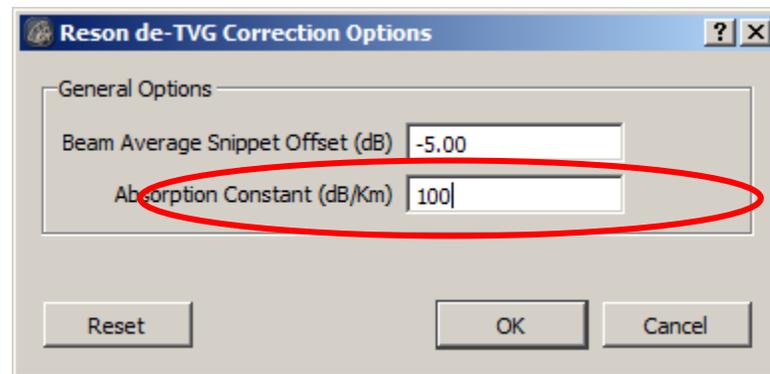
2. For each processing stage, update the plugin to be used. For a Reson system this includes the Pre-Processing, Bathymetry and Corrections stages.



In addition, the Correction stage should be set to ensure a proper absorption value is used for the frequency of the sonar. This value changes as a function of the water properties (see <http://resource.npl.co.uk/acoustics/techguides/seaabsorption/> for further information)

As a guideline, use the following absorption values:

Frequency	Absorption
100kHz	30db/km
200kHz	55db/km
400kHz	100db/km

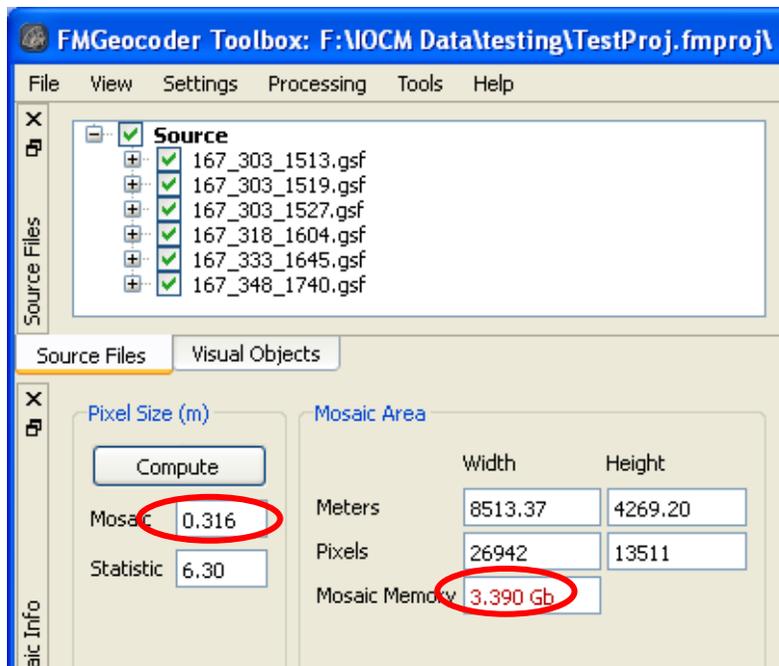


3. Click OK
4. Click OK

### 6.5 Adjust the mosaic size in FMGT

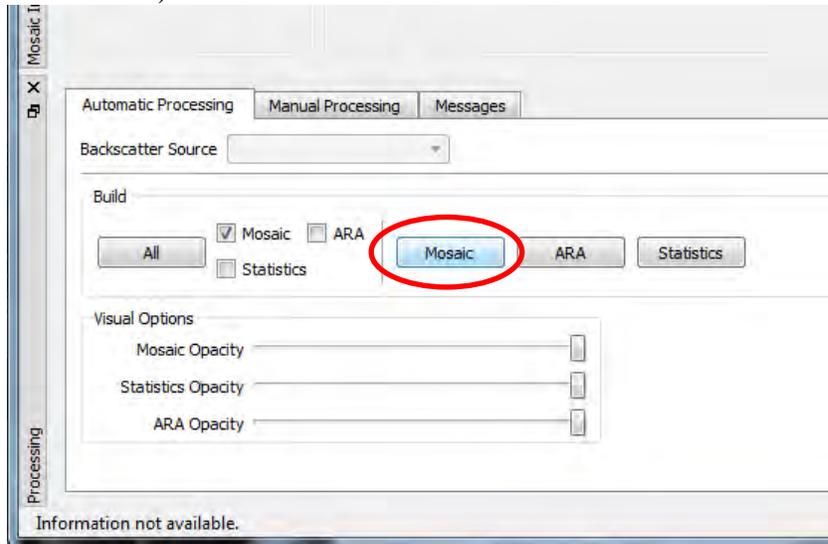
- The current HSD maximum size guideline for backscatter mosaics is 20 MB. This is only a guideline and may be exceeded if necessary. The value is set to 20 MB because it is a reasonable size file to manage (i.e. upload, download, view, etc.)

Adjust the Mosaic resolution, paying attention to the memory required by the Mosaic. The final exported mosaic (tiff) size will be 5% to 10% of the memory used to in FMGT by a single tile. A reasonable starting value for the mosaic resolution is the maximum grid node spacing in a bathymetric surface for the same area. Do not press “Compute” after this value is changed. The “Compute” button is used for estimating the finest resolution.

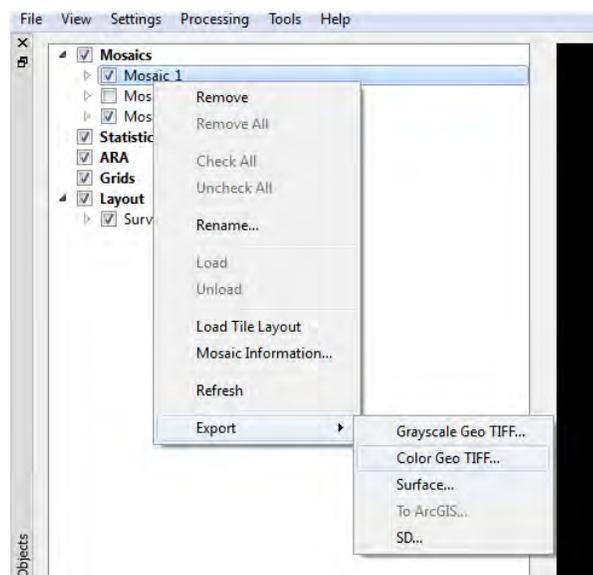


### 6.6 Creating a Mosaic

1. Once data is imported, Configuration parameters are correctly defined, the Mosaic size is set, and either the filter values or a beam pattern is set, press the mosaic button. ( If the data set is large the user may want to create tiles for more efficient processing. See section 6.9 below.)



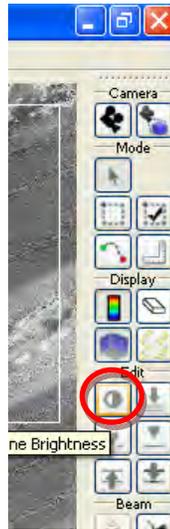
2. Export this mosaic to other formats by selecting the Visual Objects tab, right clicking on the mosaic to be exported and selecting the export type as Color Geo TIFF.



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### 6.7 Adjusting a particular line brightness

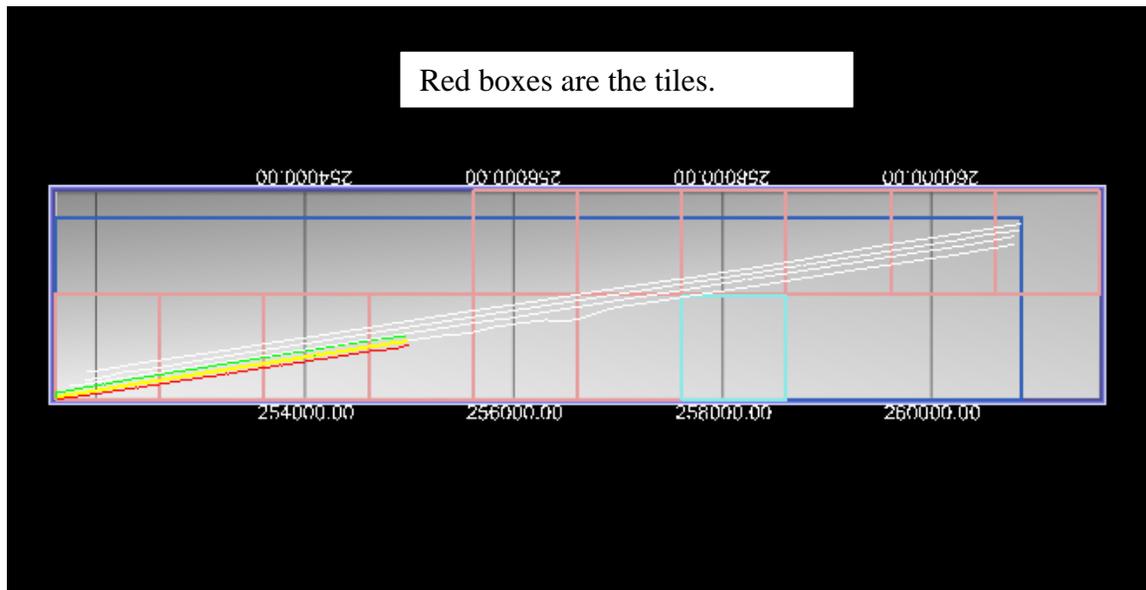
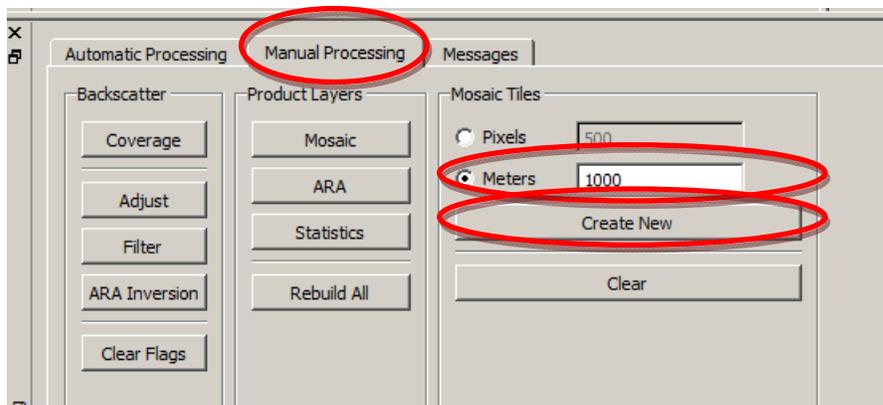
At times a particular line will not match adjacent lines due to misreported systems settings, incorrect absorption, or echosounder saturation. Select the line to be adjusted and press the brightness button. Adjust the brightness with the slider bar in the Backscatter Adjustment window.



### 6.8 Creating Tiles (optional)

For very large data sets or long track line surveys users can create tiles to break up the data for more efficient processing. Be aware, that the memory size for processing is for each tile, not for the whole mosaic.

- a. Select the Manual Processing tab.
- b. Create a tile size based on Pixels or Meters.
- c. Click Create New to view the tiles. To adjust the tile size, enter in a new value and click Create New again.

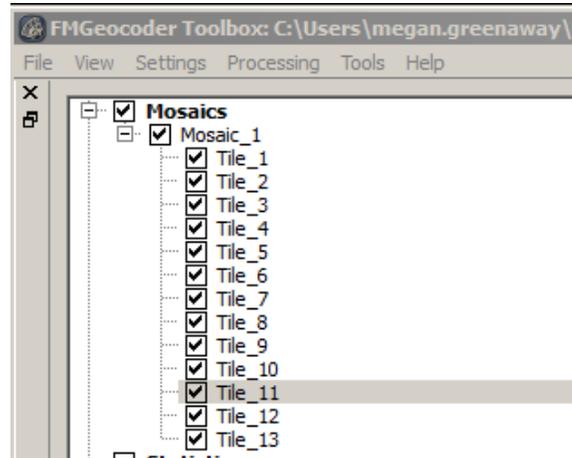


- d. Continue with the mosaic process as described in section 6.7 to create mosaics for all the tiles. (To create mosaics for only selected

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tiles use the Select Mosaic Area function described in section 6.6 above.)

The result is one mosaic per tile.



## 6.9 Troubleshooting

If files fail to convert properly contact Fledermaus support at <http://www.qps.nl/display/fledermaus/support>. If a file is oversized (a common problem on 32bit machines) or you see artifacts of interest in your mosaic contact Glen Rice at the IOCM center.

## 6.10 Documenting your Process

Metadata should accompany backscatter products so the products can be recreated. Include the name of processing software used with version number, survey number, processor name, plugins used, mosaic resolution, filtering or beam pattern information (if applicable), and histogram range for the mosaic in a text document and file along with the processed backscatter data (GSF and/or mosics).



# Reson Backscatter Acquisition

Document #:

Rev.:

3

Title:

SOP Guidelines for Reson 7000 Series Backscatter Acquisition

Page #:

1 of 6

## PROCESS OWNER

This Process is owned by the IOCM Center

SOP Custodian: Glen Rice

## REVISION HISTORY

REV	Description of Change	Author	Effective Date
0	Initial release	Glen Rice	3/1/2012
1	Updated to reflect field experience	Glen Rice	5/5/2012
2	Updated with comments and feedback	Glen Rice	6/14/2012
3	Updated for Hypack Datagram V2	Glen Rice	3/11/2013

## REFERENCE DOCUMENTS

Document Number	Document Title
	Saturation Monitor Manual
	Reson Backscatter Processing SOP

	<h1>Hydrographic Survey Review</h1>	Document #: <p style="text-align: center;">N/A</p>	Rev.: <p style="text-align: center;">3</p>
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### 1. Purpose

This document provides information for the operation of a 7000 series Reson Multibeam during hydrographic survey to also successfully collect backscatter.

### 2. Scope

Applicable to NOAA field units with a 7000 series multibeam in the 2013 season.

### 3. Definitions and Acronyms

### 4. Flowchart

### 5. Responsibilities

### 6. Procedure

#### 6.1 General

These are guidelines for the setup and acquisition of a Reson 7000 series multibeam using Hypack. The goal is to ensure that Reson Snippets are recorded with the sonar settings at the time of acquisition. Snippets are recorded in the Hypack 7K file if the correct setup is used in Hypack. The Hypack 7K file must be paired with the HSX file as the 7K file does not include navigation

#### 6.2 Setup

##### A. Recording Reson Snippets in Hypack

The following settings should be entered on the Hypack/Hysweep interface:

1. In the Administrator window go to Hysweep Hardware
2. Select the 7125 device and go to the Setup button (in center of the window)

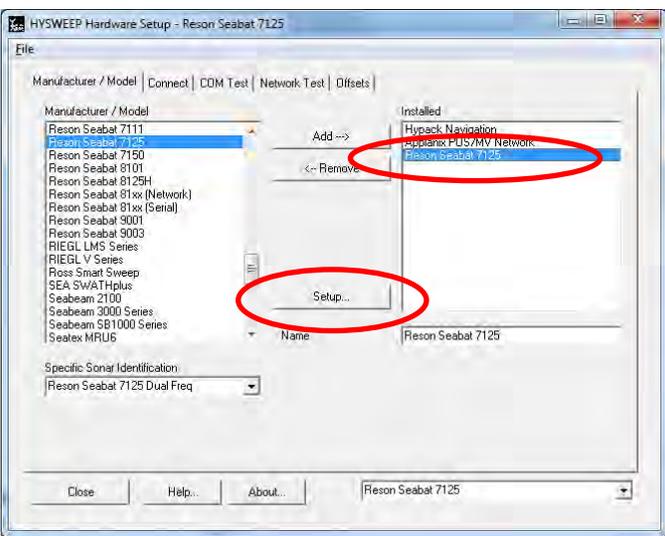


Figure 1 Setup Reson data flow in Hypack

3. Toggle on “Side Scan Option”, “Use Snippets” and “Log Seabat Datagrams”
4. Under 7k Drivers select Datagram Version 2.

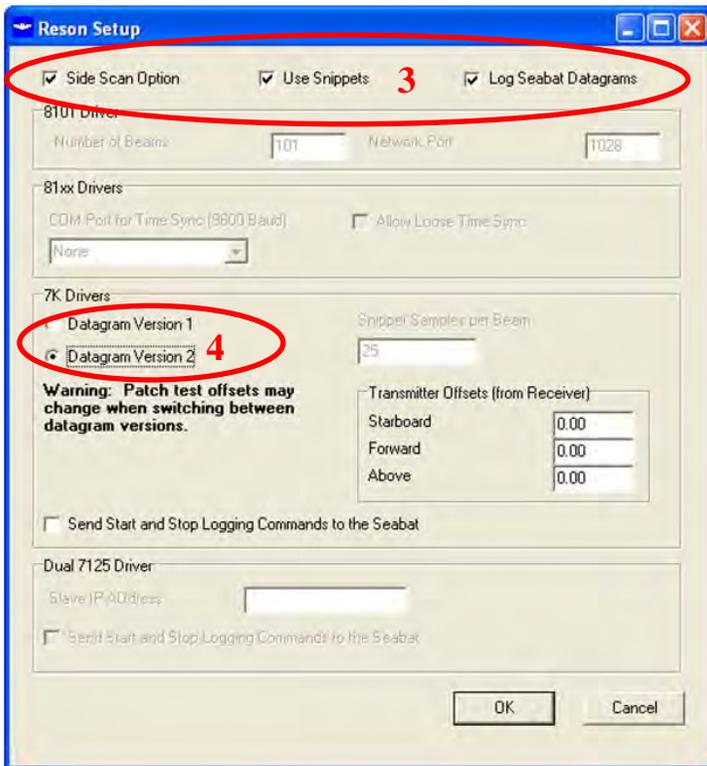


Figure 2

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As a general aside, there are differences between the “Datagram Version 1” and “Datagram Version2” records. These are the records that HYPACK requests from the Reson machine. Version 1 records consist of the 7000 (sonar settings) record, 7004 (beam configuration) record, 7006 (bottom detection information) record, 7007 (side scan) record, and 7008 (snippets) record. Reson has encouraged switching from some of these records to newer versions. The Version 2 records (as termed by HYPACK) are the 7000 record, 7006 record, 7007 record, 7027 (raw bottom detection and configuration) record, 7028 (dynamic snippets) record, and 7503 record (sonar settings extended). The primary advantage of the Version 2 records for backscatter is that the snippet size is set dynamically (7028 record), but this record is not currently supported in post processing software. The usage of the 7027 record means the bottom detection must be corrected for the receiver to transmitter offset, but Hypack is collecting this information through the 7503 record so it is set automatically and does not need to be configured by the user. The 7027 record also contains a real time estimate of uncertainty for each bottom detection.

### B. Reson Setup

When acquiring data through HYPACK, HYPACK handles which records are requested, so no specific setup different than normal survey is needed to ensure proper acquisition for backscatter. It is recommended that the “Snippet Control” on the Reson machine be secured to ensure no conflicts with HYPACK. This is found in Configuration > Data Display & Format. In the Snippets Control section, ensure “Enable Snippets” is unchecked.

### C. The Saturation Monitor

Configuration and setup of the Saturation Monitor is covered in the Saturation Monitor Manual in Satmon under General > Documentation. Basic usage, assuming correct setup and configuration has already occurred, is accomplished with the following steps.

1. Start the Saturation Monitor from Start > All Programs > Pydro > Contributions > Satmon.
2. Select Setup > From Network...
3. Press the Start button at the bottom of the Satmon Window.
4. When finished, press the same button now labeled as Stop.
5. Use General > Exit to close the program.

The purpose is to keep the Reson from saturating, and this is accomplished by keeping the Reson set so the Saturation Monitor plots are below the displayed zones.

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### 6.3 Multibeam Operation

The adjustment of multibeam settings should be minimized to limit the likelihood of artifacts in the resulting backscatter products, but changes can be made. Changes in depth or bottom type will inevitably require setting changes for good bottom detections which is also required for good backscatter. Sonar setting guidelines are as follows:

Power	190 to 210
Gain	0 to 83
Absorption	Follow Ops instructions, but okay to adjust
Spreading	30
Pulse Length	Set to 100 microseconds or greater

The sonar operator can change the power, gain, absorption and spreading during survey operations to maintain good bottom detection throughout the swath without affecting the backscatter (this is because the system is not saturated).

Changing the pulse length still affects the backscatter, Instead:

- Increase the spreading to improve the outerbeam detections.
- Decrease the power to decrease saturation.

Lower the power slowly, allowing for the projector capacitors to discharge and the output power to be close to the recorded power.

Bottom detection quality should be monitored as with a normal hydrographic survey, but in addition the Saturation Monitor should be used. Both displays are useful (found under the plot menu) and provide slightly different information.

The “Gain vs Receive” plot (Figure 3 left) shows all the bottom detections as a function of the gain applied to the sounding and the received (uncorrected) backscatter level, and they are displayed with the saturation curve. Soundings below the curve are estimated to be in an unsaturated (and linear) state. Changing the absorption and spreading will make the soundings move up and to the right, but will also spread the soundings out along the horizontal axis. This is because the outerbeams, which are the soundings more to the right, have more gain applied because they are further away and so have more time varying gain applied. Power will move the sounding up and down vertically because it effects the backscatter strength (vertical axis) but not the gain (horizontal axis).

The “Beam vs Percent Nonlinear” plot displays by beam (horizontal axis) the received magnitude relative to the maximum allowable magnitude for the applied gain as defined by the saturation curve. In a nut shell, keep the histogram below the red line and below



Title:

**SOP Guidelines for Backscatter Acquisition Setup and Execution**

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also the yellow line when possible. Changing the absorption and spreading will affect the outer beams more than the inner beams, but power and gain will change them all together.

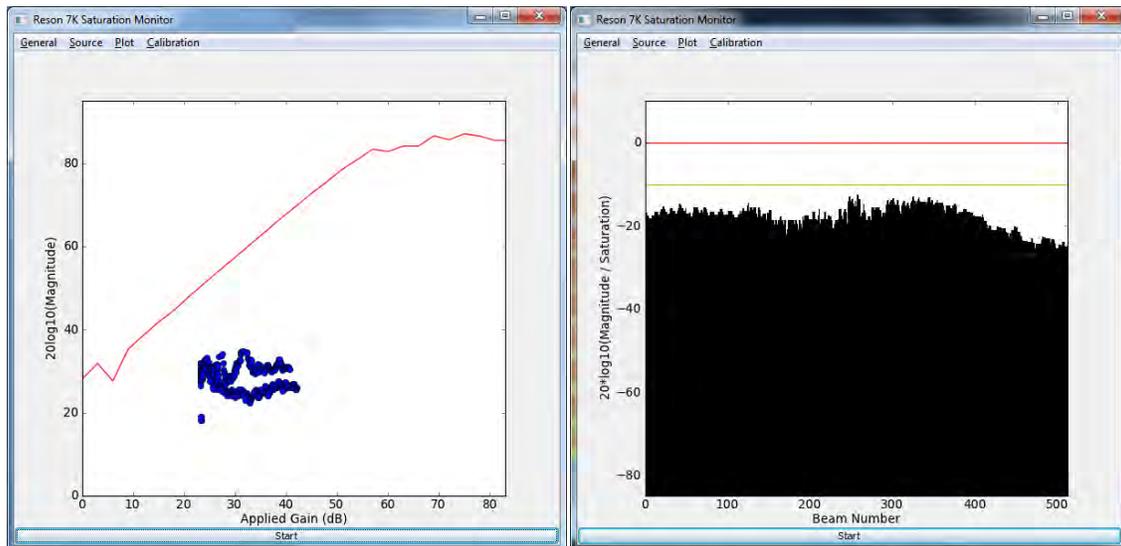


Figure 3

Power will lower the whole histogram, while absorption and spreading will help push up the outer beams.

## 6.4 Quality Check

To ensure that data is actually being collected, one line from each vessel from each day should be processed in Fledermaus Geocoder Toolbox (FMGT). Please see the Processing SOP for how to perform this check.

**Metrics**

**Quality Records**

**Form(s)**

**Table 4-9. Uncertainty values for use in CARIS with vessels equipped WITH an attitude sensor**

Entry in HVF		1 Sigma Recommended Value (Units)
<b>Attitude</b>		
Gyro error (heading)	for POS/MV 320	0.02 deg
Heave (amplitude)*	for POS/MV 320	5 %
Heave *	for POS/MV 320	0.05 m
Roll	for POS/MV 320	0.02 deg
Pitch	for POS/MV 320	0.02 deg
Nav. position	0.5 to 2.0 depending on differential quality	1 m
<b>Sonar timing</b>		
Nav. Timing**	Integration dependent	.01 (.005)s
Gyro Timing**	Integration dependent	.01 (.005)s
Heave Timing**	Integration dependent	.01 (.005)s
Pitch Timing**	Integration dependent	.01 (.005)s
Roll Timing**	Integration dependent	.01 (.005)s
<b>Vessel variables</b>		
Offsets (x, y, z)	mm to dm depending on measurement accuracy	m
Vessel speed	0.03 plus average current in the area (used for dynamic draft table entry)	m/s
Loading	Range = 1cm to 30cm, dependent on vessel, fueling frequency and frequency of draft measurement.	m
Draft	Range = 1cm to 20cm, depends on how accurately draft may be read (sight glass, six inch draft marks, etc)	m
Delta draft	Range = 1cm to 3cm, dependent on methodology and magnitude of effect	m
MRU alignment (yaw)	Uncertainty in the patch test offset value determined for transducer yaw. (Standard deviation of several calibration iterations) [Multibeam boats only]	<1 deg
MRU alignment (roll/pitch)	Uncertainty in the patch test offset value determined for transducer pitch/roll. (Standard deviation of several calibration iterations) [Multibeam boats only]	<1 deg
Entry in TPE Controller Window		1 Sigma Recommended Value (Units)
<b>Tides</b>		
Measured	Range (0.01m - 0.05m) dependent on gauge accuracy and duration of deployment	m
Zoning (discrete)	Range (0.01m - 0.40m) dependent on distance from gauge, range of tide, rate of tide change, and meteorological factors. Value provided by CO-OPS in the tide document in the project instructions package.	m
Zoning (TCARI)	TBD	m
<b>Sound Speed</b>		
Measured	Range (0.5m/s to 4 m/s) dependent on spatial and temporal variability Use 1 m/s for casts every 15 min or less Use 4 m/s for casts every 4 hours	m/s
Surface	Range (0.2 m/s to 2 m/s): dependent on surface sound speed gradient	m/s
<p>*Note: For heave accuracy must use the larger value of 0.05m or 5%.                      **Note: All timing depends on integration: serial connections = 0.01s, ethernet with precise timing = 0.005s.</p>		

**Table 4-10. Uncertainty values for use in CARIS with singlebeam vessels WITHOUT an attitude sensor**

Entry in HVF		1 Sigma Recommended Value (Units)
<b>Attitude</b>		
Gyro error (heading)	Dependant on crab angle and boat handling conditions	5-20 deg
Heave (amplitude)	N/A	0 %
Heave	Based on heave experienced in the field	0.707*(heave amplitude) m
Roll	N/A	0 deg
Pitch	N/A	0 deg
Nav. position	0.5 to 2.0 depending on differential quality	1 m
<b>Sonar timing</b>		
Nav. Timing	Integration dependent	.01 s
Gyro Timing	N/A	0 s
Heave Timing	N/A	0 s
Pitch Timing	N/A	0 s
Roll Timing	N/A	0 s
<b>Vessel variables</b>		
Offsets (x, y, z)	mm to dm depending on measurement accuracy	m
Vessel speed	0.03 plus average current in the area (used for dynamic draft table entry)	m/s
Loading	Range = 1cm to 30cm, dependent on vessel, fueling frequency and frequency of draft measurement.	m
Draft	Range = 1cm to 20cm, depends on how accurately draft may be read (sight glass, six inch draft marks, etc)	m
Delta draft	Range = 1cm to 3cm, dependent on methodology and magnitude of effect	m
MRU alignment (yaw)	N/A	0 deg
MRU alignment (roll/pitch)	N/A	0 deg
Entry in TPE Controller Window		1 Sigma Recommended Value (Units)
<b>Tides</b>		
Measured	Range (0.01m - 0.05m) dependent on gauge accuracy and duration of deployment	m
Zoning (discrete)	Range (0.01m - 0.40m) dependent on distance from gauge, range of tide, rate of tide change, and meteorological factors. Value provided by CO-OPS in the tide document in the project instructions package.	m
Zoning (TCARI)	TBD	m
<b>Sound Speed</b>		
Measured	Range (0.5m/s to 4 m/s) dependent on spatial and temporal variability Use 4 m/s for casts every 4 hours For less frequent casts, estimate variability of the area and use an appropriate value	m/s

## Customized Attribute Equivalencies CARIS – HYPACK - Pydro

### NOAA Required Attribution:

CARIS & HYPACK	Pydro	Comments
descrip	Chart -?	Description
remrks	Remarks	Remarks
recomd*	Recommendations	Only required for new and charted feature disprovals
sftype*	Keyword==ATON or AWOIS DTON Flag	Special Feature Type. Only required for special feature types.

\*Conditional attributes

### NOAA Discretionary Attribution:

CARIS & HYPACK	Pydro	Comments
asgmt	Keyword==Assigned	Assignment Flag
images	Images	Images
keywrđ	Keyword	Customized keyword
prmsec	Status	Primary/Secondary status
acqsts	Investigate & Resolved Flags	Acquisition status
invreq	Remarks	Investigation requirements
prkyid	NA – CARIS and HYPACK only	Primary key ID – supports manual correlation in CARIS and HYPACK
userid	DispName	Unique ID

## Combining Grid Requirements

### 1. OVERVIEW

The goal of this document is to create a combined surface to be referenced while conducting data analysis and quality assurances during the SAR process. It is best to combine the source grids using the program CARIS BDB and apply the appropriate combining rules and use the appropriate conflict rule file (\*.crfx).

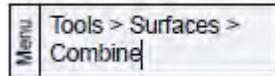
### 2. PROCEDURE

The combining process is used to combine multiple source grids into a new output grid to be stored locally or on a database server. The bathymetric grids are combined when there are adjacent or overlapping surfaces that one intends to merge into one continuous and complete grid. The resolution of the single combined grid is usually combined at the coarsest resolution of the source grids. The intent is to maintain the shoalest depths from the source grids, incorporating to a coarser resolution grid. The combined grid is considered a product surface such that soundings may be extracted for comparison, conduct quality assurances of the gridded data, and also for generating the HCell products. Overlapping areas are de-conflicted with the application of user-defined rules. The user defined rules are referenced in a conflict rule file named "BDB\_ConflictRules.crfx." This file is normally located in the "Reference" sub-directory within the working "AHB" directory. The conflict file rules are based upon the following criteria and in this order:

1. Depth is least
2. Resolution is least
3. Uncertainty is least

### 3. WORK INSTRUCTIONS (SOP)

To combine surfaces:



1. Open the surfaces that are selected for combining.
2. Select the Combine command. The Combine Surfaces dialog box is displayed.

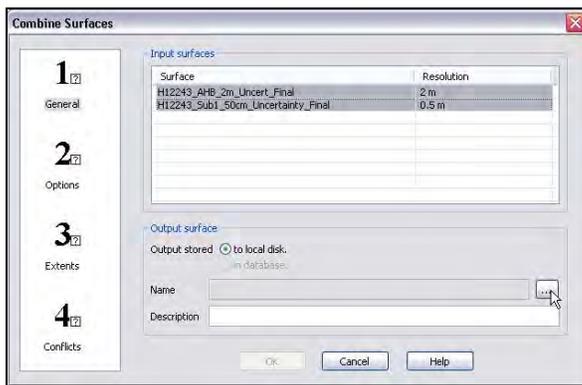


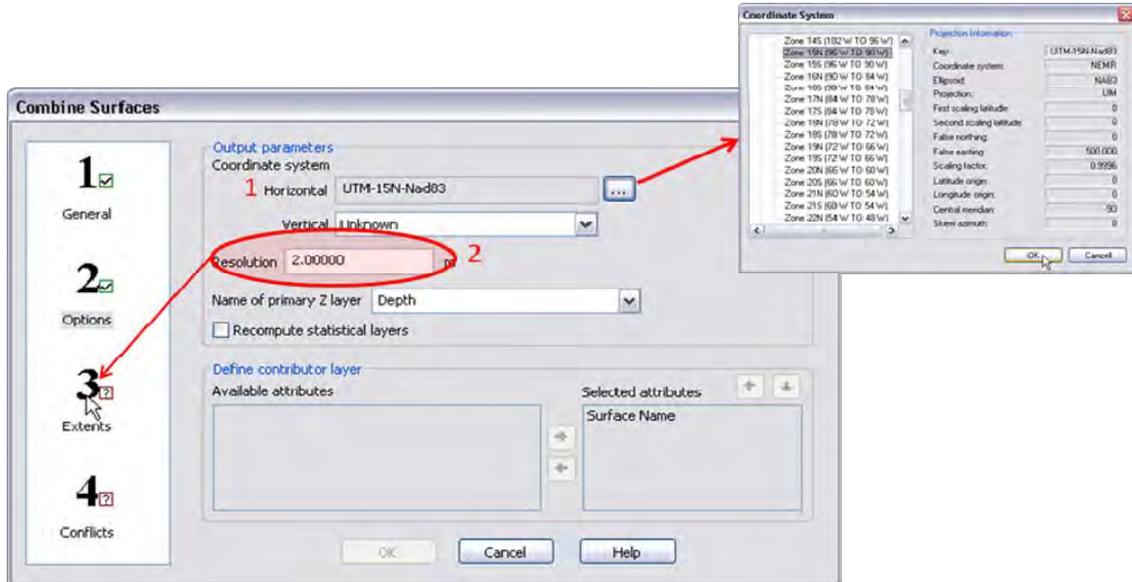
Figure 1: Combined Grid, 1

3. In the *Input Surfaces* field, while pressing the <Ctrl> key, select the surfaces to be combined.

4. Select **Output stored to local disk** to save the surface on the local machine
5. Click Browse (...) to select the Name and location for the output surface.
6. Click check 2: Options.

Click **Browse (...)** for the selection of the proper **Horizontal** projection.

7. Select the appropriate resolution of the combined surface: for the SAR, this will be the resolution of the coarsest grid (i.e. if combining a 50cm, 1m and 2m grid the appropriate resolution will be 2m. (Reference HTD 2010-6)
8. Next, Click 3: Extents



**Figure 2: Combined Grid, 2**

9. Using the cross hairs, select the extent of the combined grid in order to minimize the “white space” that will be included in the combined grid



**Figure 3: Combined Grid, 3**

10. Next click, 4: Conflicts

11. In the Conflicts window select > tag Import, then navigate to the following directory within the survey data directory structure: AHB\_HXXXXX\Reference and select the file named “BDB\_ConflictRules.crx.”

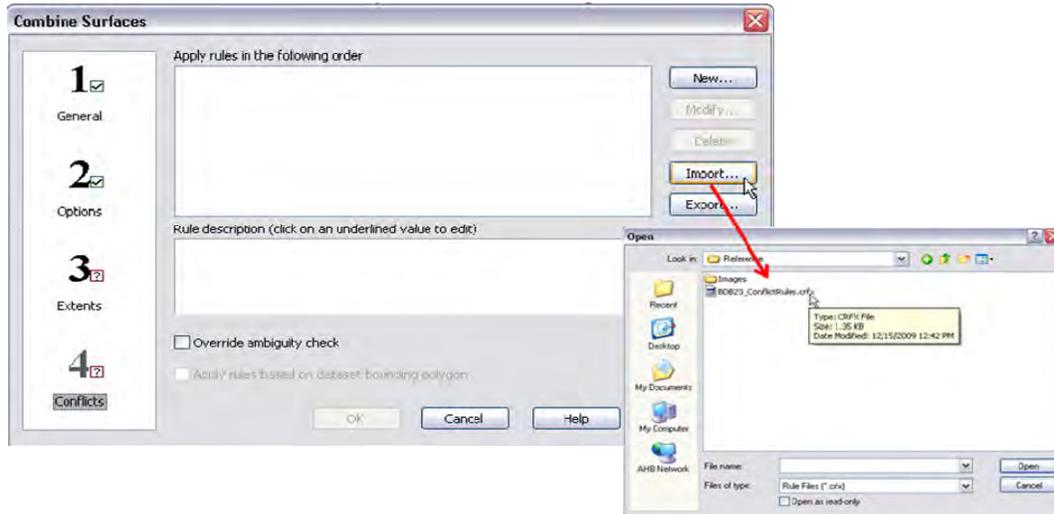


Figure 4: Combined Grid, 4

12. Once one has selected the conflict rules to apply, the “OK” button will become active. Click the “OK” button to execute the combined grid process

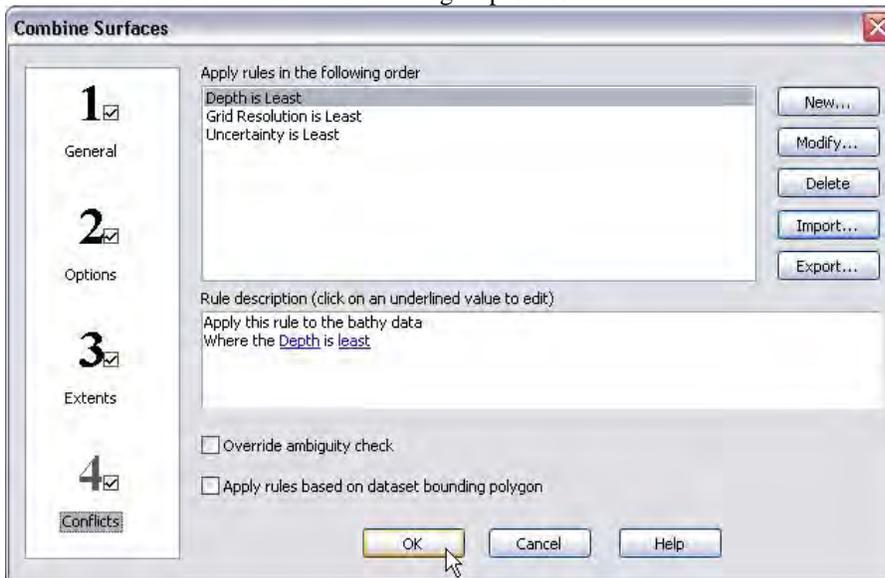


Figure 5: Combined Grid, Finishing

#### 4. REFERENCE DOCUMENTS

- CARIS HIPS&SIPS User Manual
- AHB’s *BDB\_ConflictRules.crx* file (XML format)

```
<?xml version="1.0" encoding="UTF-8"?>
```

```
<CARIS_RULES_EXPORT>
```

```
<Rules operator="and">

  <Rule name="Primary Z Value is Least" version="1.0" conditionsOperator="and"
exceptionsOperator="or">

    <RuleElement name="Apply this rule to the bathy data" elementType="RULETYPE"/>

    <RuleElement name="Where the primary Z value is &lt;%least%&gt;"
elementType="CONDITION"/>

  </Rule>

  <Rule name="Grid Resolution is Least" version="1.0" conditionsOperator="and"
exceptionsOperator="or">

    <RuleElement name="Apply this rule to the bathy data" elementType="RULETYPE"/>

    <RuleElement name="Where the attribute &lt;%acronym%&gt; is &lt;%least%&gt;"
elementType="CONDITION">

      <RuleValue name="class GORuleValueAttributeAcronym">

        <Value>SurfaceResolution</Value>

      </RuleValue>

      <RuleValue name="class CSupersedeAttributeCompareCondition">

        <Value>LEAST</Value>

      </RuleValue>

    </RuleElement>

  </Rule>

  <Rule name="Uncertainty is Least" version="1.0" conditionsOperator="and"
exceptionsOperator="or">

    <RuleElement name="Apply this rule to the bathy data" elementType="RULETYPE"/>

    <RuleElement name="Where the &lt;%attribute%&gt; is &lt;%least%&gt;"
elementType="CONDITION">

      <RuleValue name="class GORuleValueComboEntry">

        <Value>Uncertainty</Value>

      </RuleValue>

      <RuleValue name="class CombineBandCondition">

        <Value>LEAST</Value>

      </RuleValue>

    </RuleElement>

  </Rule>
```

</Rules>

</CARIS\_RULES\_EXPORT>

**Ellipsoidally Referenced Surveys**  
Standard Operating Procedure

Corey Allen
Manager / Process Owner Approval

**Revision History**

Date	Revision Description (Reason/What)	Updated by
3/7/2011	New Document	JCA
4/3/2012	Minor Edits	JCA
2/1/2013	Minor Edits	KRW

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## 1. OVERVIEW

This SOP outlines processing procedures to process an Ellipsoidally Referenced Survey (ERS). Any errors or concerns with the technical information herein should be addressed to Corey Allen ([Corey.Allen@noaa.gov](mailto:Corey.Allen@noaa.gov))

## 2. GLOSSARY OF PROCESSING TECHNIQUES

***Applanix IN-Fusion Single Baseline “SingleBase”*** - One dedicated base station is used to process a tightly coupled solution for short base line processing up to approximately 20km. The base station may be user-installed or downloaded from the various available networks (CORS/IGS/SOPAC). Ephemeris corrections should be downloaded to obtain to highest level of precision of ephemeris available at the time of processing (e.g. Ultra-Rapid, Rapid, Precise).

***Applanix IN-Fusion Smartbase*** – Smartbase processing is based on Trimble VRS technology, the virtual reference station solution that uses a network of user-installed or continuously operating reference stations to compute a set of correctors for the roving receiver anywhere within the network. Smartbase processing requires a minimum of four reference stations surrounding the rover, but distance to the nearest reference station can be extended to 70km.

***Applanix IN-Fusion PPP*** – Precise Point Positioning is a processing method that provides positioning accuracies on the order of a few decimetres without needing a reference station. This application is useful when a reference station cannot be found or installed within allowable distance tolerances.

### Acronyms

SBET—Smooth Best Estimate of Trajectory

RINEX—Receiver Independent Exchange Format

POSPac—Position and Orientation System Post-Processing Package

QC—Quality Control

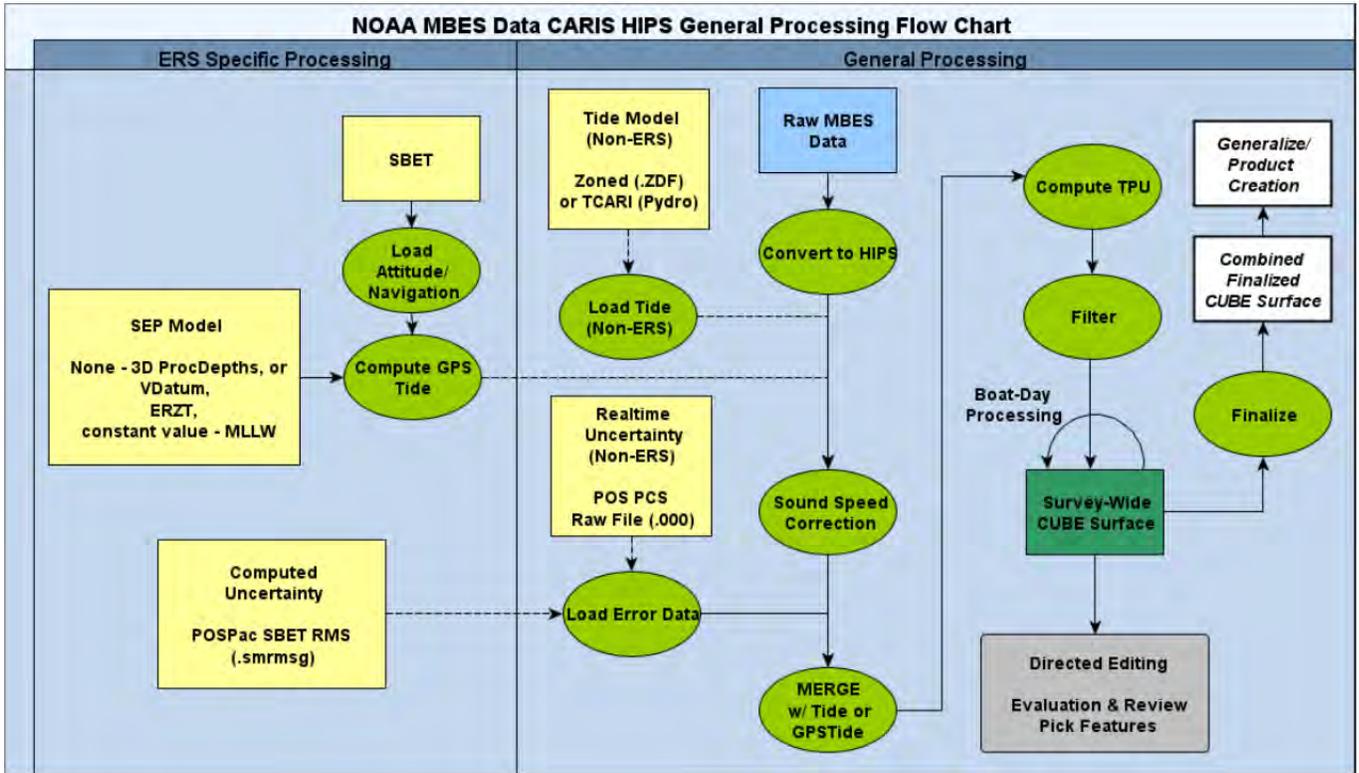
RMS—Root Mean Squared

GNSS—Global Navigation Satellite System

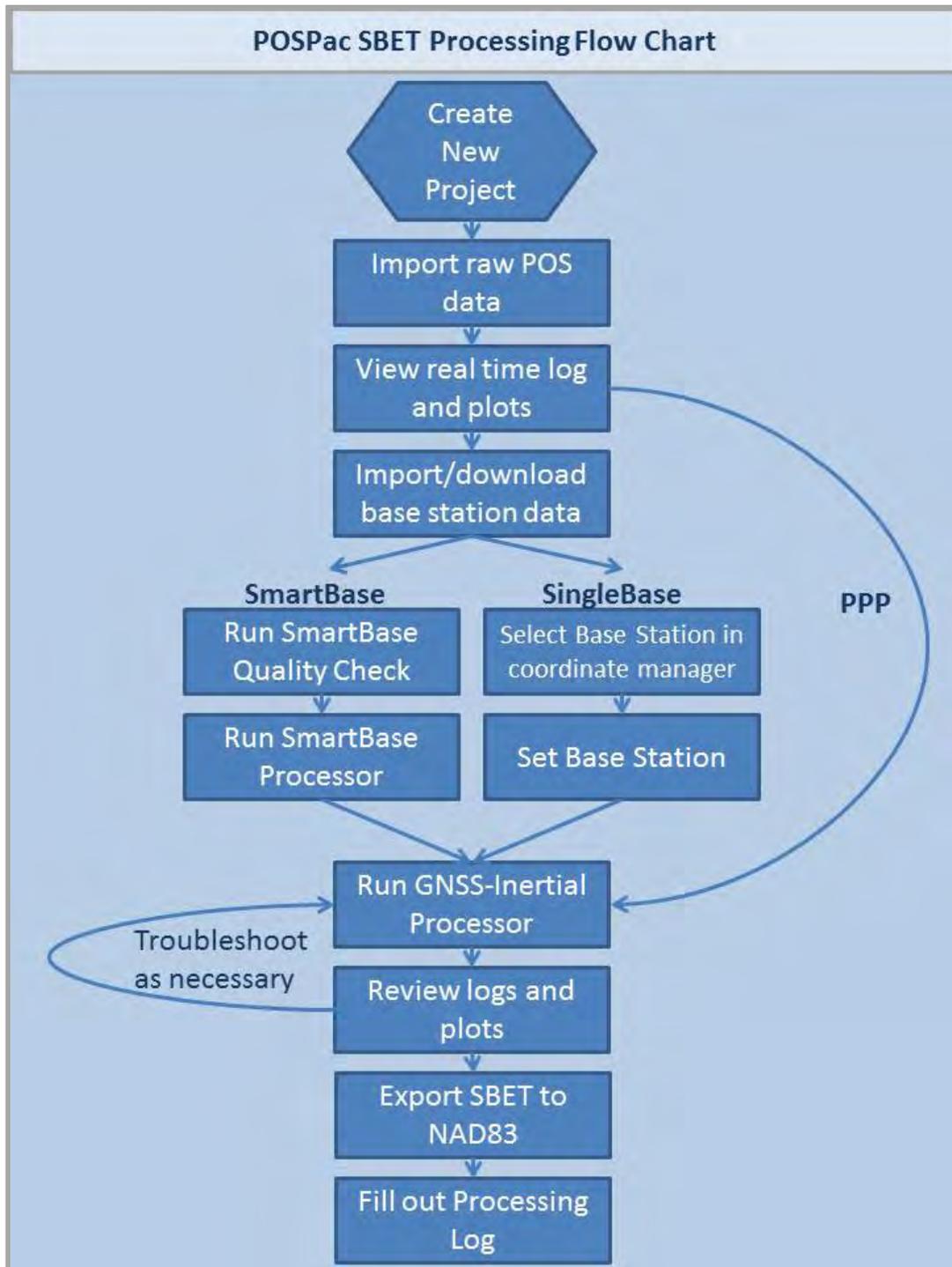
PPK—Post processing kinematics

### 3. FLOWCHART

The following figure shows the NOAA MBES Data CARIS HIPS General Processing Flow Chart



The following figure shows the POSpac SBET Processing Flow Chart



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***CARIS HIPS:***

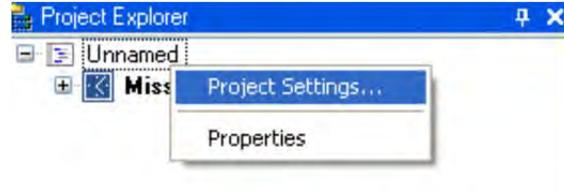
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***ANCILLARY:***

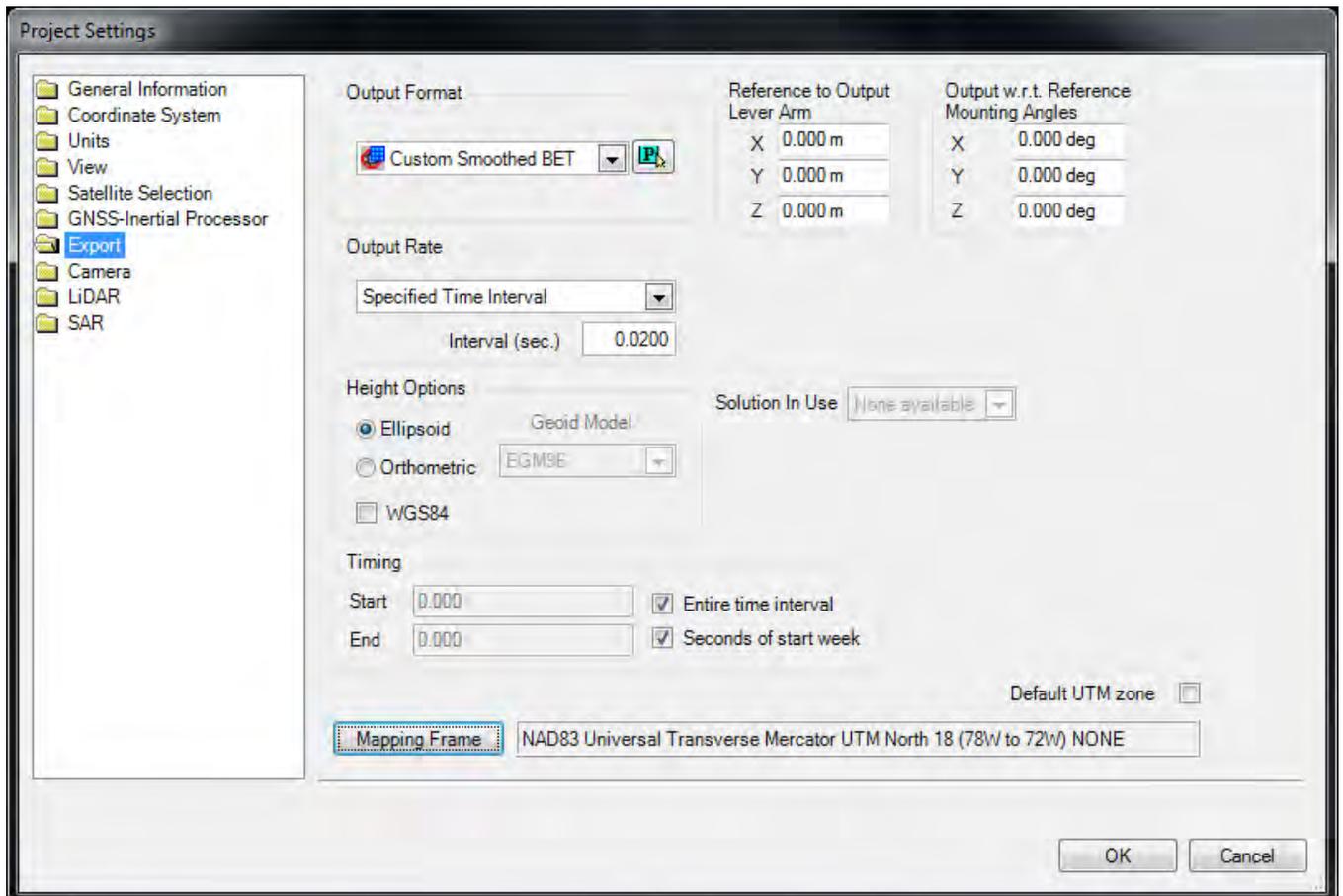
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## CREATING A TEMPLATE TO USE IN POSPAC 6.1

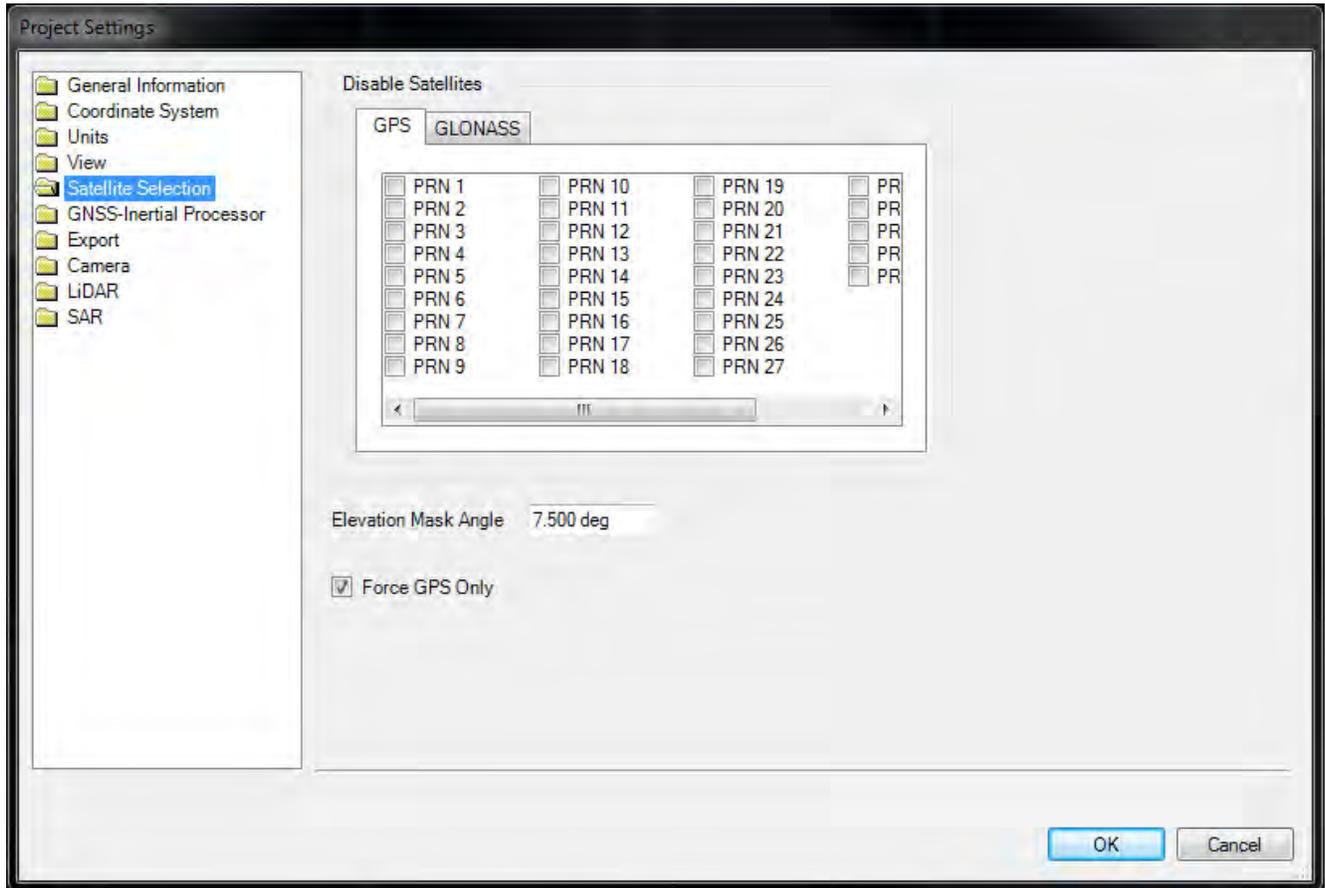
- File, New Project, double click on <Blank Template>
- Under Project Explorer, right mouse click on Unnamed and select Project settings



- Navigate to the Export tab and change the output format to “Custom Smoothed BET” with an output rate “specified time interval” of 0.02 seconds.
- Unclick the “Default UTM Zone box. Click on Mapping Frame button. Set the Datum to NAD83 and select the appropriate UTM Zone. NOTE: You will need to save a separate template for each UTM Zone data is collected in.

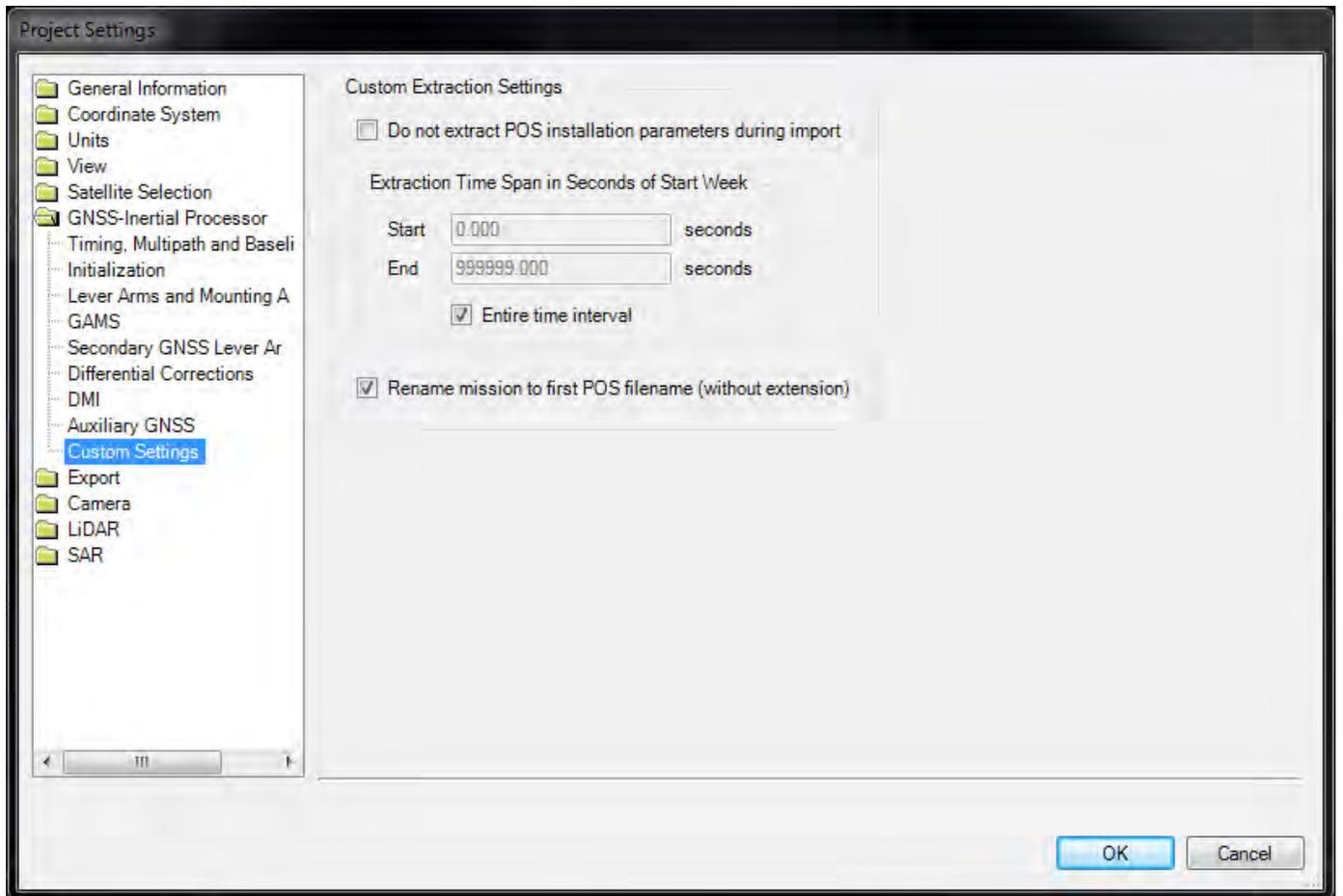


- Navigate to the Satellite Selection tab and click on the “Force GPS Only”

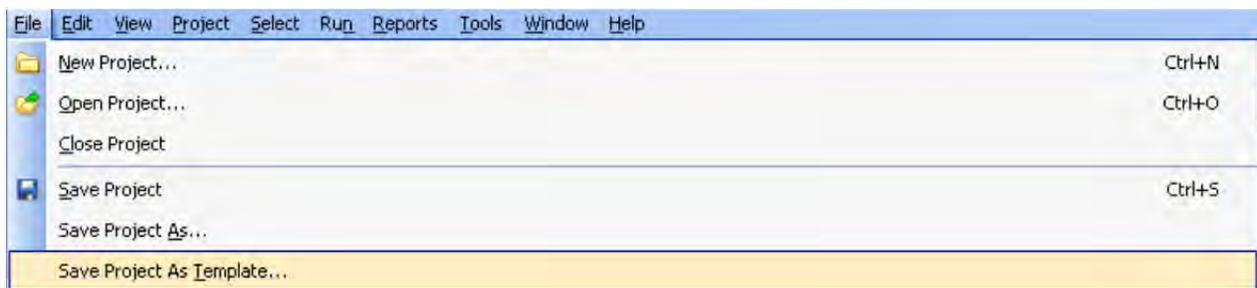


**NOTE:** If this is not done, GLONASS data will be downloaded and used in the SBET solution. Base stations that have GLONASS data will display as lime green in the plan view. Also, the ‘find base stations’ GUI will differentiate between GPS and GNSS stations before import. NGS has NOT stripped out all GLONASS data from CORS stations, only some.

- Navigate to the GNSS-Inertial Processor tab and click on Custom Settings. Click the “Rename mission to first POS filename (without extension).”

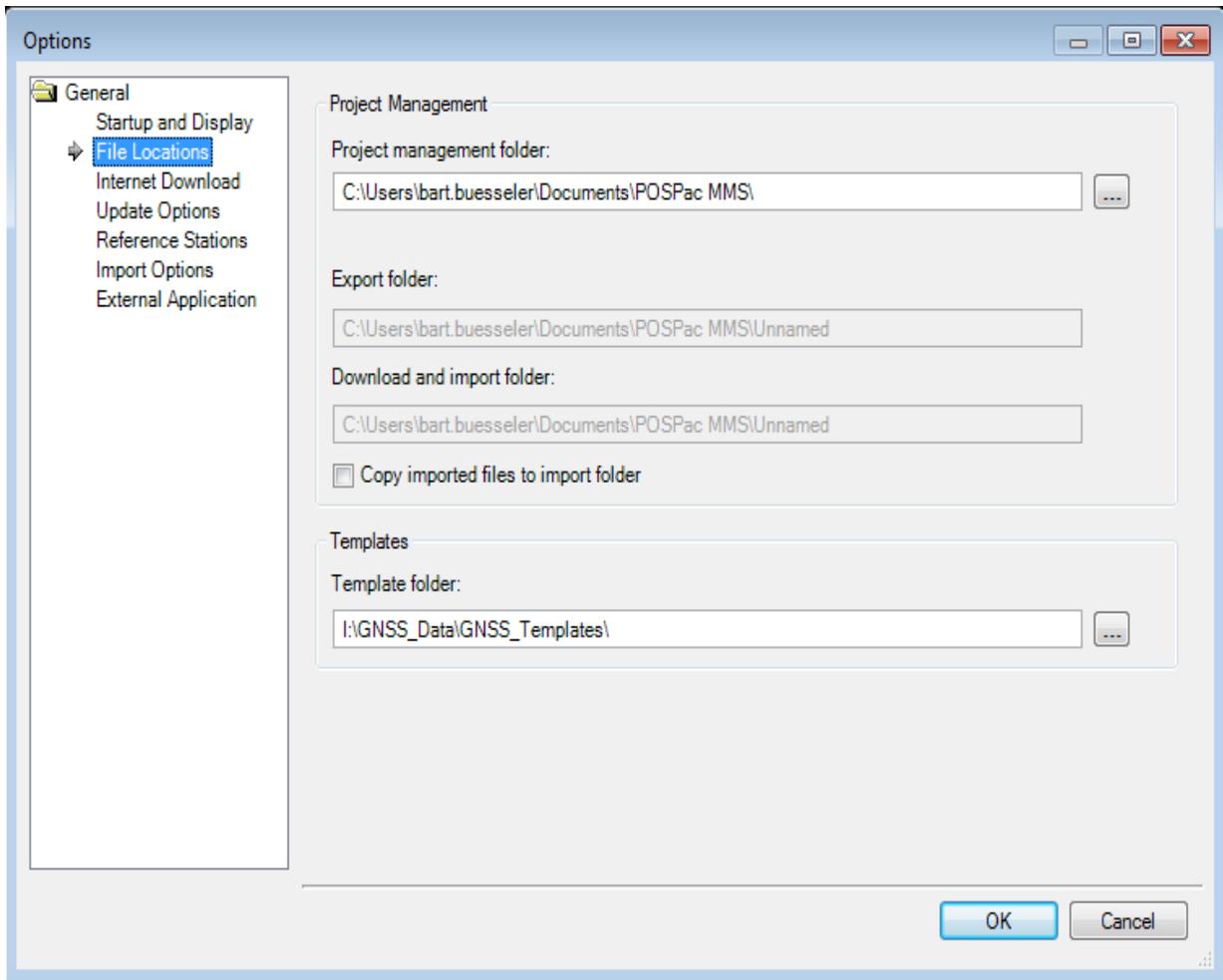


- File, Save Project As Template



- Name the template and click the set as default button, then ok

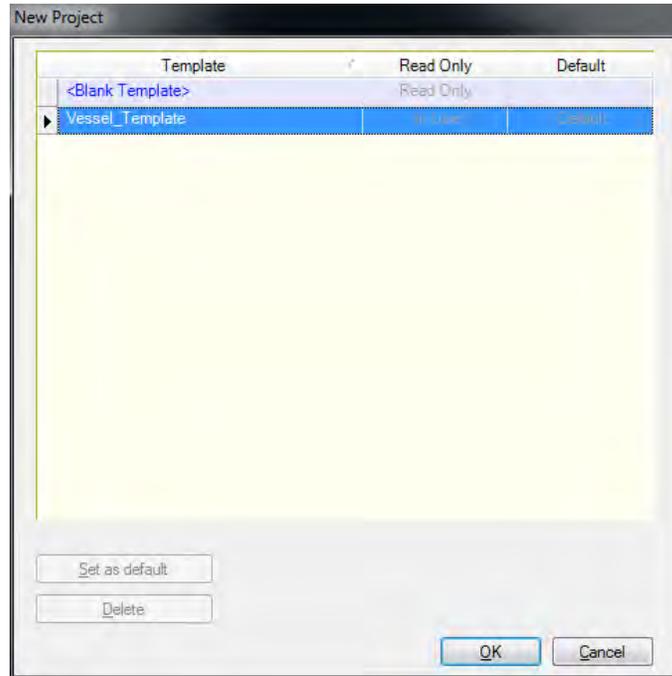
The template can be saved in a common location on the ship's network for all to access. This can be done by going to Tools→Options and setting the File location\Template Folder to that specific network location.



## SINGLEBASE STANDARD PROCESSING IN POSPAC 6.1

### Step One: Create a POSPac 6.1 Project:

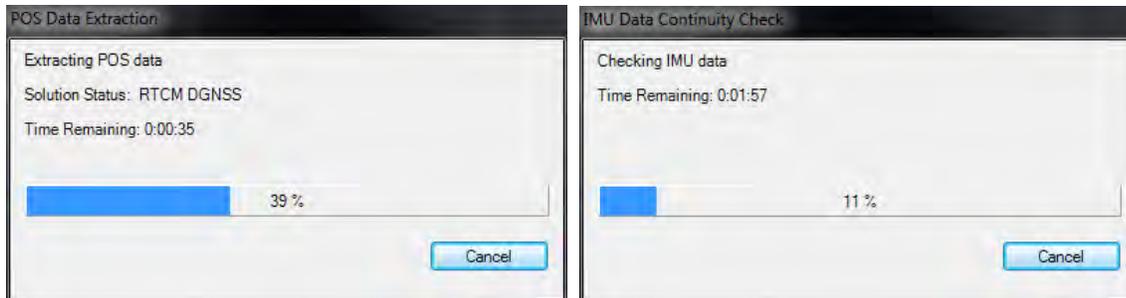
- File, New project. Highlight the vessel template and click OK



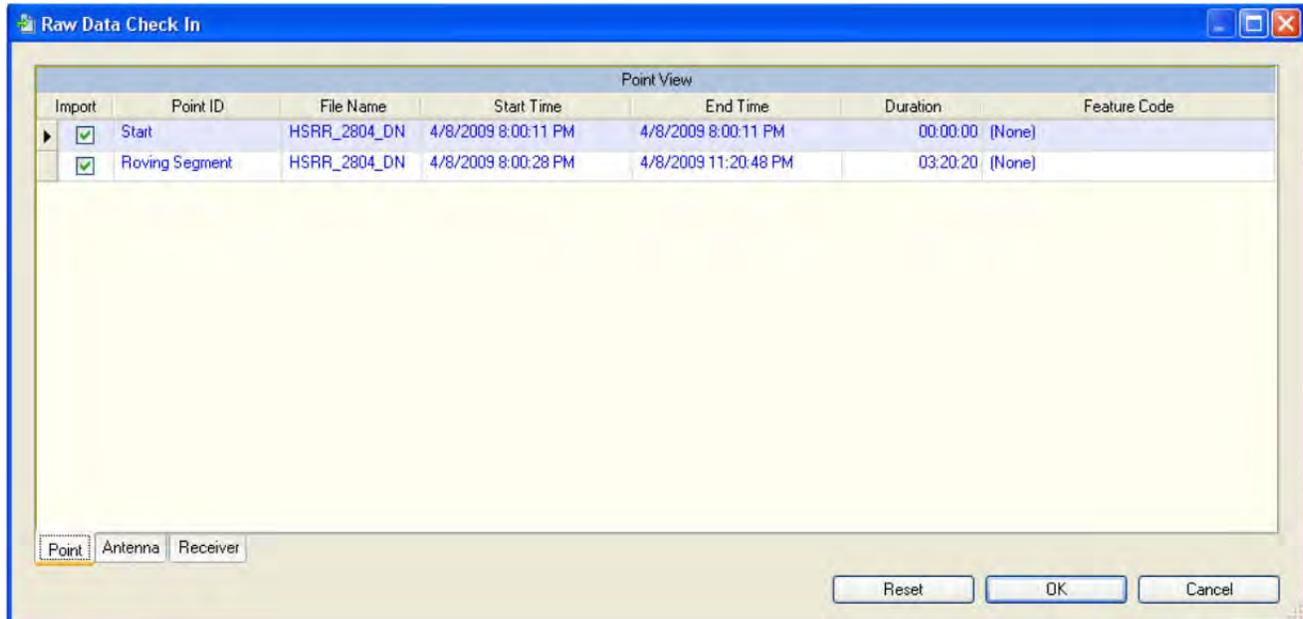
- File, Save Project. Save as *YYYY\_DDD\_VSSL*

### Step Two: Import the Raw POS

- Open a windows explorer window and locate the UNFIXED, contiguous time stamped, true heave file for the specific project, vessel and day. Drag and Drop your .000 file into the Plan View window. Note: you can also use the Project→Import GUI.



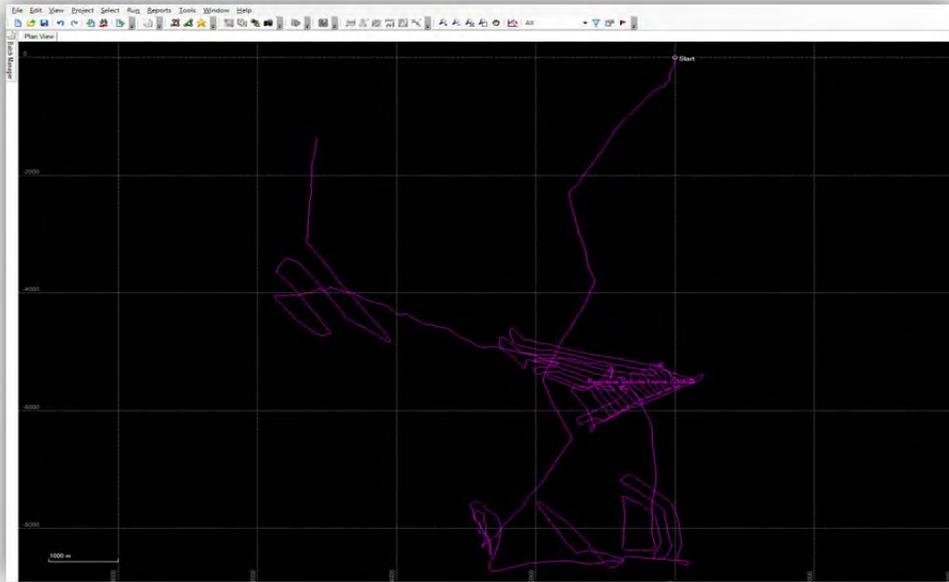
- In the Raw Data Check In window look to see if data was collected over UTC midnight into the following UTC day. This will determine how many days of base station data to load. Make note if it spans one or two days and then click ok.



- The project definition can remain unchanged.



- The vessel's raw POS data is now loaded and is displayed in purple with the tag of 'Real-Time Reference Frame (RNAV)'

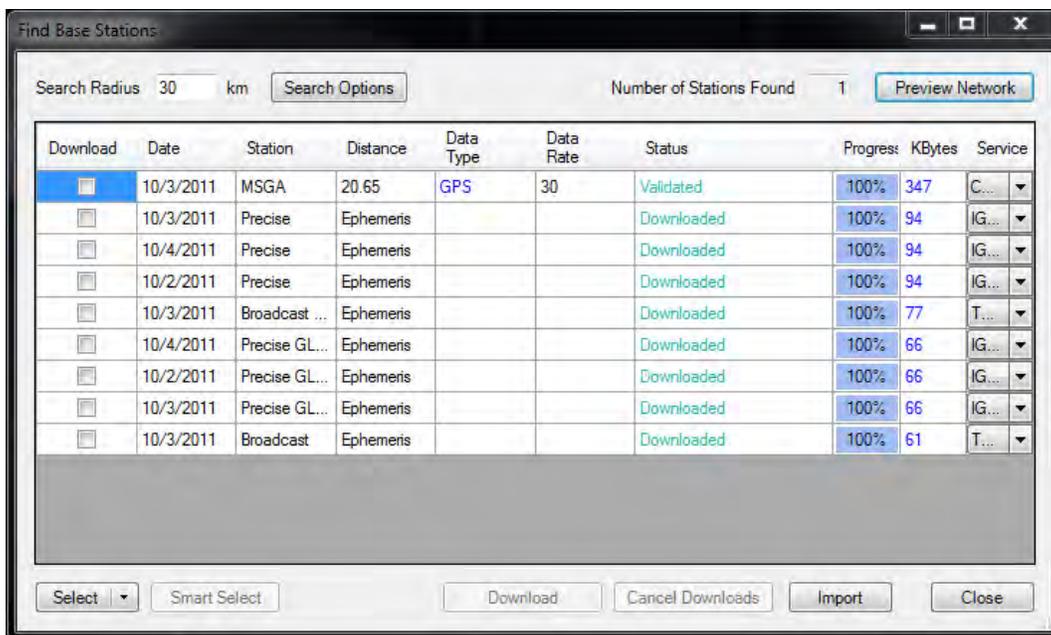


### Step Three: Import/Download Base Station

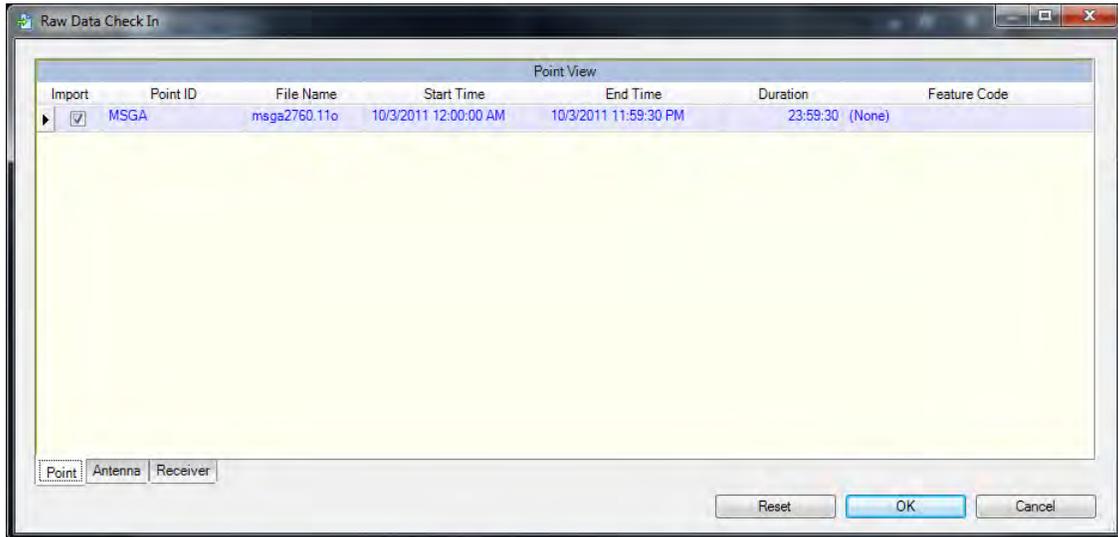
**\*Two workflows: either (A) download data from an existing base station within 30km or (B) import Rinex format data acquired from a field unit installed base station\***

#### (A) Download

- Click on the Find Base Stations icon or Project→Find Base Stations
- Type 30km in the search radius box and click on Preview Network.
- Select the single base station and all ephemeris data and click download



- After the data is downloaded, click Import
- Review the Raw Data Check In and click Ok

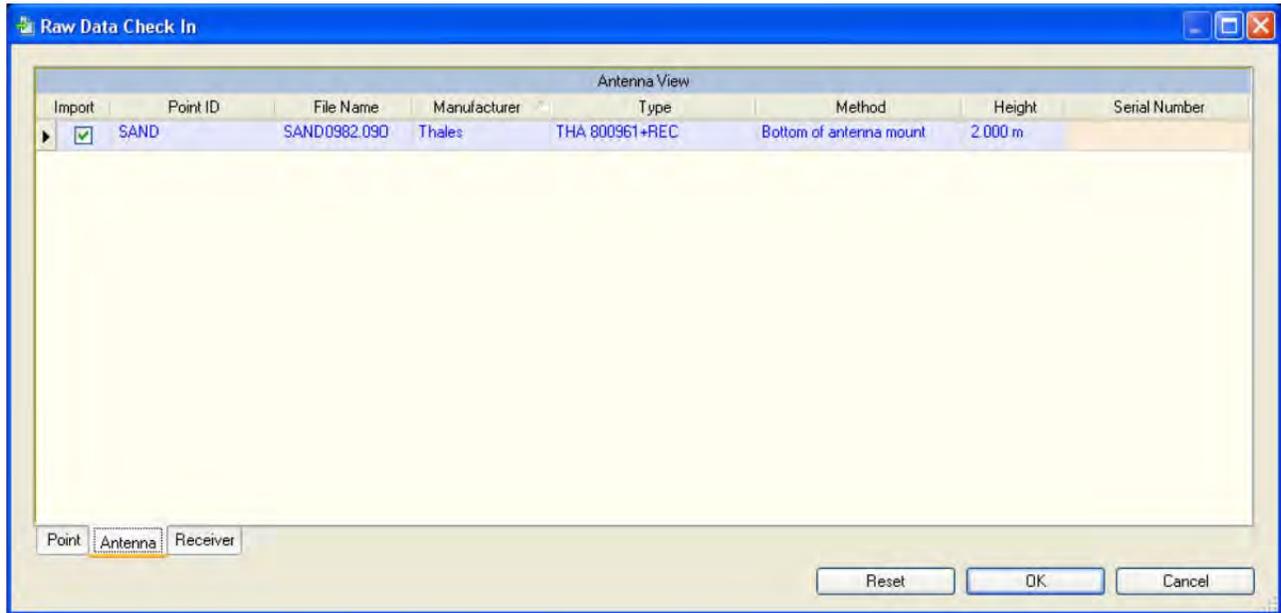


### (B) Import

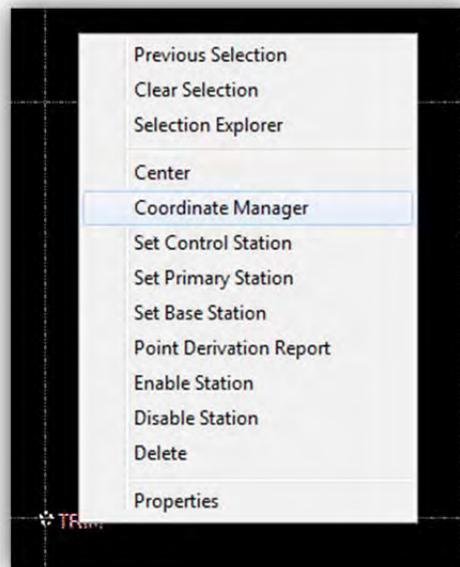
- Click on the Import button or Project → Import or drag and drop base station files from a window explorer window
- Browse to the appropriate directory and select the Rinex file or files (.YYo) you wish to Import. Note: Ensure that the Rinex file or files covers the entire POS file you are processing where bathymetric data exists. *If the boat-day spans two UTC-days, both UTC day's base station data will need to be added to the project*



- When the Base Station data is finished importing the Raw Data check in window will appear; verify the Manufacturer, Type, and Height of tripod of the GPS Base Station.



- Draw a box around the base station in the project window to select it, then right click on the base station and select Coordinate Manager



- The Coordinate Manager window will come up and the proper base station must be selected from the database. Once you select the base station, the ITRF Coordinates will automatically update, then select Apply Changes and Close.

From POSPac: **CAUTION** - When manually importing a Base Station, the average coordinates for that station are computed. These coordinates are **not** accurate. It is critical for the user to edit the

coordinates and update them with the known accurate ones. This is accomplished by right clicking on any Base Station point in the Project Explorer or Plan View and running the **Coordinate Manager.**

Station Information

Station ID: ERTS

ITRF Coordinates

Latitude: N 55 52 39.86741

Longitude: W 155 34 28.67859

Altitude: 19.808 m

Decimal Degrees

Antenna

Height: 1.500 m

Method: Bottom of antenna mount

Manufacturer: Trimble

Type: Zephyr Geodetic 2

Offset from Measured Point to APC: 0.085 m

Ground Reference Point (GRP) coordinates

Apply Changes

Station Database

Station ID: Point Roberts

Add Delete Update

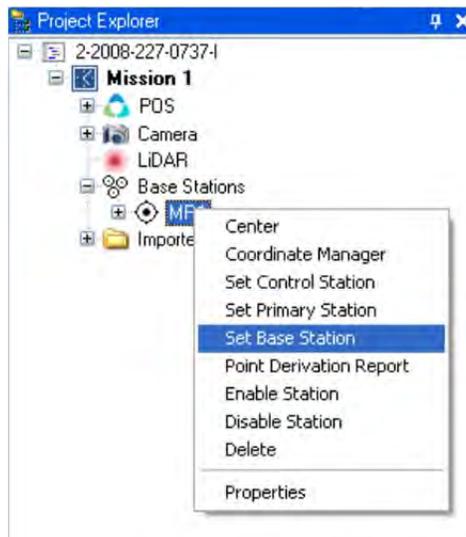
Station ID	X (ECEF)	Y (ECEF)	Z (ECEF)	Antenna Height
Pigeon Island	-2499896.9598	-2628196.2649	5228716.7428	1.5
Cherry Point	-2274156.184	-3535452.1779	4780751.9692	1.5
Point Roberts	-2286924.5899	-3515975.4221	4788953.8272	1.5
Point Roberts, AK	-3265174.384	-1482892.226	5256934.6362	1.5

Import Coordinates Export Coordinates

Close

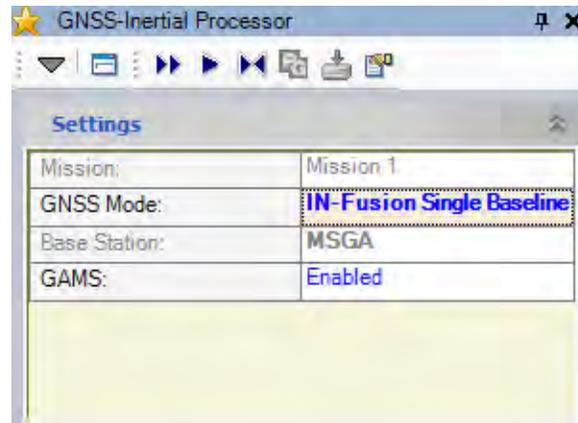
#### Step Four: Set Base Station

- Right mouse click on the base station and select Set Base Station

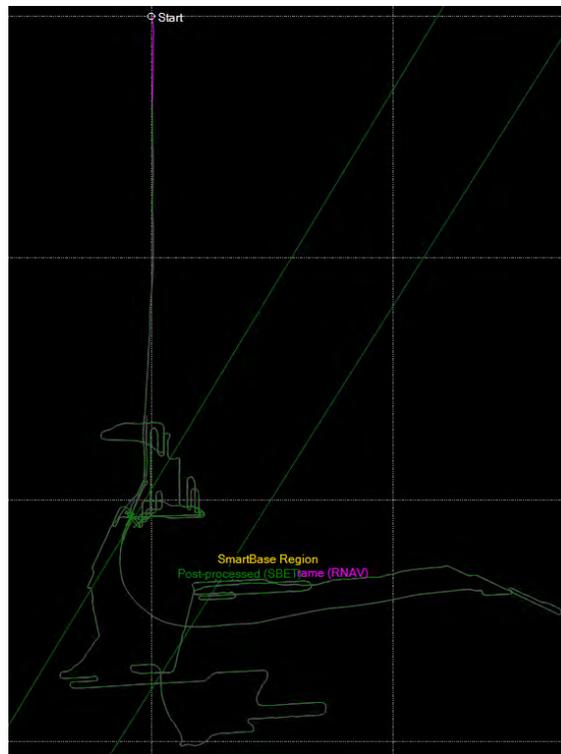
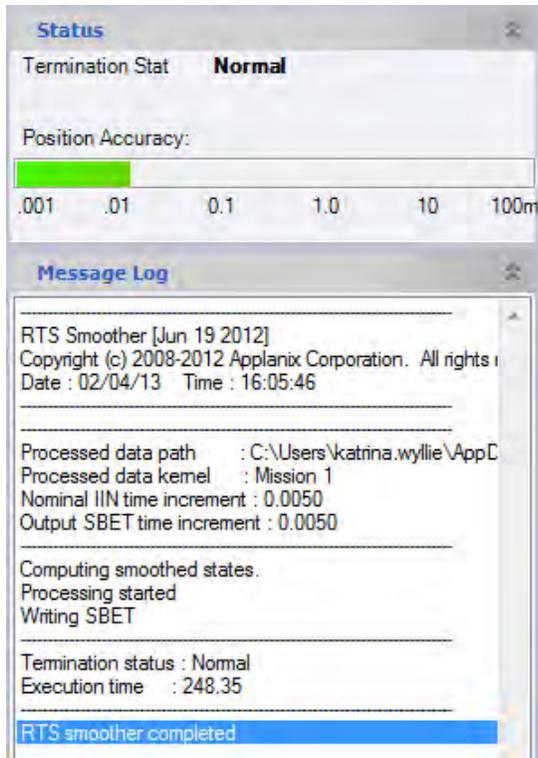


## Step Five: GNSS Inertial Processor using SingleBase

- From the toolbar select the yellow star, GNSS-Inertial Processor or Run→GNSS-Inertial Processor
- Verify that the processing mode is set to In-Fusion Single Baseline



- Select Run, or click on the All Processing icon (fast forward) to run the GNSS-Inertial processor
- Close when completed. The track lines should now appear green representing the data has been corrected with a fixed integer solution.

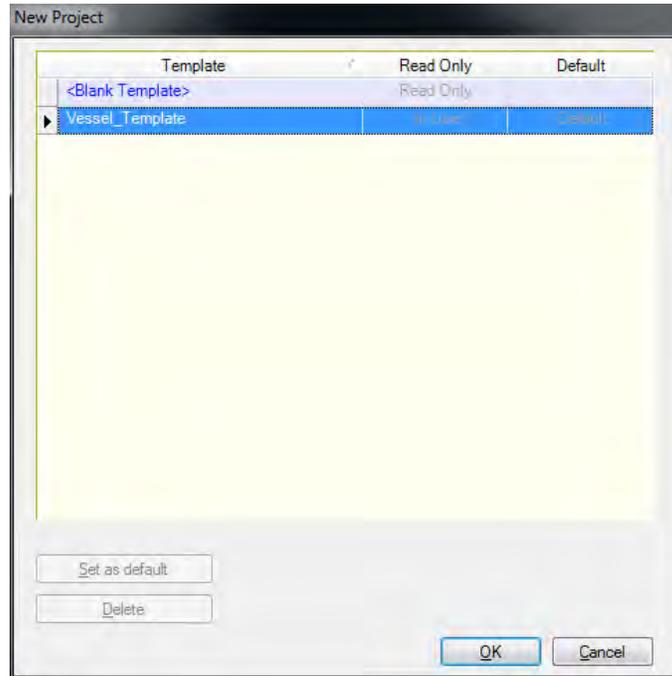


## Continue to Quality Control Checks SOP and then to Export

## SMARTBASE STANDARD PROCESSING IN POSPAC 6.1

### Step One: Create a POSpac 6.1 Project:

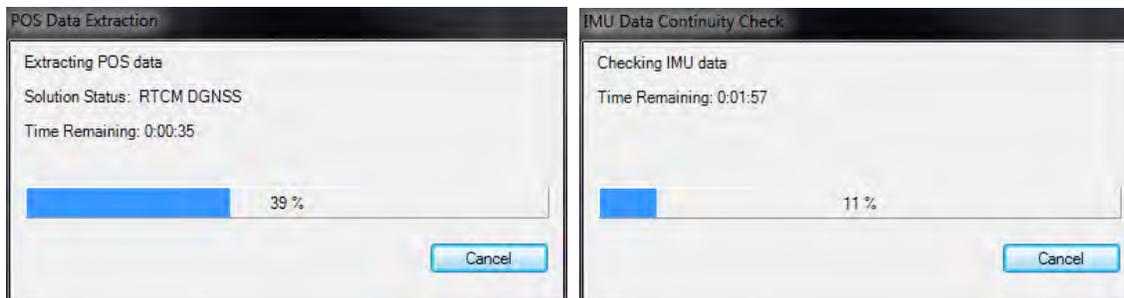
- File, New project. Highlight the vessel template and click OK



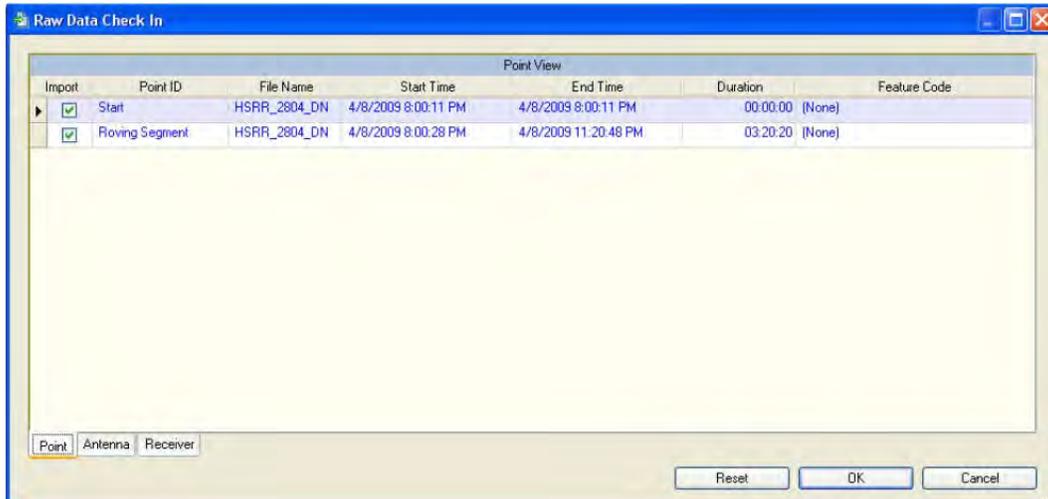
- File, Save Project. Save as *YYYY\_DDD\_VSSL*

### Step Two: Import the Raw POS

- Open a windows explorer window and locate the UNFIXED, contiguous time stamped, true heave file for the specific project, vessel and day. Drag and Drop your .000 file into the Plan View window. Note: you can also use the Project→Import GUI.



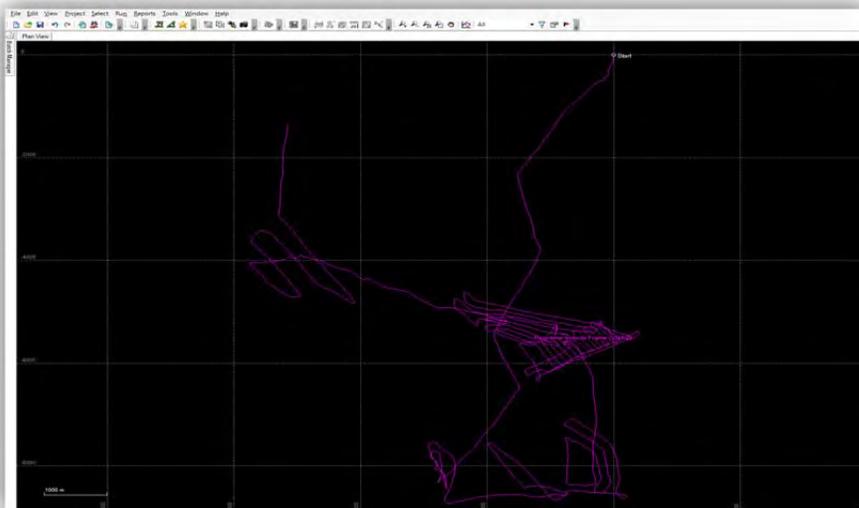
- In the Raw Data Check In window look to see if data was collected over UTC midnight into the following UTC day. This will determine how many days of base station data to load. Make note if it spans one or two days and then click ok.



- The project definition can remain unchanged.

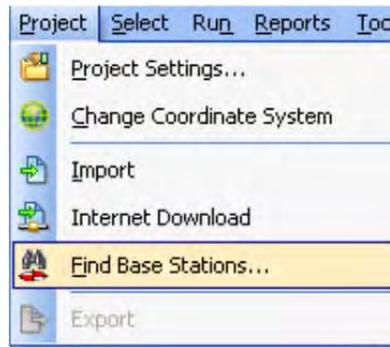


- The vessel's raw POS data is now loaded and is displayed in purple with the tag of 'Real-Time Reference Frame (RNAV)'

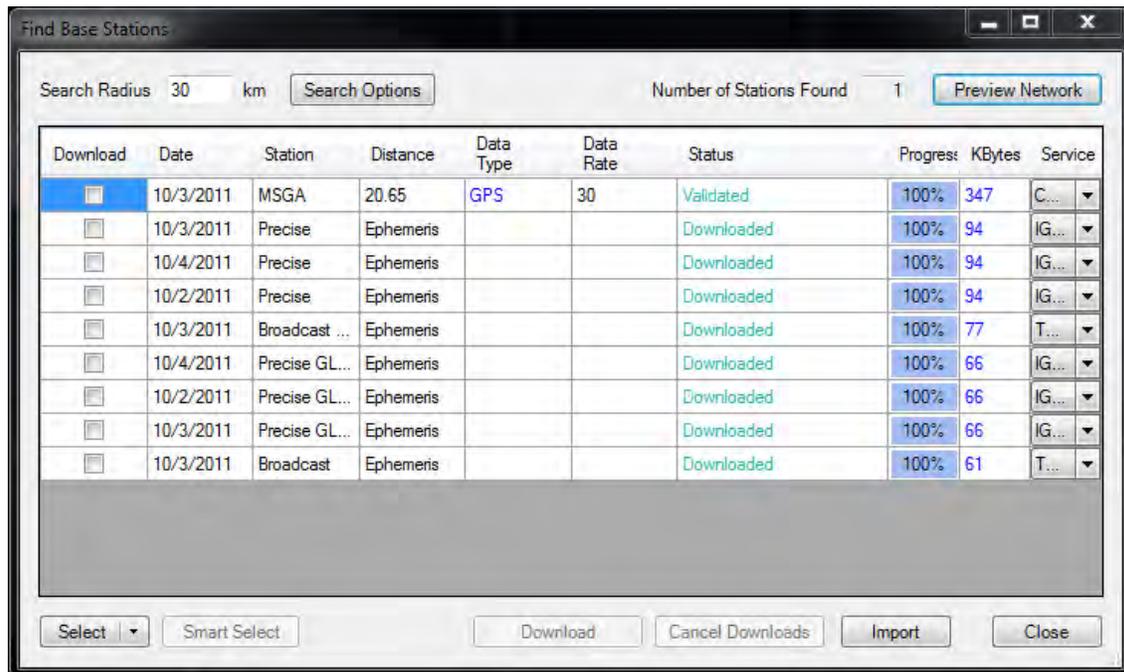


### Step Three: Download base station and ephemeris data

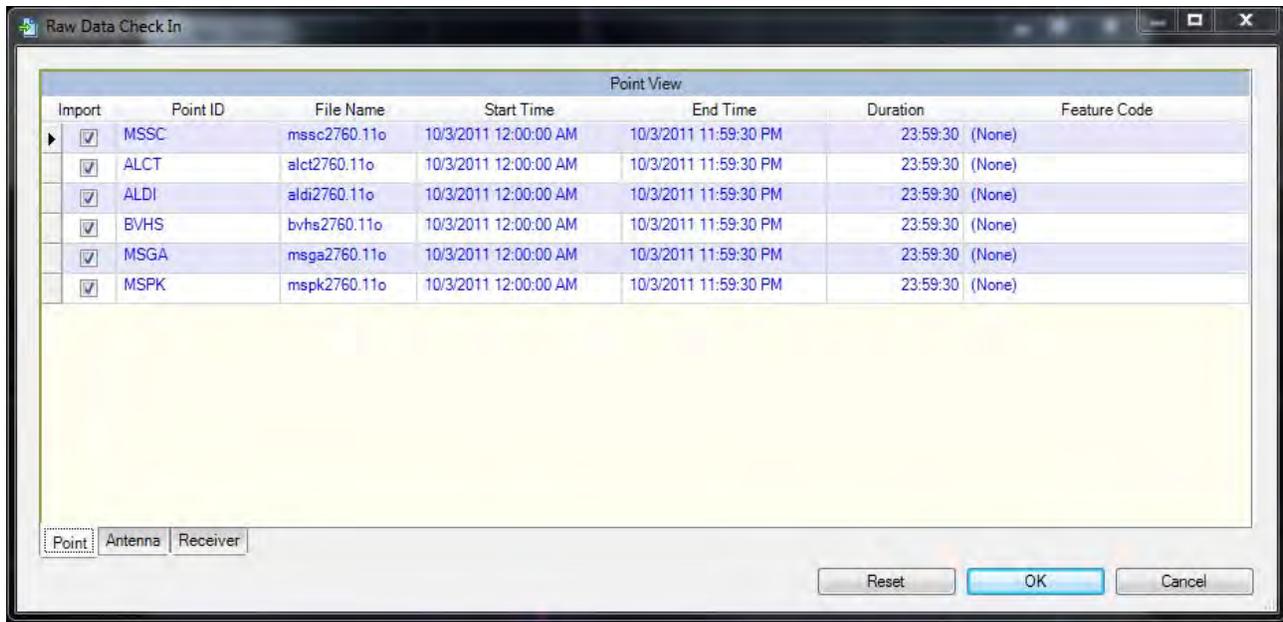
- Project → Find Base Stations



- Click Smart Select and POSPac will automatically select a network and download the base station and ephemeris files. At least four base stations are needed for SmartBase.

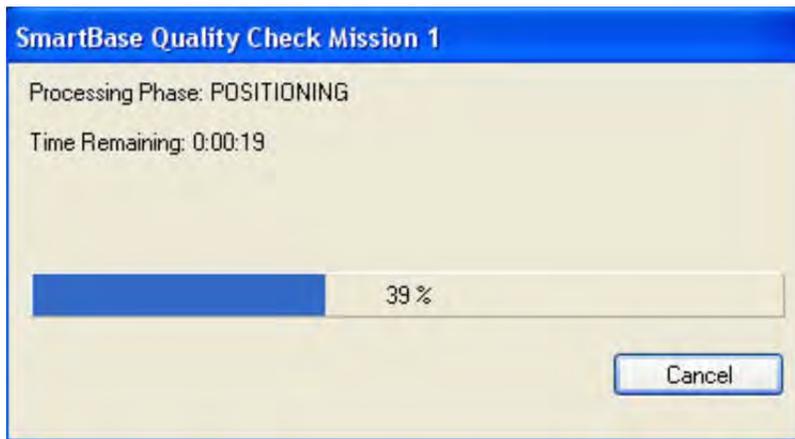


- Raw Data Check in will appear, select OK

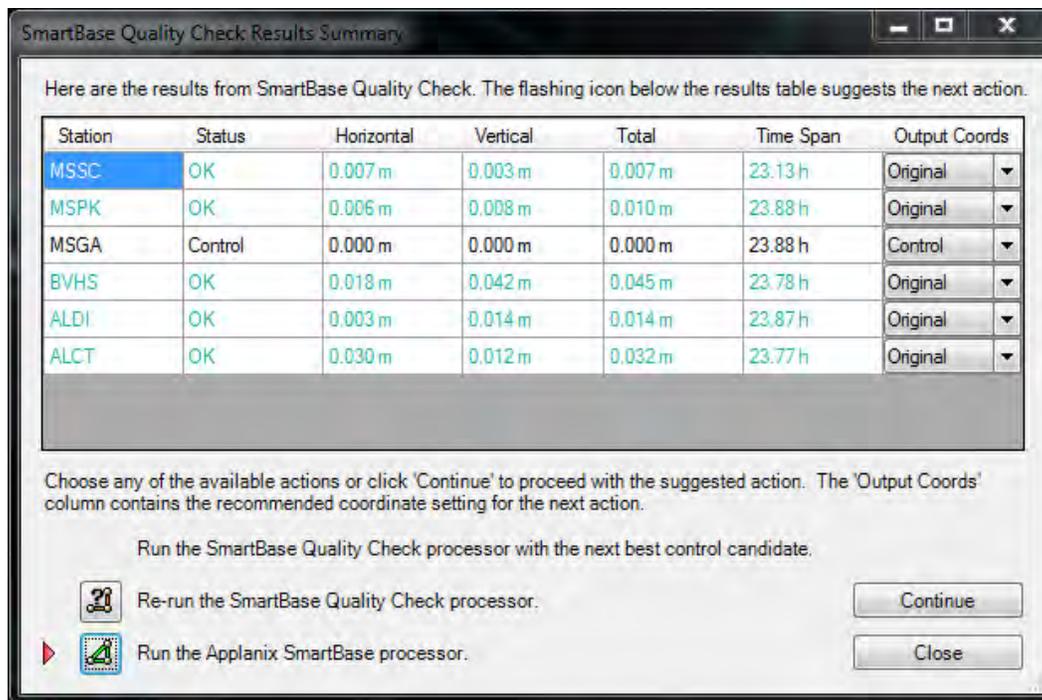


#### Step Four: Run SmartBase Quality Check

- Select *Run* → *SmartBase Quality Check*. The Quality Check Summary will appear.

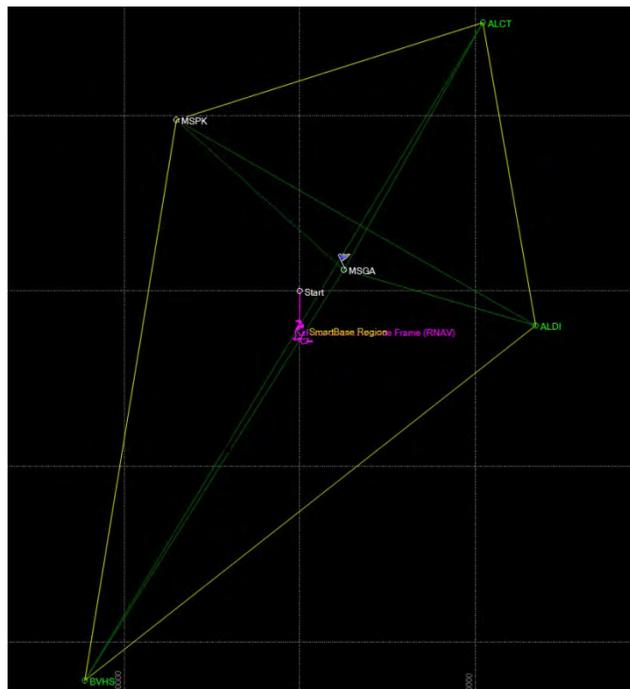


Bad or adjusted positions will be highlighted in red. Do not accept adjusted positions! It is possible to disable a station with a bad position but only if there is another one to take its place in the network. If neither of these solutions works, consider changing the processing mode to SingleBase or PPP.



### Step Five: Run Applanix SmartBase Processor (ASB)

- Select the flashing “Run the Applanix SmartBase processor” button
- If no errors appear, the network was successfully created and a yellow line will surround the SmartBase network. Proceed to next step



- If any error logs appear, it is usually because Applanix SmartBase (ASB) was not satisfied with a base station either because of gaps or cycle slips. Open the message log and scroll to the ASB Processing log
- Look for “Total full data gaps” over 30 seconds. If possible, disable this base station and rerun the Smartbase Quality Check and ASB. Or, if possible, try selecting/downloading another station to replace the unsatisfactory base station.

Reference Station Raw Data Analysis											
Station	Data	Time Span	Start time	End Time	Data rate	Total Gap	Max Gap	Min Gap	GPS Unrepaired	Simul unrepaired_CS	SBQI
ID		(sec)	week : sec	week : sec	(s)	Gap	Gap	Gap	CS	unrepaired_CS	
BVHS	GNSS	22350.0	1656:142890	1656:165240	30	0	0	0	2	0	9
ALCT	GNSS	22350.0	1656:142890	1656:165240	30	0	0	0	3	0	9
MSSC	GPS	22350.0	1656:142890	1656:165240	30	120	60	60	21	0	8
MSPK	GPS	22350.0	1656:142890	1656:165240	30	0	0	0	0	0	9
ALDI	GNSS	22350.0	1656:142890	1656:165240	30	0	0	0	1	0	9
MSGA	GPS	22350.0	1656:142890	1656:165240	30	0	0	0	6	0	9

Table 16.3 from Chapter 16 of the *POSPac MMS GNSS-Inertial Tools User Manual* also provides some insight to sources of error messages:

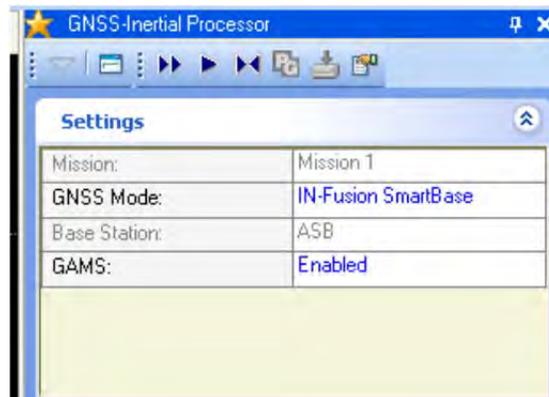
Table 16.3 Applanix SmartBase Messages

	PROC_STATUS_VRS_DATAGAP	PROC_STATUS_VRS_LOWPERCENTAGE
<b>Possible sources</b>	<ol style="list-style-type: none"> <li>1. Physical data gaps in the Primary station raw data file. This is usually the main source.</li> <li>2. Poor quality primary station data, Where there are simultaneous unrepaired cycle-slips present and ambiguities cannot be fixed.</li> <li>3. Poor quality primary station data where ambiguities for all satellites cannot be fixed.</li> <li>4. Possibly network ambiguity is unresolved.</li> </ol>	<ol style="list-style-type: none"> <li>1. Data gap in the Applanix SmartBase solution file caused by physical data gap in Primary station.</li> <li>2. Data gap in the Applanix SmartBase solution file caused by simultaneous unrepaired cycle-slip in Primary Station.</li> <li>3. Bad data quality causing many unresolved ambiguities if there are no data gaps.</li> <li>4. Data gap in the Applanix SmartBase solution file caused by Bad network configuration and data quality, network ambiguity resolution fails.</li> </ol>
<b>Action</b>	<p>For the first three cases, the recommendation is to change Primary station based on the raw data analysis information.</p> <p>For the fourth case, the only course of action to follow is to change the network configuration, for example, reduce the inter-station distance by adding more reference stations.</p>	
<b>Criteria for choosing a good Primary Station</b>	<p><b>The list is in the order of priority.</b></p> <ol style="list-style-type: none"> <li>1. No continuous data gaps larger than 30 seconds (Max-Gap, Min-Gap).</li> <li>2. No occurrences of Simul_unrepaired_CS (simultaneous unrepaired cycle-slips).</li> <li>3. Nearest distance to trajectory centre.</li> <li>4. Lowest number of unrepaired cycle-slip.</li> </ol>	

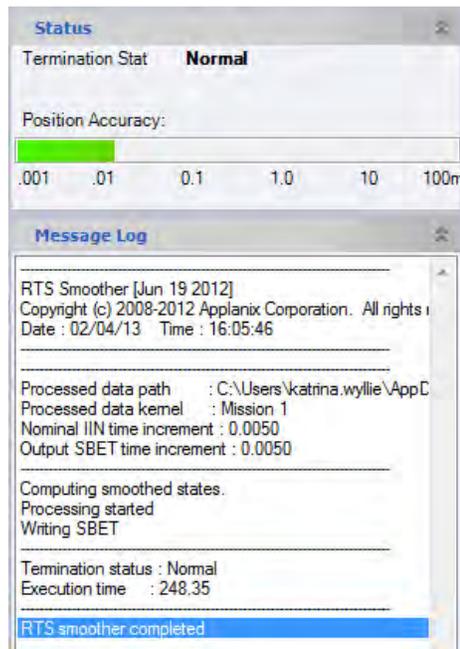
- Run the Applanix SmartBase Processor until a solution is generated. It may be necessary to switch to SingleBase or PPP if troubleshooting does not work.

### Step Six: GNSS Processor using SmartBase

- From the toolbar select the yellow star, GNSS-Inertial Processor or Run→GNSS-Inertial Processor
- Ensure the GNSS mode is IN-Fusion SmartBase.



- Select Run, or click on the All Processing icon (fast forward) to run the GNSS-Inertial processor
- Close when completed. The track lines should now appear green representing the data has been corrected with a fixed integer solution.

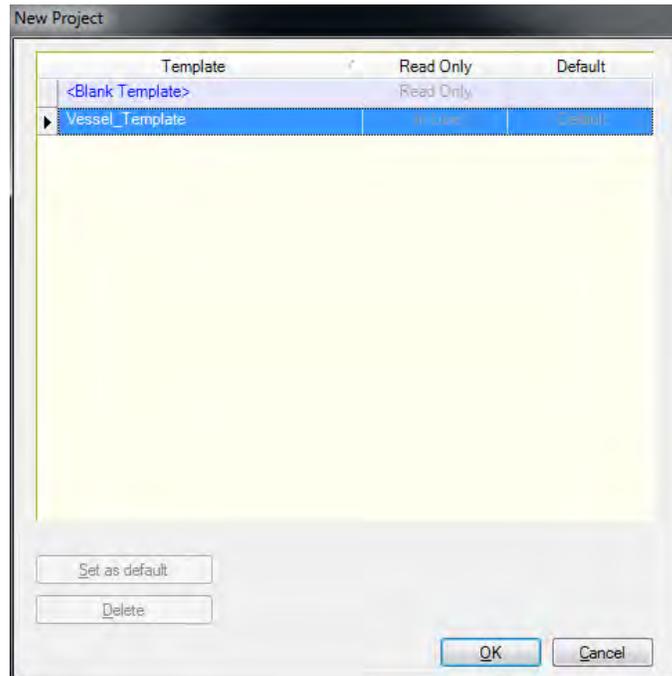


### Continue to Quality Control Checks SOP and then to Export

## PPP PROCESSING IN POSGNSS (PRECISE POINT POSITIONING)

### Step One: Create a POSpac 6.1 Project:

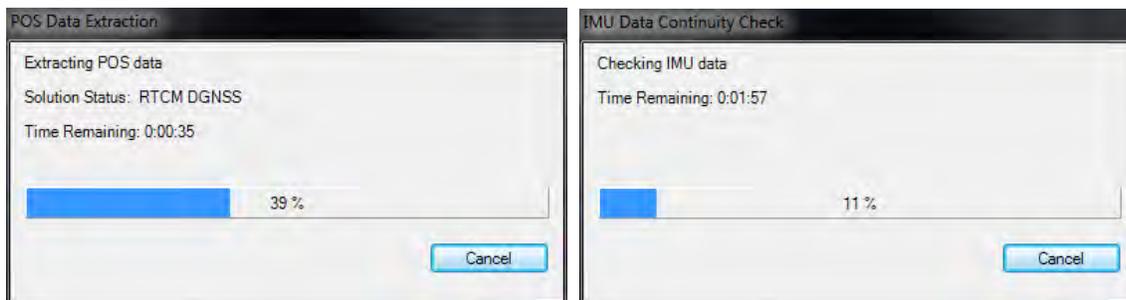
- File, New project. Highlight the vessel template and click OK

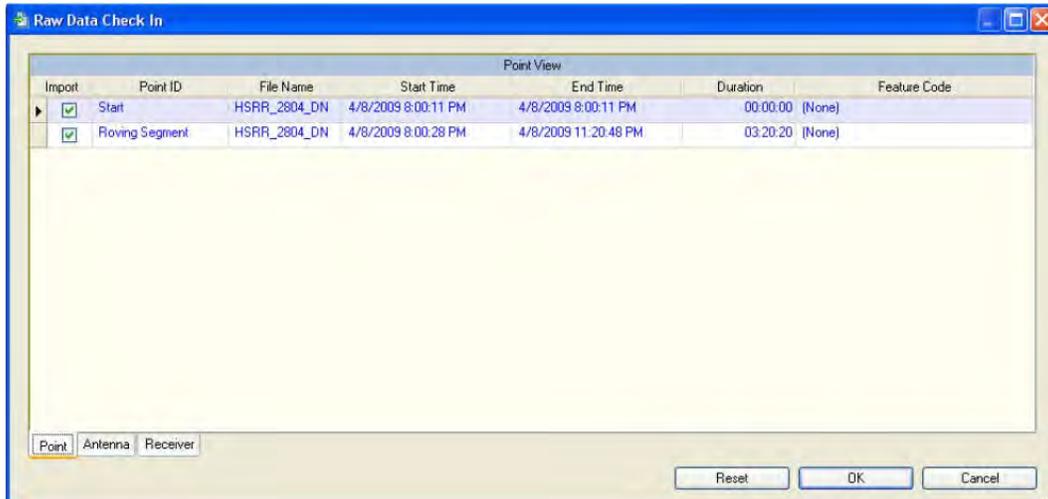


- File, Save Project. Save as *YYYY\_DDD\_VSSL*

### Step Two: Import the Raw POS

- Open a windows explorer window and locate the UNFIXED, contiguous time stamped, true heave file for the specific project, vessel and day. Drag and Drop your .000 file into the Plan View window. Note: you can also use the Project→Import GUI.





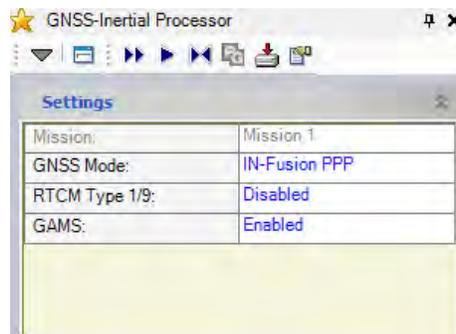
- The project definition can remain unchanged.



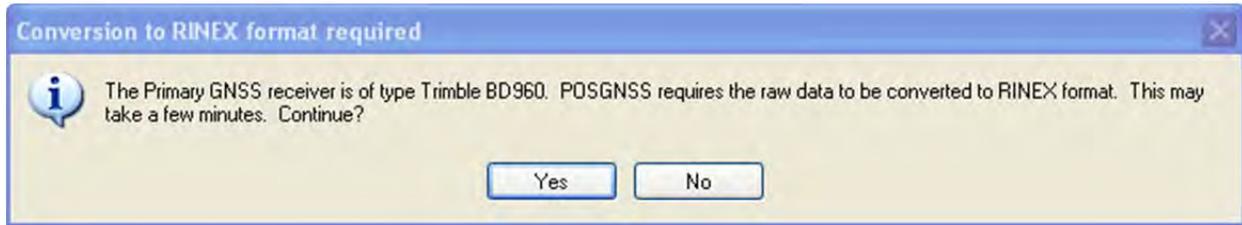
- The vessel's raw POS data is now loaded and is displayed in purple with the tag of 'Real-Time Reference Frame (RNAV)'

### Step Three: POSGNSS

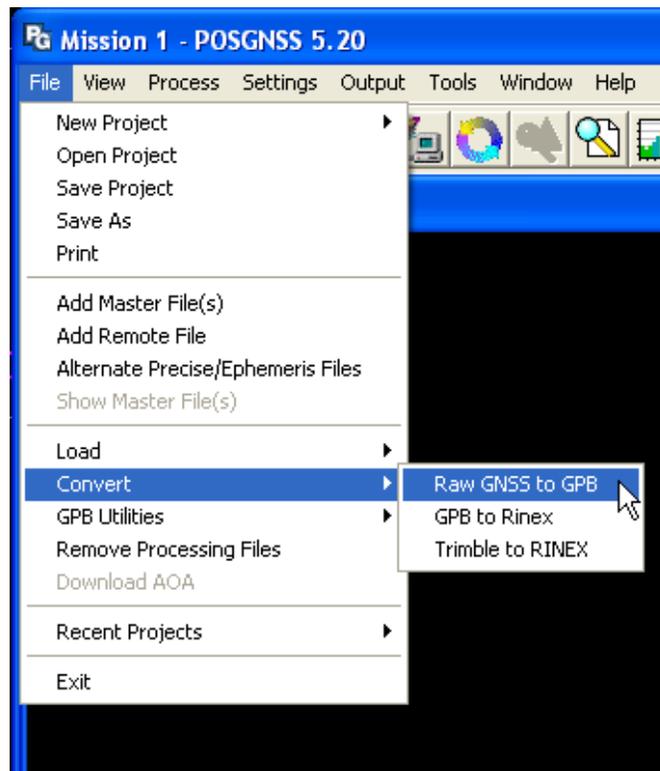
- From the toolbar select the yellow star, GNSS-Inertial Processor or Run→GNSS-Inertial Processor
- Ensure the GNSS mode is IN-Fusion PPP and click on the POSGNSS icon



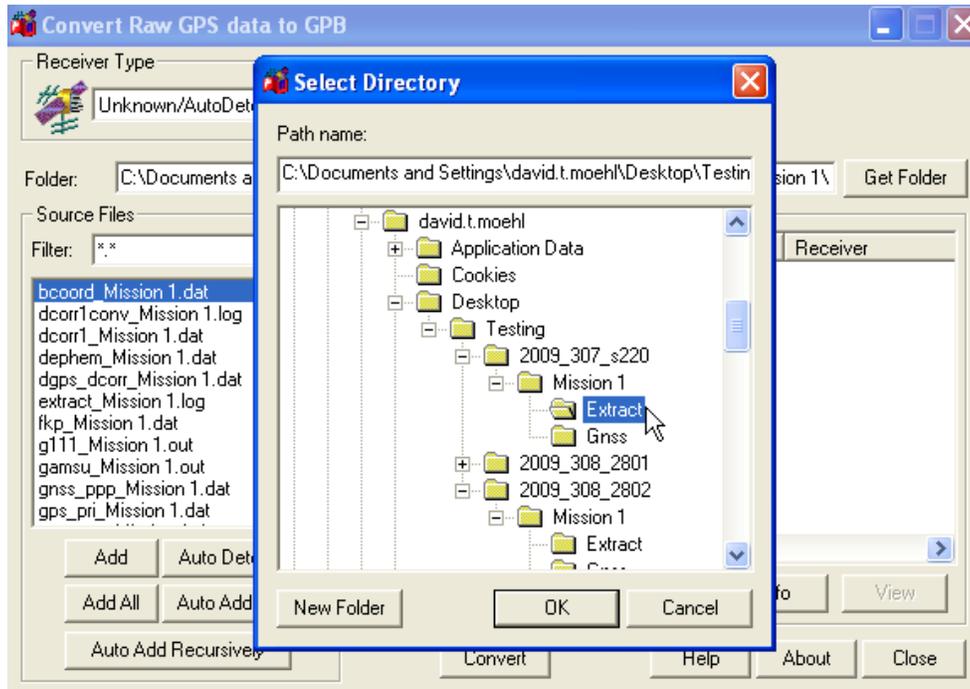
- Click yes if this message appears. If this message appeared then you will use the RINEX file when completing the following steps.



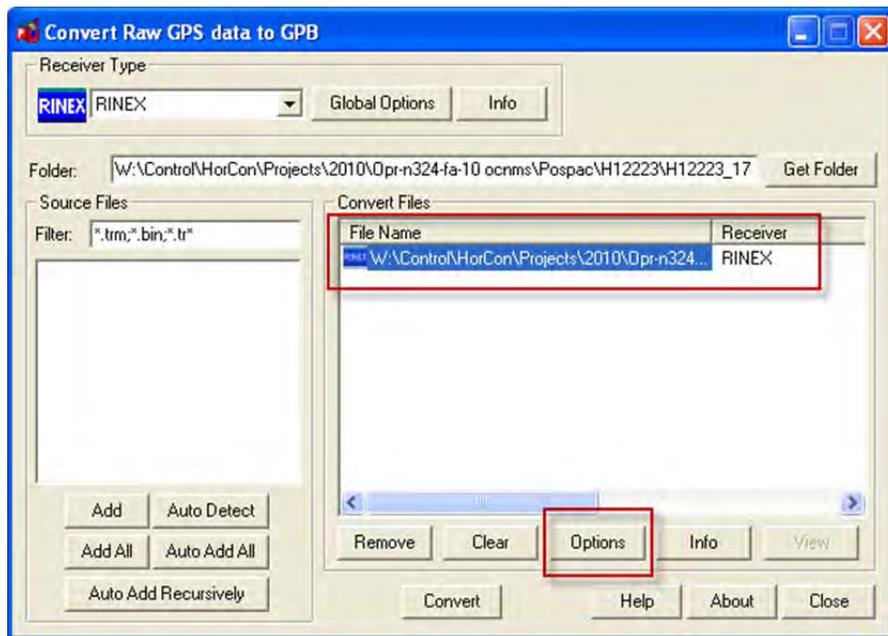
- If POSGNSS asks to download manufacture files say YES, otherwise PPP will not work
- Convert Raw GNSS to GPB



- Select the *Get Folder* button and navigate to your project's Extract folder and click ok

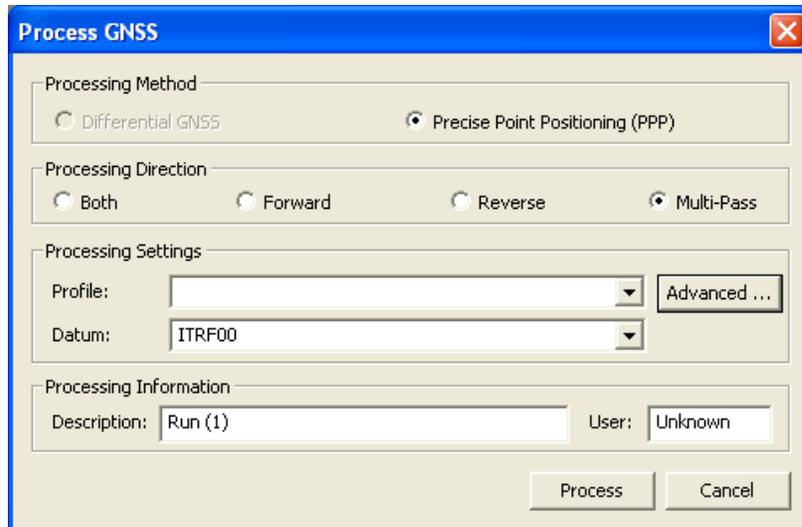


- Auto add all → delete the second one ('sgps') and keep the master ('mgps'), except when converting Rinex Data, then do the following two additional steps:
  - After Auto Add All, remove all files except the Rinex, click options

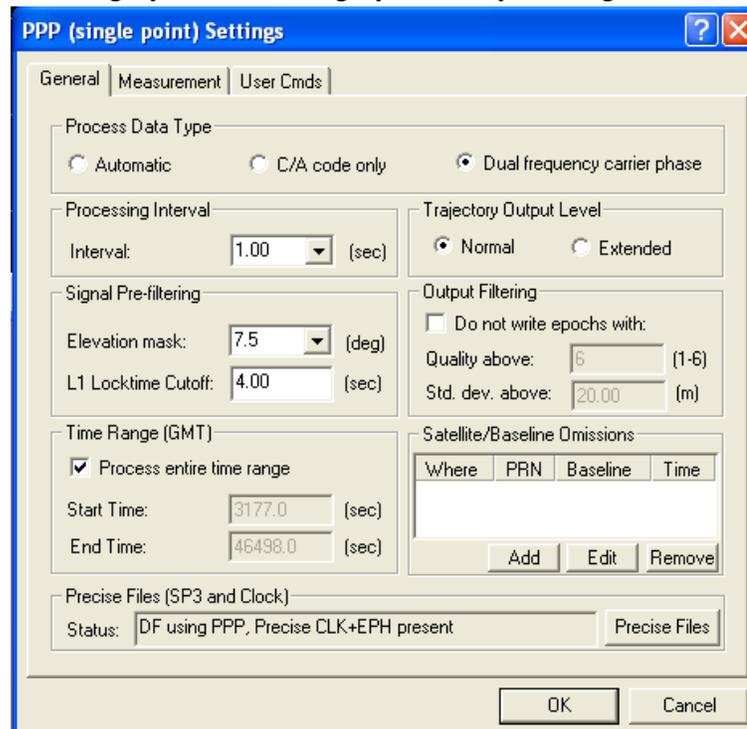


- Check “make all epochs kinematic” and all other boxes should be ok

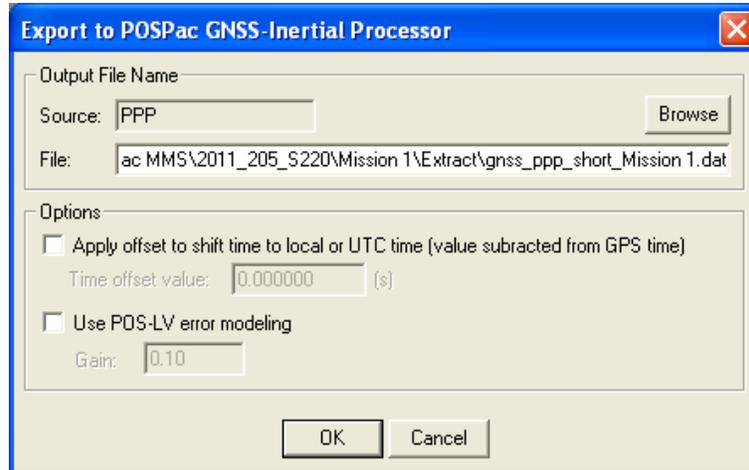
- Click the convert button to convert the file. Upon success, close the output and convert window
- File→Add remote file. Navigate to the .gpb file you created while converting (in the extract folder) and press okay when it asks about antennas
- File→Add Precise files. At the bottom of the window you can download the precise files from the days noted or define a path where the ephemerides reside.
- Process→Process GNSS. Processing Direction=Multipass. On the initial window, set your processing datum to ITRF00



- Click on “Advanced.” Process Data Type =Dual frequency carrier phase. Process Information must not be grayed out if it is grayed out try loading the remote file again.



- If you get a “Detected Trimble or dual clock receiver,...do you wish to enable this setting” warning, click Yes
- Output→Export to POSPac GNSS Inertial Processor. Save to the path provided. This should be the Extract folder, filename “gnss\_ppp\_short\_Mission1.dat” Click OK to export



- Save and close POSGNSS
- In POSPac, click all processing (the fast forward button)



### Continue to Quality Control Checks SOP and then to Export

Note that there will be nothing in the solution status column which is relevant. Put N/A in the Processing log

**HELPFUL LINKS FOR PPP:**

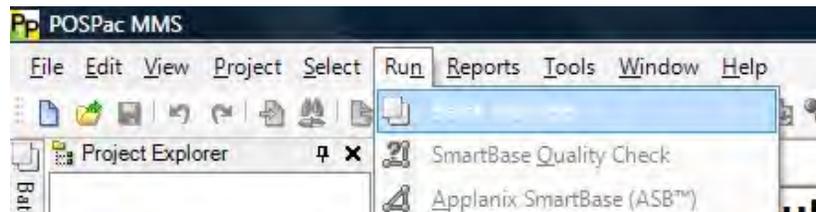
<http://csrc.ucsd.edu/scripts/convertDate.cgi>? – GPS Date converter, for GPS Week to Julian DN and vice versa.

[http://igsceb.jpl.nasa.gov/components/prods\\_cb.html](http://igsceb.jpl.nasa.gov/components/prods_cb.html) - Download site for ephemeris and clock data, seems to be quicker than downloading through POSGNSS, probably because the clk files are significantly smaller. Filenames are igsWWWWD.clk and igsWWWWD.sp3 where WWWW is GPS week and D is the day of the week (0 to 6) starting on 0 being Sunday.

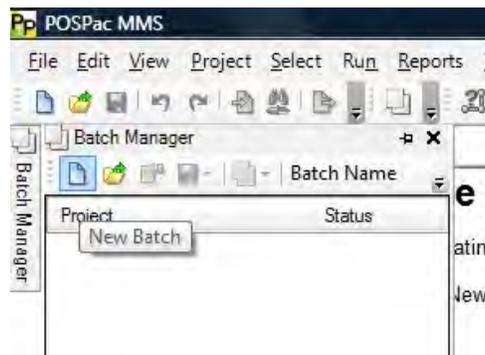
## BATCH PROCESSING IN POSPAC 6.1 FOR SINGLEBASE AND SMARTBASE

To optimize time spent processing smooth best estimates of trajectory (SBET)s, a batch file can be set to run for several POSpac projects at once. Batches can be created for a project, a day, port side, starboard side, or a combination of all of the above. During active survey ops, it is recommended to batch by day number. It is necessary to wait until at least four hours after acquisition to post-process navigation (PPP requires rapid, **not** ultra-rapid orbit data). A size-restricted internal file in POSpac MMS does not allow a 24-hour day of POS data to be processed without crashing. Essentially, a 24-hour acquisition day batch will produce two SBETs per IMU.

- Select Run → Batch Manager



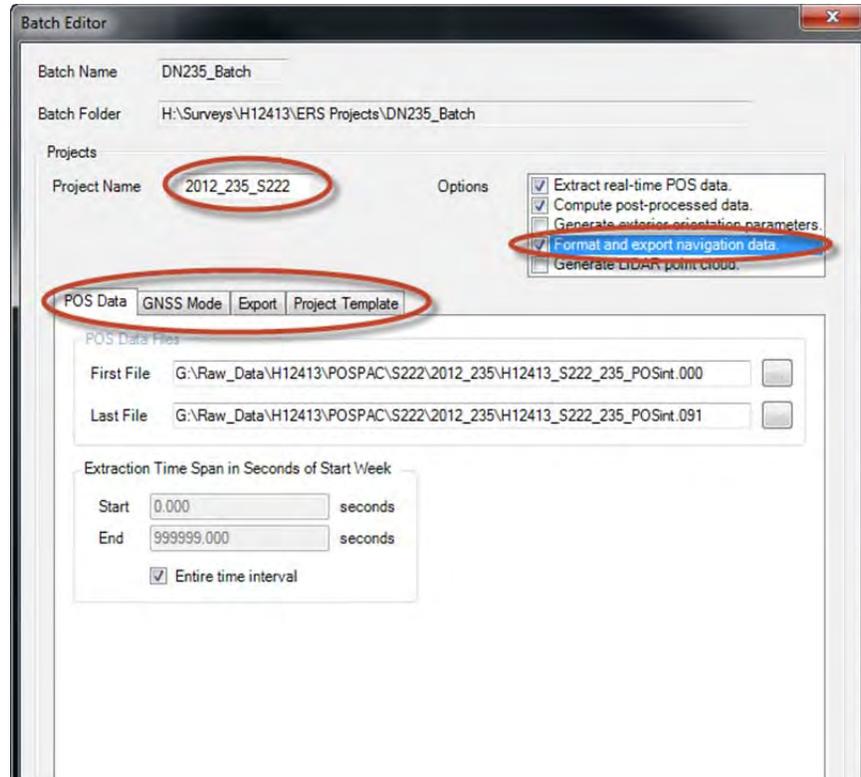
- Click the New Batch icon in the upper left corner of the pane



- Save the batch configuration file to the POSpac folder in the appropriate project, use the naming convention DN###\_batch.posbat
- In the Batch Editor window
  - Enter a project name: YYYY\_DDD\_VSSL
  - Navigate to and select the appropriate *First File* POS data file for the vessel and day
  - The *Last File* field will auto populate but will need to be set manually if the number of POS files goes beyond \*.099 (i.e. \*.100). If that is the case, you need to switch to view ALL files and select the last file for that day (remembering if it is 24hr operations the day needs to be split into two projects and there needs to be overlap for these two project because only one SBET can be loaded to an individual CARIS

line. Example .000→.115 for the morning SBET and .105→.230 for the afternoon SBET)

- In *Options*, click on Format and export navigation data



- Next select the *GNSS Mode* tab and pick either IN-Fusion SmartBase, IN-Fusion Single Baseline or IN-Fusion PPP



- IN-Fusion Single Baseline requires the user to either (a) select the Base File(s) (Rinex). This may include two files if data was logged after UTC midnight. Or (b) if the base station is in the database, click *Retrieve from DB* button and select the appropriate station. Note: if this is the first time using the base station, enter the OPUS ITRF solution *Latitude, Longitude, Altitude* (ellipsoid height), station *Name*

and *Height* of antenna. Then click *Add to DB* so that information is stored for future processing.

- With the GNSS Mode selected, click on the Export tab and click the *Use Project Template Settings Only* box
- Click on the Project Template tab and select the appropriate vessel template

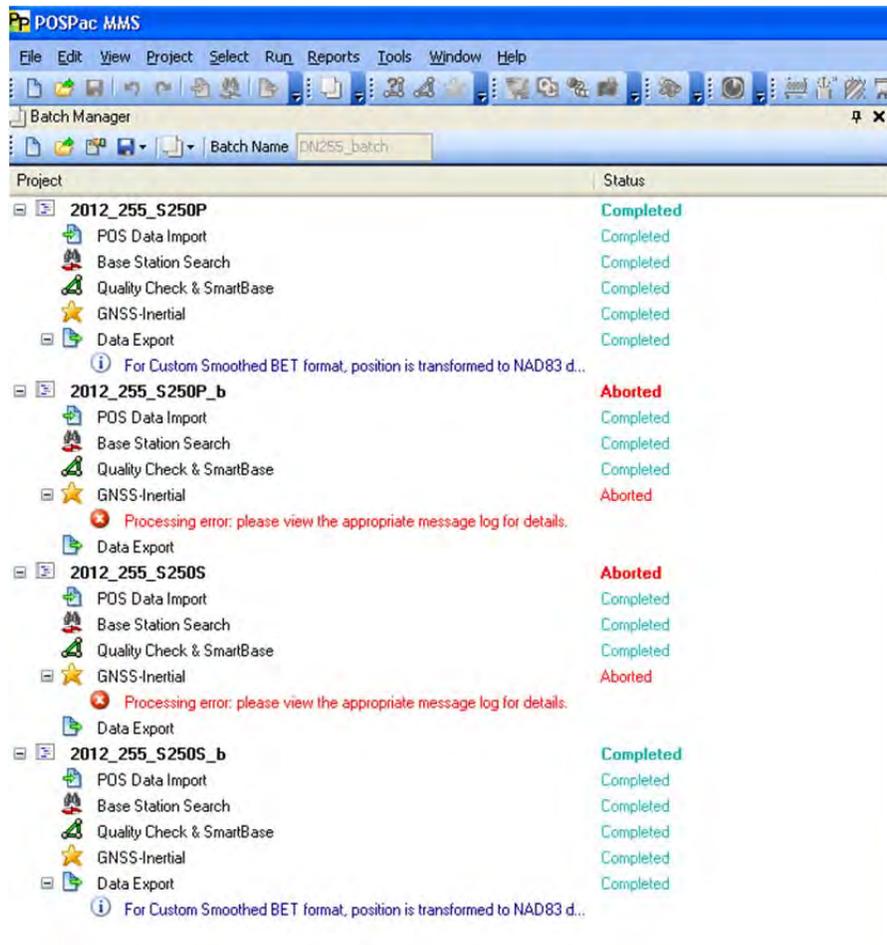
- With all parameters set, add the project to the queue.
- With the project added, enter the next project name and associated POS files and add that project to the queue. Continue until all projects are in the processing queue. Then press ok

Project	First POS File	GNSS Mode	Base GNSS File
2012_235_S222	G:\Raw_Data\H12413\POSPAC\S222\2012_235\H12413_S222_235_P...	IN-F...	
2012_235_3101	G:\Raw_Data\H12413\POSPAC\3101\2012_235\H12413_3101_235_P...	IN-F...	
2012_235_3102	G:\Raw_Data\H12413\POSPAC\3102\2012_235\H12413_3102_DN235...	IN-F...	

- The Batch Manager window will update with a list of the projects in the processing queue and the various tasks to be performed for each project. Select the *Run Batch* button to run all of the projects (POS Data Import, Base Station Search, Quality Check & SmartBase, GNSS-Inertial and Data Export)



- The projects will either complete or abort. Aborted projects will indicate what task caused the abortion and will recommend viewing the message log for details. **Continue to Quality Control Checks to troubleshoot any projects that did not complete and to QC the projects that did.**

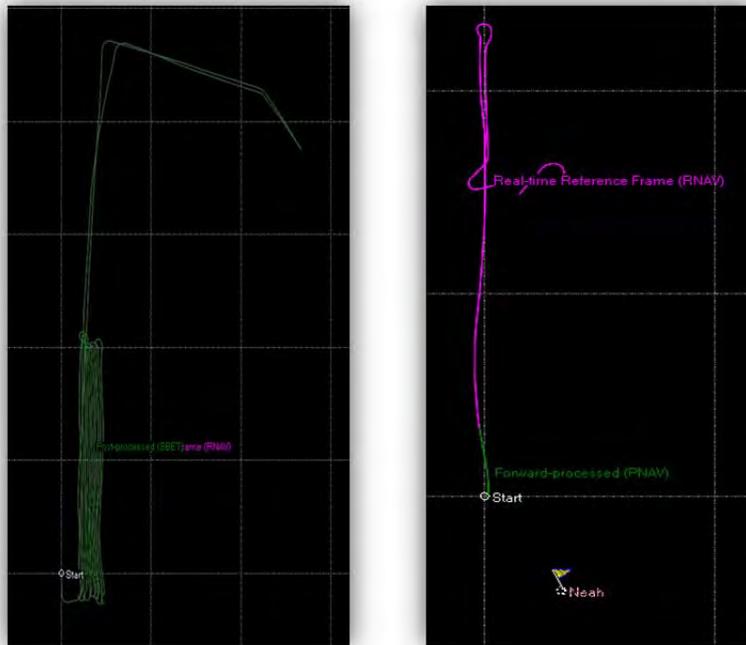


## SBET QUALITY CONTROL PROCEDURES

Once your POSpac project has processed successfully, you may now do quality control of the SBETs (Smoothed Best Estimated Trajectories). This can be done manually or automatically. Keep the SBET Processing Log handy as that should be filled out during the QC process.

### Manual Quality Control

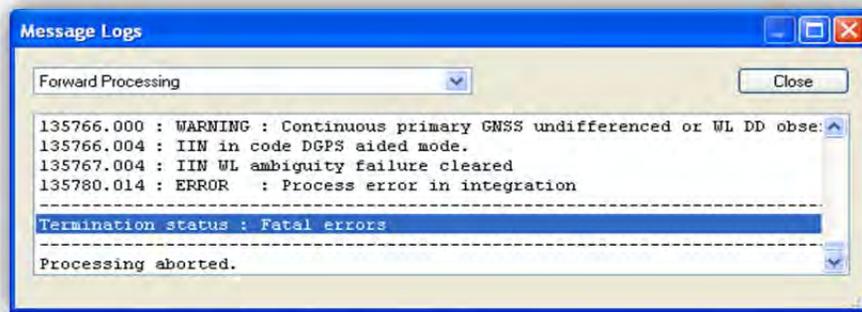
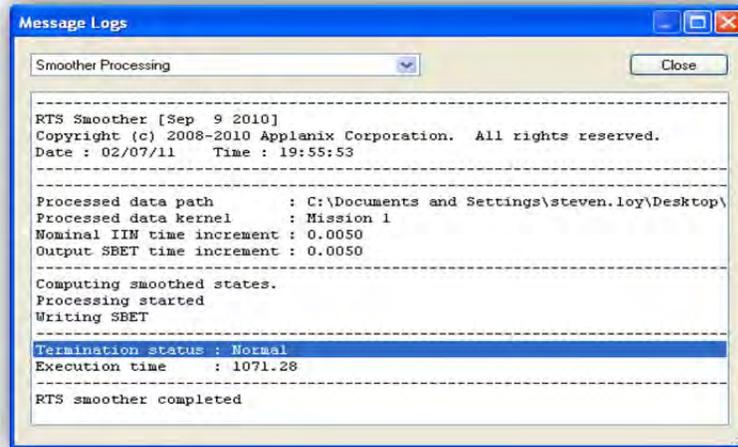
- In the project window, verify that the post-processed solution (Green Solution, PNAV) covers the vast majority of the real-time solution (Purple, RNAV). If you see lots of purple the raw POS file might not have been processed with all the needed days of base station data, or encountered a fatal error.



- SingleBase: Check that the correct Base Station was used for the data, this can just be a visual check to confirm the base station is in the right position relative to the survey area
- For any “aborted” projects, view the message logs



- Check each step, and scroll to the bottom, where you should note if the “Termination status:” is anything other than “Normal.” “Fatal errors” are cause for immediate concern and further review.

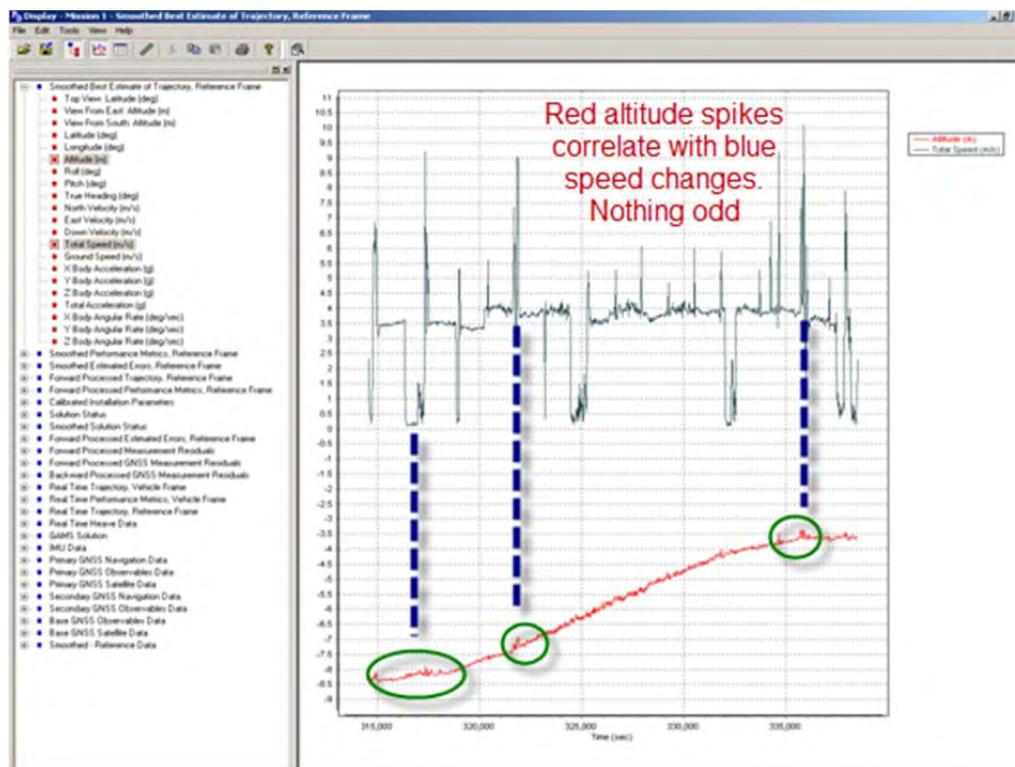


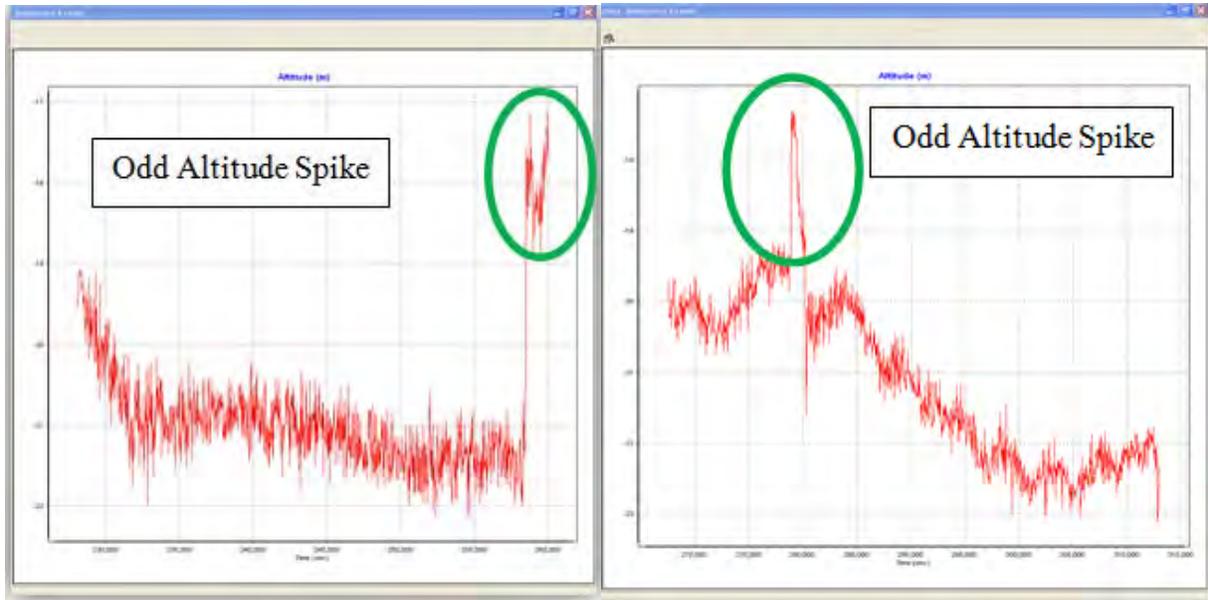
- There should be a “forward” “backward” and “smoother” processing, in addition to other steps. If any of these are missing, a processing error likely occurred.
- Under POS Data Import, ensure that the POS status reached Full Navigation, or at Least Fine Align, if it did not, note this.
- Under IMU Data Continuity note any reported IMU data gaps. IMU data gaps are typically caused by a data communication failure between IMU and the POS computer.
- In Primary/Secondary GNSS Import, note any decoding errors, likely caused by data communication failures due to corrupted bytes from the GNSS receiver data stream.

- Examine the plots for the solution. Fill out processing log.

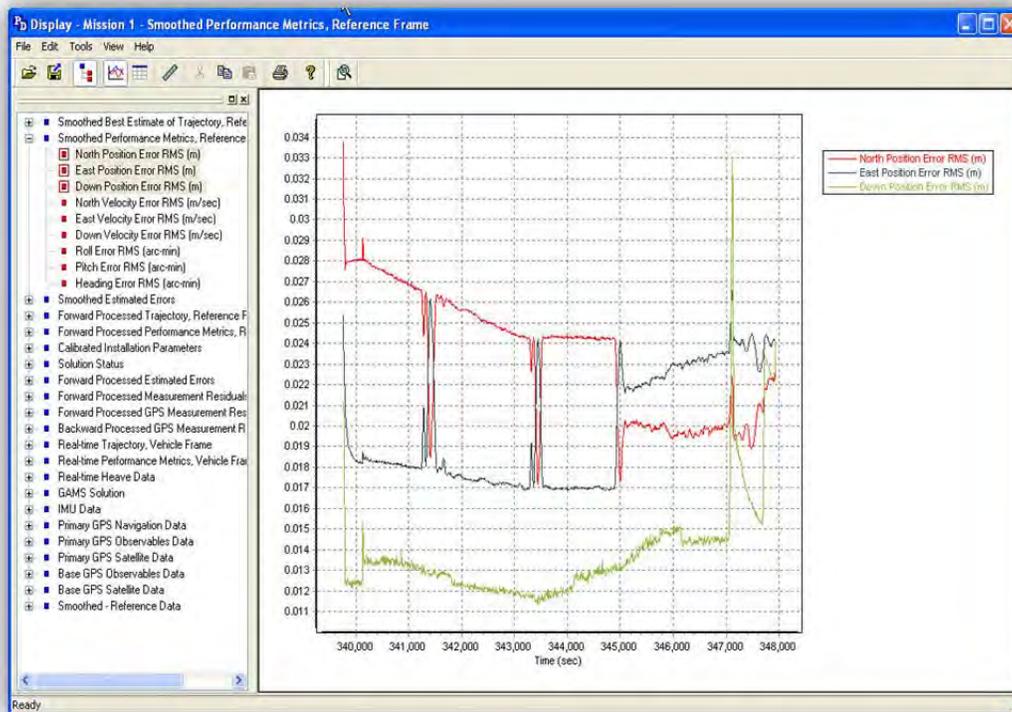


- **Altitude.** Altitude can be viewed with Total Speed. Odd behaviors in the Altitude should correspond to changes in the Total Speed. If not, make a comment in the Remarks section of the Processing Log. Jumps in altitude should be noted and logged. Such offsets will cause problems if the data is used to produce ellipsoidally referenced surfaces. Jumps like this can be highly indicative of other positioning problems.

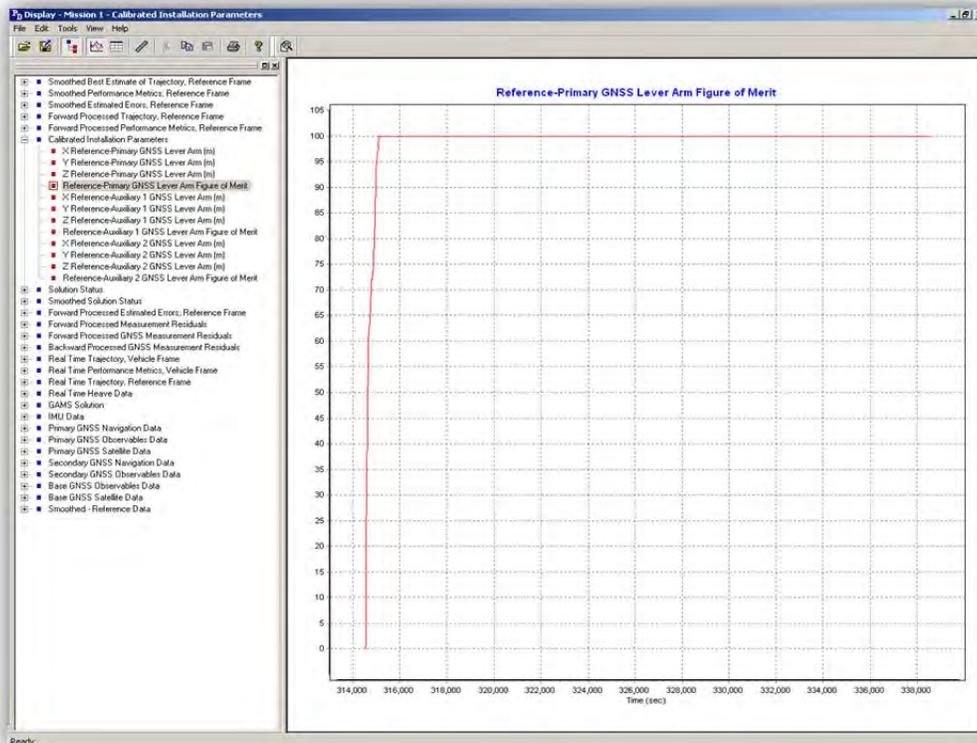
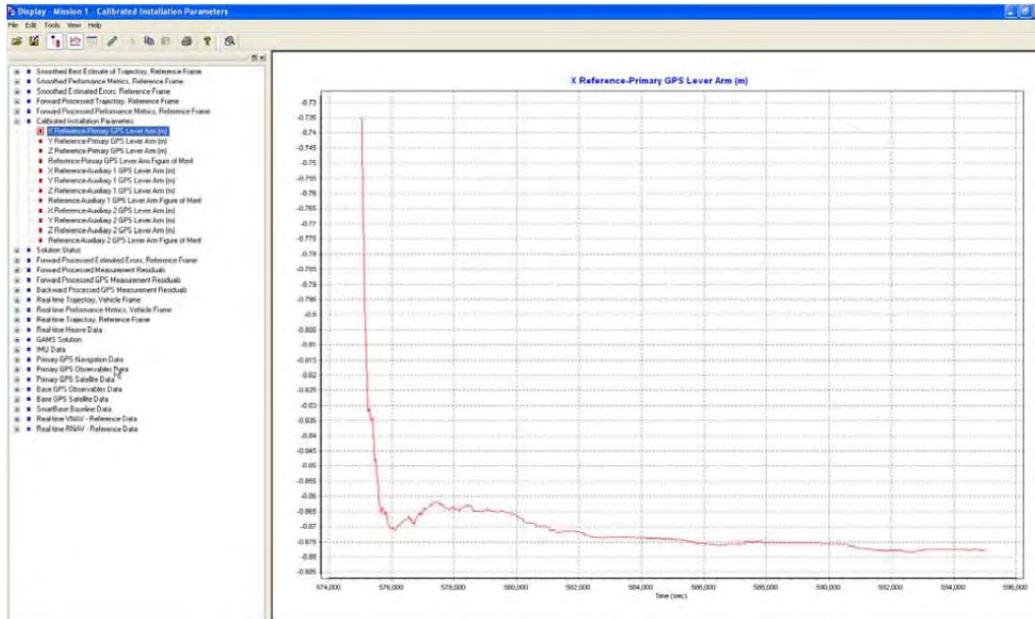




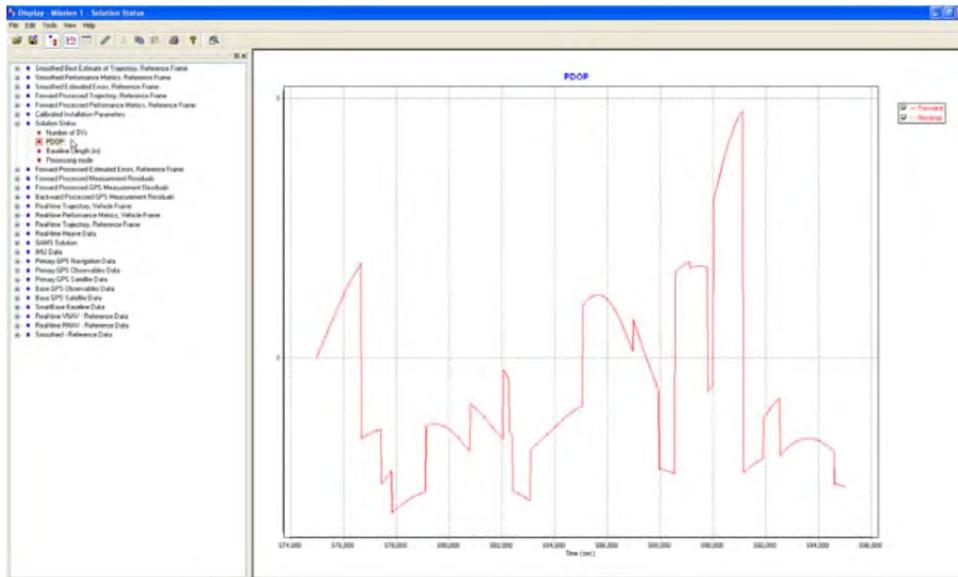
- **RMS Data.** Found under “Smoothed Performance Metrics, reference frame” and North, East, and Down Position Error RMS (m). Record the peak values (ignoring the spike at the very beginning and end of the data). Also record the peak RMS values for Pitch, Roll, and Heading Error.



- **Calibrated Installation Parameters.** X, Y, and Z Reference- Primary GPS Lever Arm. These values should settle out to an approximate value for x, y and z. The Reference-Primary GNSS Lever Arm Figure of Merit should be 100. Note in the log if it is not.

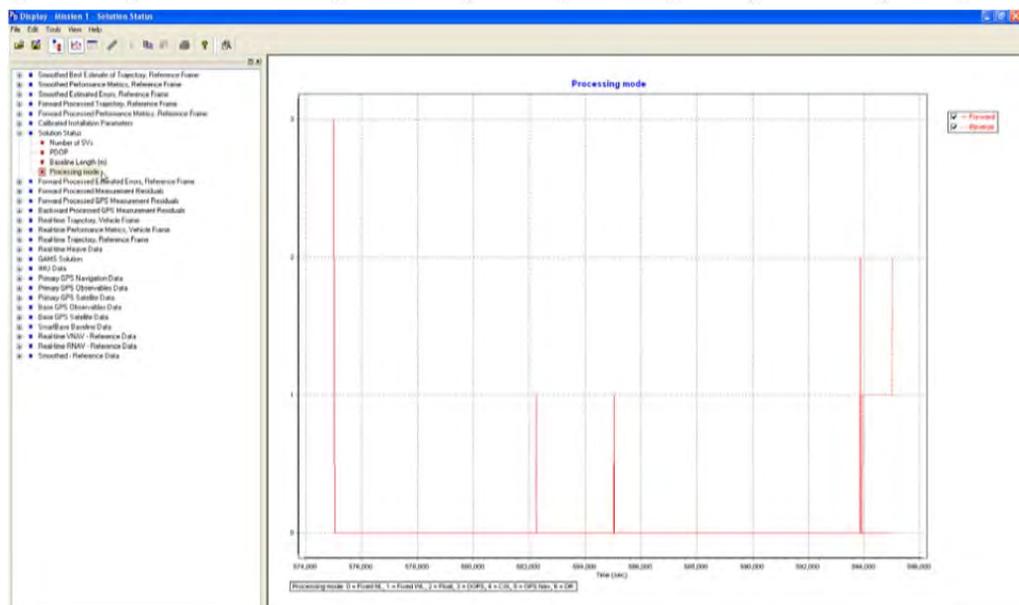


- **Smoothed Estimated Errors.** Look at the x , y, and z accelerometer bias values. If the data fluctuates significantly with time, then make a note in the remarks.
- **Number of SV's.** Found under “Smoothed Solution Status.” SVs greater than 7 should give a reliably accurate solution. This should be reviewed with PDOP.
- **PDOP.** The PDOP values less than 3 normally give a reliably accurate solution. The FPM has guidelines to keep this number below 6. *If the satellite count drops, the PDOP value will increase.* Monitor PDOP during field acquisition.

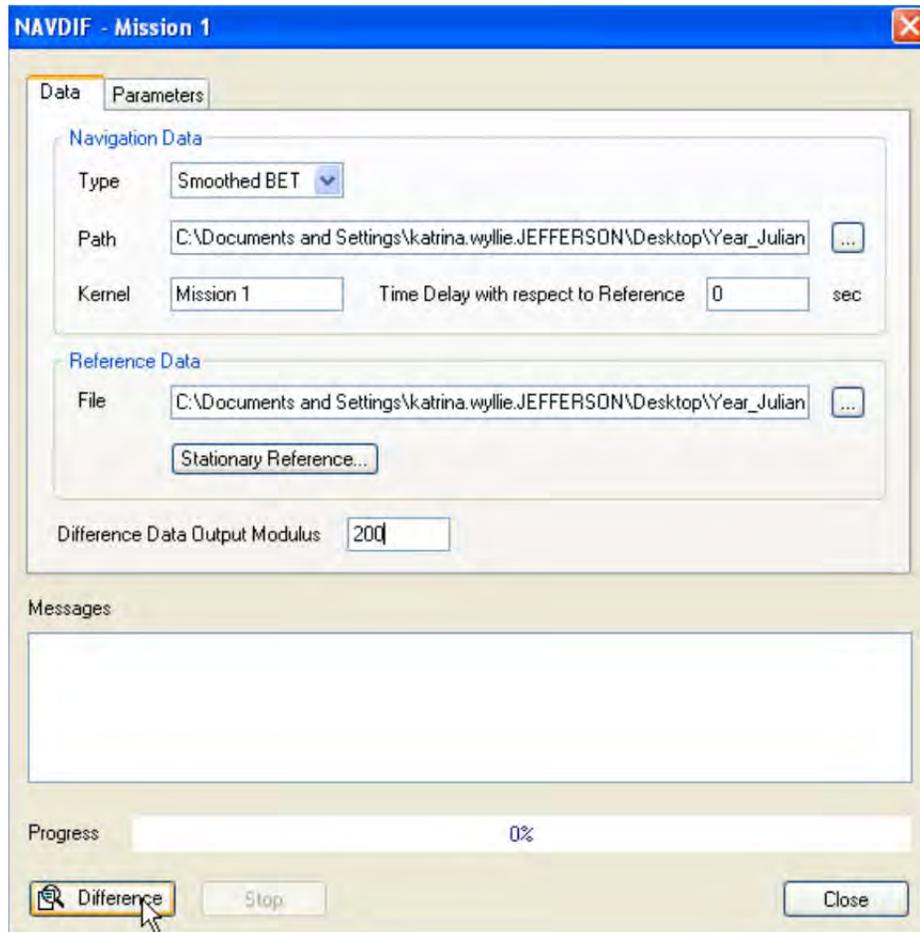


- **Processing mode.** The best solution would be a 0, or Fixed NL. Disregard momentary spikes, only log processing modes that have multiple spikes or peaks that last longer than ~10 minutes

Processing mode: 0 = Fixed NL, 1 = Fixed WL, 2 = Float, 3 = DGPS, 4 = C/A, 5 = GPS Nav, 6 = DR

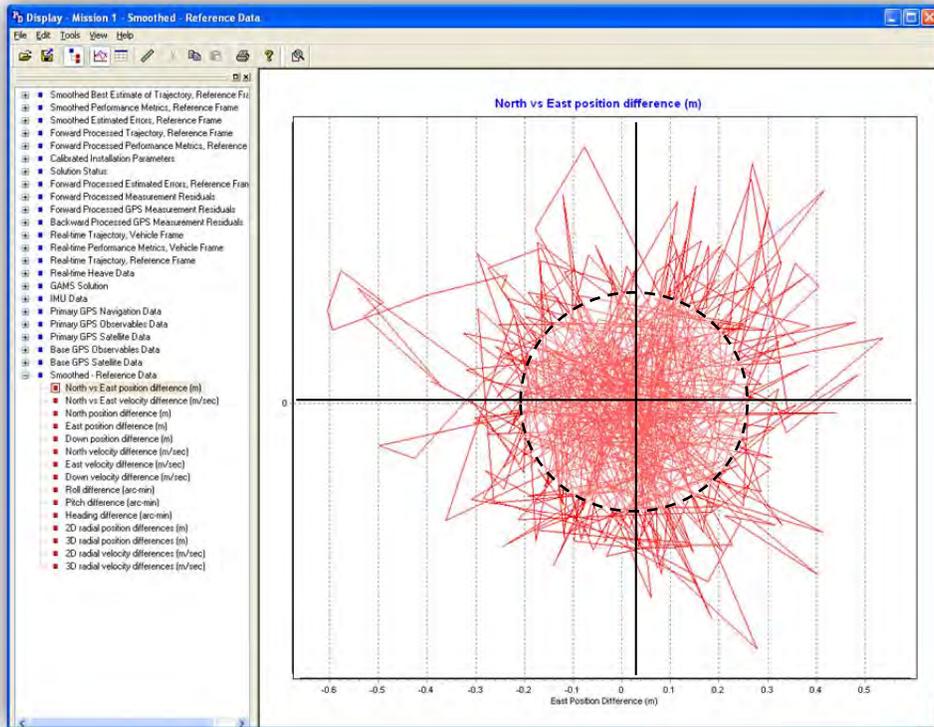


- **Smoothed- Reference Data.** First, click on Tools, NAVDIF. Under the Reference Data file, browse to \YYYY\_DDD\_VSSL\Mission 1\Extract folder and select vnav\_Mission 1.out. Change the Difference Data Output Modulus to 200. Click Difference.

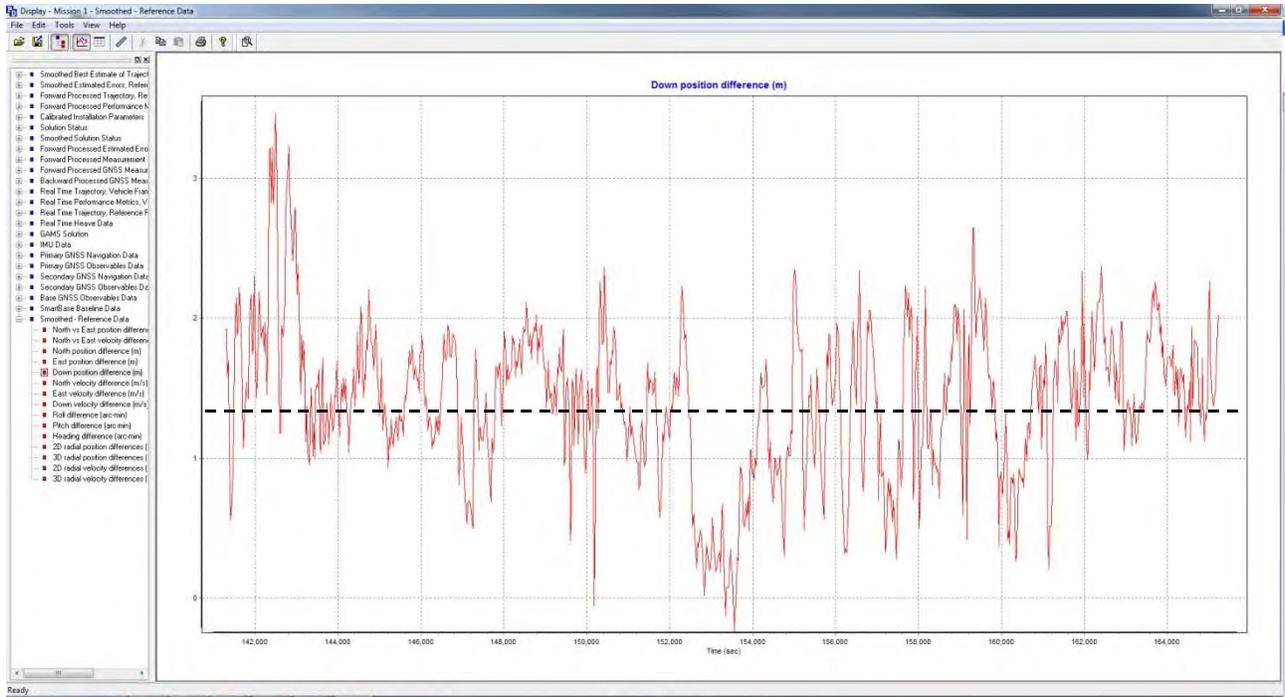


You are differencing the real-time navigation to the SBET solution. When the difference is done, close the NAVDIF box. A new plot will pop up, called Smoothed- Reference Data. Select North vs. East position difference (m) You should be looking at an approximately round scatter plot – zoom into the most dense area of data and approximate the central point of the scatter plot. Log the N/S (Y-axis) and E/W (X-axis) values of this central point.

*This graph can be highly erratic and confusing. Simply give your best approximation of the central point. What you are looking at is the average distance that POSPac adjusted position by. If the values are large, it implies poor GPS data, if the values are small, it implies good GPS data, probably DGPS*



Select Down Position Difference (m) Log the approximate average value for the Down position difference (m) where half the data is above the line and half the data is below



- **2D radial position differences** (m), generally below 2m is okay.
  - **3D radial position differences** (m), generally below 3m is okay.
  - For any abnormally large spikes, reference the Real-Time Performance Metrics, North, East and Down Position Errors and compare with the radial position difference time when there are large jumps in the position differences. If the radial spike corresponds to any spikes in the Real-time positions, we can assume the error occurred in real time and was not introduced by the post-processing.
- Make a recommendation to apply the SBET
    - **Apply:** You believe the data looks good and have seen no reason to suspect the data quality
    - **Apply with inspection:** You believe the data looks okay, however you have seen some questionable values in the data that the sheet manager should be aware of
    - **Needs troubleshooting:** You believe this data is of poor quality, with fatal errors, or highly suspicious values. This data should not be applied to a sheet

### **Advanced Troubleshooting and considerations**

If you encounter any major issues, one of the key questions will be determining if the vessel was even logging data during the time of the error. Convert the time displayed on a plot or in the overview screen into a time to compare to .hsx logging times (or vice versa). If the error is within logging times, inspect the lines manually and using directed editing techniques.

Files can be reprocessed in POSPAC using alternative processing methods (PPP, Smartbase, Singlebase) and without using batch and have the resultant solutions compared using plots, or navdiff the resultant sbets. Start and end times of processing can also be altered to not process certain parts of the file.

Errors apparent in a given vessel can be compared across the same vessel during different days, or compared to other vessels at the same time. Many vessels experiencing a similar error at the same time could imply external sources (Atmosphere, satellites, etc), whereas a recurring error on one vessel may be indicative of an internal issue (settings, hardware, software).

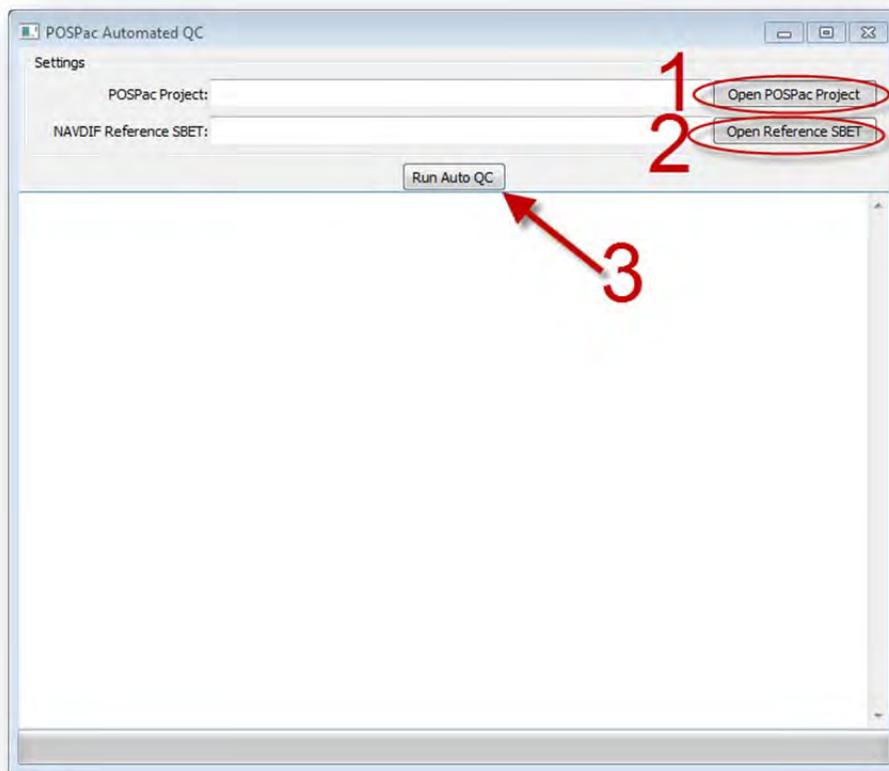
## Automated SBET QC

This feature allows you to run a small program which requires an input of POSPac Project and the associated NAVDIF Reference SBET and will output the required metrics including: Smoothed Performance Metrics, Calibration Installation Parameters, Solution Status Values, and Smoothed-Reference Data. This method can be used as an alternate to manually going through the individual plots to get the required metrics as it is much quicker to obtain.

Double click on the AutoQC script to start the program

Run the Auto QC program

1. Open POSPac Project you want to QC
2. Select Open Reference SBET and navigate to the SBET in the associated POSPac folder (YYYY\_DDD\_VSSL\Mission 1\Proc\sbet\_Mission 1.out)
3. Click Run Auto QC



This process will output a report that will include all of the quality control metrics that should be reviewed for an SBET. These values will then be entered into the SBET processing log.

POSPac Automated QC

Settings

POSPac Project: C:\Users\albert.davison\Documents\POSPac MM

NAVDIF Reference SBET: C:\Users\albert.davison\Documents\POSPac MM

Processing test

**Smoothed Performance Metrics -**

	Max	(StDev) - Tolerance
North:	0.056	(0.011) - 0.07 m
East:	0.028	(0.003) - 0.07 m
Down:	0.041	(0.006) - 0.07 m
Roll:	0.966	(0.086) - 1.2 arc-min
Pitch:	0.958	(0.084) - 1.2 arc-min
Heading:	5.966	(0.638) - 1.2 arc-min

**Calibration Installation Parameters -**

	Avg.	(StDev)
X Ref Pri:	-0.811	(0.0001)
Y Ref Pri:	0.482	(0.0001)
Z Ref Pri:	-3.487	(0.0)

Max Figure of Merit: 100.0

**Solution Status -**

Min # SVs: 5.0  
 Max PDOP: 4.35 (out of tolerance for 9.1 minutes)  
 Max Baseline: 25263.0 m

**Processing Mode:**

Fixed Int./WL (0/1): 423.4 minutes  
 DGPS Mode (3): 1.5 minutes

**Smoothed-Reference Data (Realtime Difference) -**

	Avg.	(StDev)
North Pos. Diff:	0.617	(0.618) m
East Pos. Diff:	-1.366	(0.739) m
Down Pos. Diff:	-0.142	(0.48) m

## EXPORT SBET TO NAD83

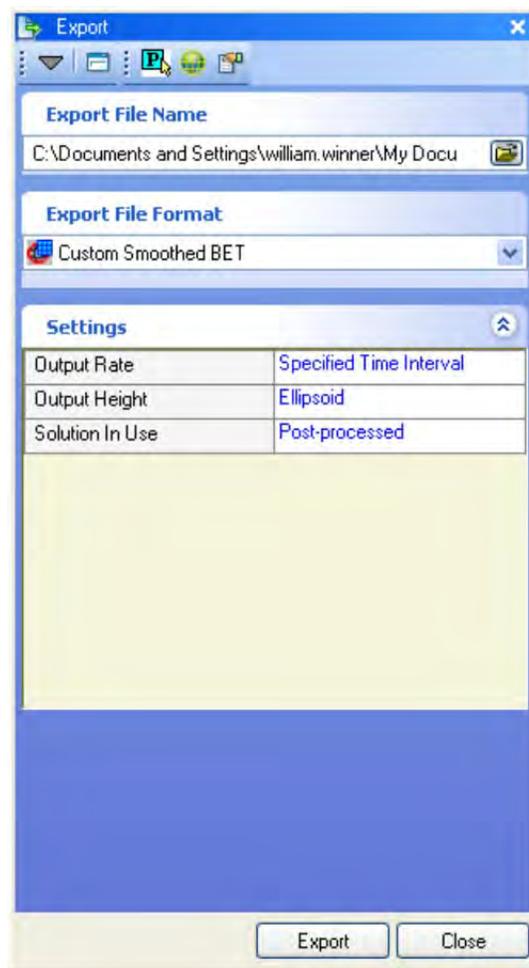
\*This export step does not need to be performed if it was part of the batch process\*

### Export SBET

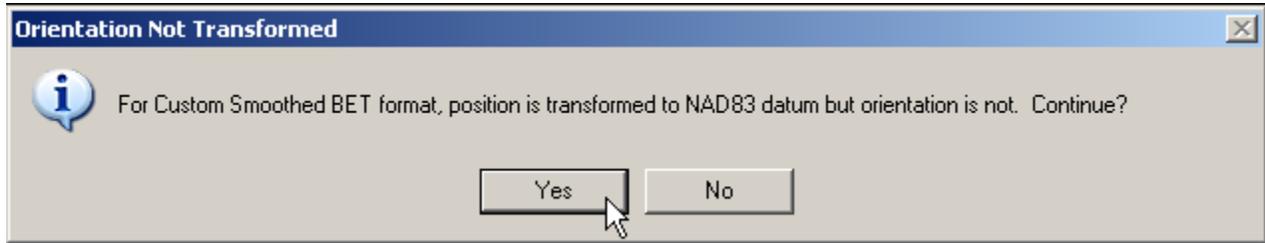
- Select Project/Export or click the “Export” Icon



The Export File name can be changed if desired or the file can be manually copied to the correct network folder after export is completed. Ensure the project settings are as described in the Template SOP.



- Select Yes to the following.



Save POSPac project.

### **Rename SBET and Associated Error File (if needed)**

If the template was used as described within this SOP, the name of the SBET and RMS file will be sbet\_RAWPOSFILENAME.out and smrmsg\_RAWPOSFILENAME.out. If this was done, there is no need to rename the files.

If this was not done:

- Browse to \YYYY\_DDD\_VSSL\Mission 1\Proc folder. Locate the sbet\_Mission 1.out file and rename it to sbet\_YYYY\_DDD\_VSSL.out
- Browse to YYYY\_DDD\_VSSL\Mission 1\Proc folder. Locate the smrmsg\_Mission 1.out and rename it to smrmsg\_YYYY\_DDD\_VSSL.out

*Note: if these files are cut and moved to a different network location, the display plots will not be able to reference the raw/processed data and they will not display correctly.*

## SBET PROCESSING LOG

The metrics below shall be filled out in a processing log for all ERS surveys.

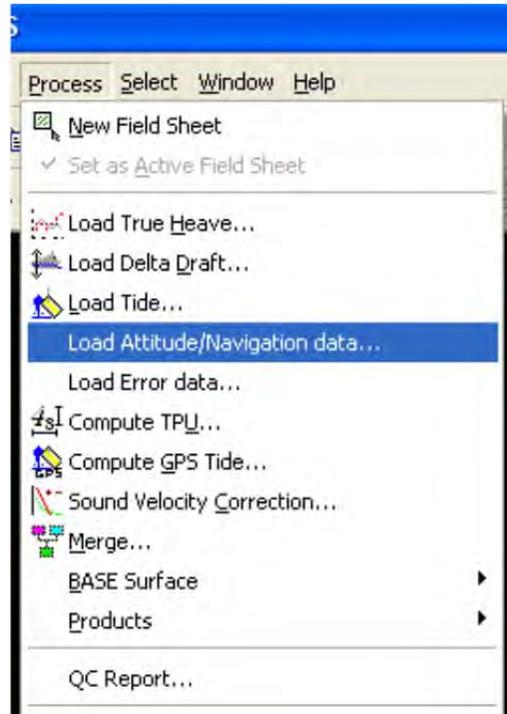
	A	B	C	D	F	G	H	I	J
1			<b>Imported POSMV Files</b>						
2	<b>DN</b>	<b>POSPAC Project Name</b>	<b>First</b>	<b>Last</b>	<b>Processing Mode</b>	<b>Processing</b>	<b>Remarks</b>	<b>Processor</b>	<b>Station(s) Used</b>

K	L	M	N	O	P	Q	R	S	T	U
<b>Smoothed Performance Metrics (max value)</b>				<b>Calibrated Install Parameters</b>			<b>Solution Status</b>			
Horiz Position RMS	Vert Position RMS	Roll/Pitch RMS	Heading RMS	X Ref Pri	Y Ref Pri	Z Ref Pri	Min #SVs	Max PDOP	Max Baseline	Process Mode

V	W	X	Y	Z	AA	AB
<b>Smoothed-Reference Data</b>						Processed Files
North	East	Down	<b>Recommendation</b>	<b>Remarks</b>	<b>QC Reviewer</b>	<b>Transferred</b>

## LOAD ATTITUDE/NAVIGATION DATA IN CARIS HIPS

- Select lines that correspond to an SBET file
- Select Process, Load Attitude/ Navigation Data...

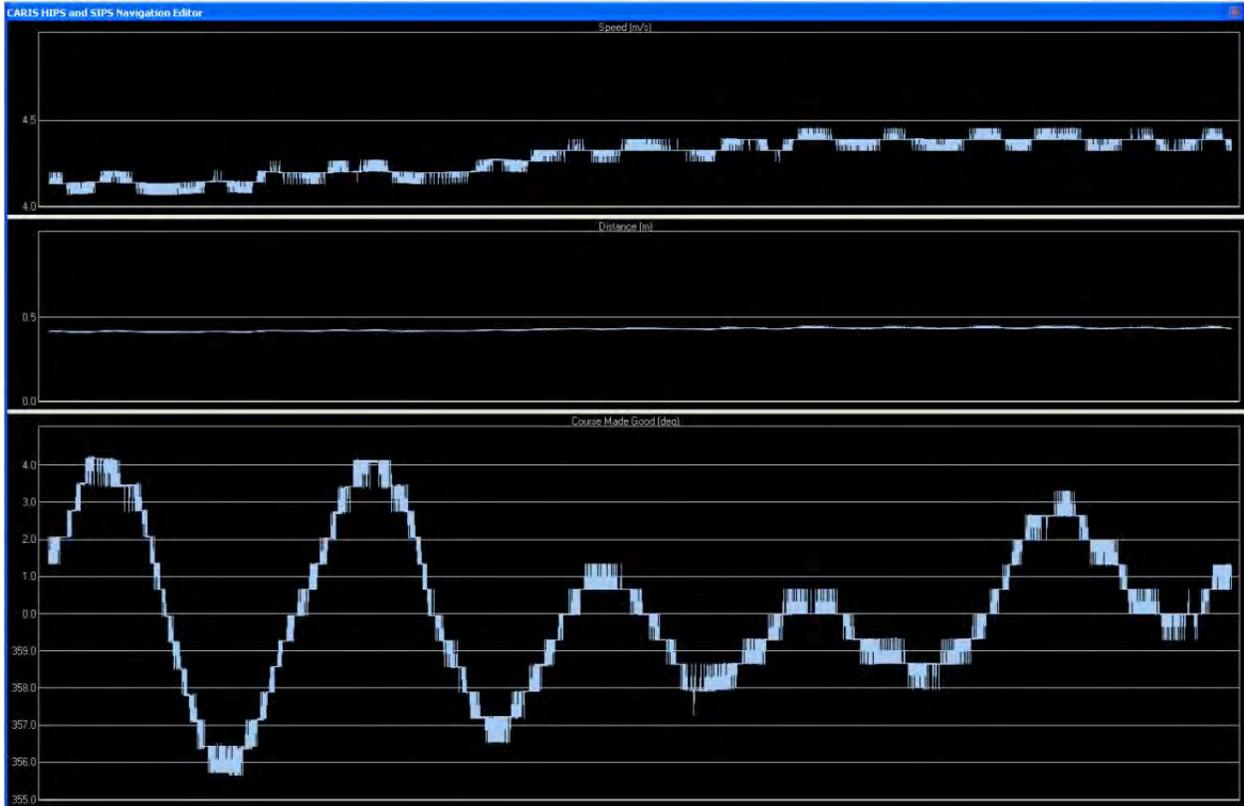


- Click “Add” and select the .sbet file(s) that correspond to the same time period as the lines being loaded.

*Note: If you are applying SBETs for an entire project, the processing is limited to a single vessel and to a single GPS Week.*

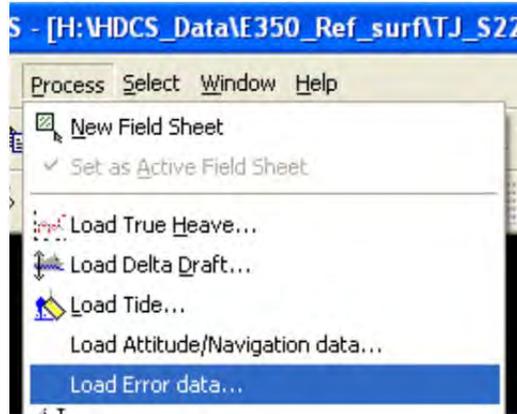
- Uncheck default under reference week and select the day
- Enter 0.10 seconds for Navigation, 0.02 seconds for GPS Height and Allow gap between data records max of 0.08 seconds
- Select “Load”. **Check the HIPS Output window to ensure no errors are reported.** A correct application will not report an error.
- After applying PPK, lines can be re-examined using the Navigation Editor tool

The selected lines now have the correct navigation and attitude information loaded. This will be applied during SVC

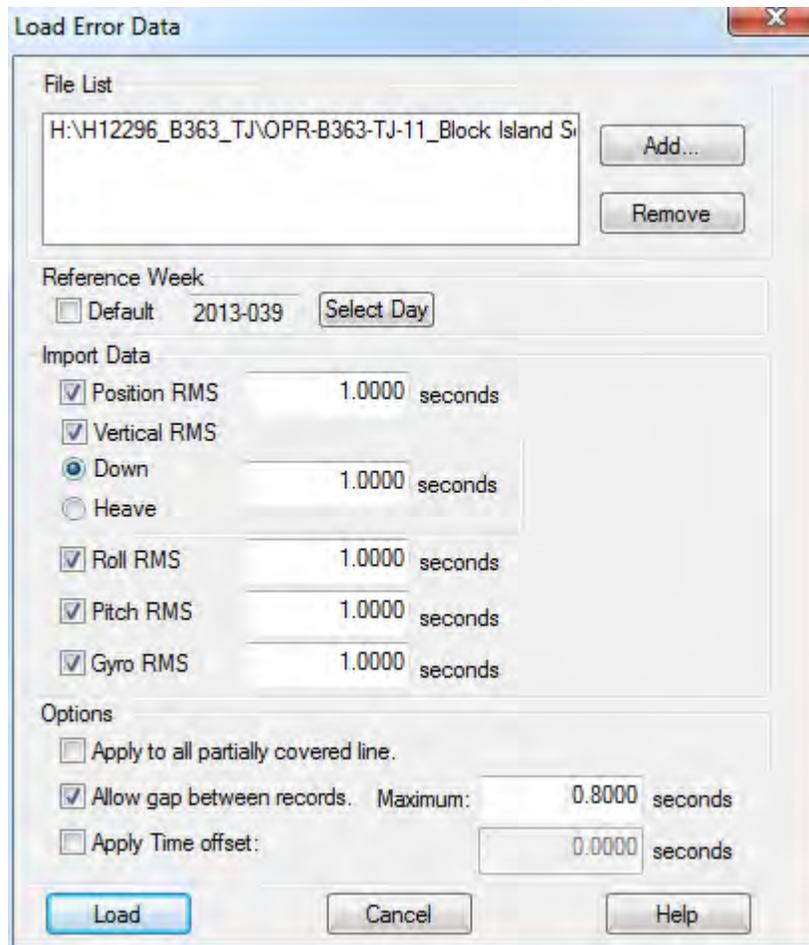


## LOAD ERROR DATA IN CARIS HIPS

- Select applicable survey lines
- Process, Load Error Data...



- Click *Add* and locate the appropriate vessel and day and select the corresponding RMS file(s)



- Uncheck default Reference week and select the day
- Under “Import Data” check Position RMS and Vertical Down RMS Down with a time of 1.00 seconds
- Under “Options” box select Allow gap between records with a maximum time of 0.8 seconds
- Click Load
- Check the CARIS Worksheet window and view the summary report for all survey lines. Make sure there are values for all the areas checked above, and no error reports.



## COMPUTE GPS TIDE IN CARIS HIPS

**Note:** HSD will be providing the Separation file (VDATUM or ERZT) to the field. If necessary, this file should be renamed to *ProjectNumber.txt* so it is CARIS compatible.

- Select all survey lines you want to compute GPS Tides for
- Process, Compute GPS Tide...

### Process Data to the Ellipsoid

- Enter a single height of 0.00m to keep the data referenced to the ellipsoid
- Apply dynamic heave, MRU remote heave, dynamic draft and waterline offset. See Compute GPSTide reference table
- Click Compute
- Check the output window to ensure no errors occur

### Process Data to MLLW using Separation Model

- Browse to Vdatum or ERZT separation model
- Apply dynamic heave, MRU remote heave, dynamic draft and waterline offset. See Compute GPSTide reference table
- Click Compute
- Check the output window to ensure no errors occur

**COMPUTE GPS TIDE REFERENCE TABLE**

GPS Tide = GPS Height - Datum Height - Dynamic Heave + Remote Heave + Antenna Offset + Dynamic Draft - Waterline + Height Correction

The GPS Tide calculation is dictated according to how components are included in the formulation, if at all (per CARIS HelpDesk - Service Request #00800588):

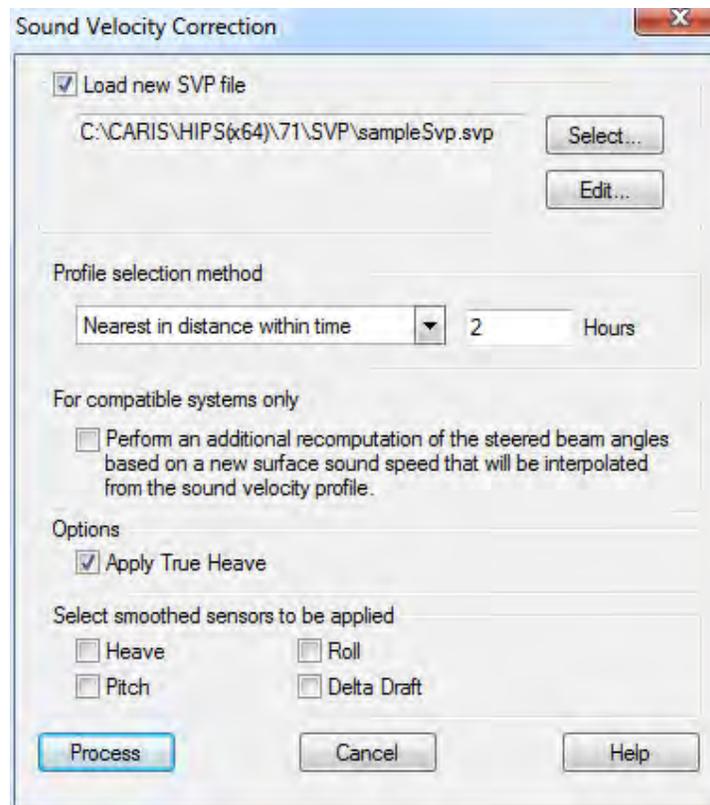
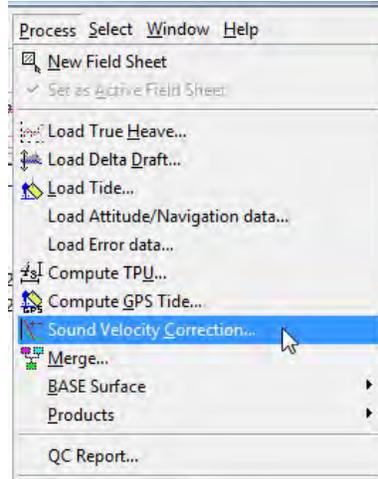
<b>“Apply” = “Remove”</b>	<b>GPS Tide Component Option</b>	<b>Notes</b>
	<i>Smooth [GPS] Height</i>	GPS Height time series data may be smoothed according to smoothing coefficients computed in HIPS Attitude Editor.
X	Apply Datum Height	"Apply" to subtract a constant offset or linearly-interpolated offset from a scalar (gridded) field of offsets to achieve the desired (ellipsoid-to-chart) datum transform.
X	Apply Dynamic Heave	"Apply" to subtract dynamic heave from the GPS Height. Select this option to remove dynamic heave from the GPS Height time series. In particular, if heave is applied during HIPS "Sound Velocity Correct", select Apply Dynamic Heave in the GPS Tide calculation to prevent double-compensation of heave motion (assuming heave present in the GPS Height data).
X	Apply MRU Remote Heave	"Apply" to subtract remote heave from the GPS Height. In computing remote heave, HIPS treats the HIPS Vessel File (HVF) reference point (RP) as the center of rigid body rotations for moment arm calculations. Remote heave is that vertical component of the moment arm calculation resulting from an off-RP mounting of the vessel motion reference unit (MRU). Now, MRU remote heave is applied when heave is applied in HIPS "Sound Velocity Correct"; therefore, Apply MRU Remote Heave is necessary only when the Apply Dynamic Heave Option is set (assuming remote heave not already removed from the GPS Height data).

X	Apply Antenna Offset (only meaningful if HVF Navigation ≠IMU)	"Apply" to adjust the GPS Height for roll- and pitch-projected antenna vertical component offset per those x,y,z offsets entered in the Navigation sensor section of the HVF. Note that if the GPS Height was reduced to the HVF RP during data acquisition, the Navigation offsets in the HVF would be zeroed; hence, checking this option would not affect the computation.
X	Apply Dynamic Draft	"Apply" to add dynamic draft affects into the GPS Height time series data. In particular, if the dynamic draft table in the HVF is applied during Sound Velocity Correction (for accurate determination of the initial conditions for geometric ray-tracing) it is necessary to apply dynamic draft in GPS Tide computation.
X	Apply Waterline Offset [Simrad only]: -From Installation XML, if available	"Apply" to adjust the GPS Height to the waterline as per the HVF; optionally, for Simrad, use the waterline value from the installation XML metadata. RP - WL
	Apply Height Correction	"Apply" to add a constant offset to the GPS Height time series data.

The “Apply” = “Remove” field is to undo what SV Correction initially did to the observed depths if these fields are set to “Apply” = Yes in the HVF. This checking to remove paradigm exists in a Tide/ERS scenario, in a strait ERS paradigm the HVF could be modified to “Apply”=NO at the project’s onset.

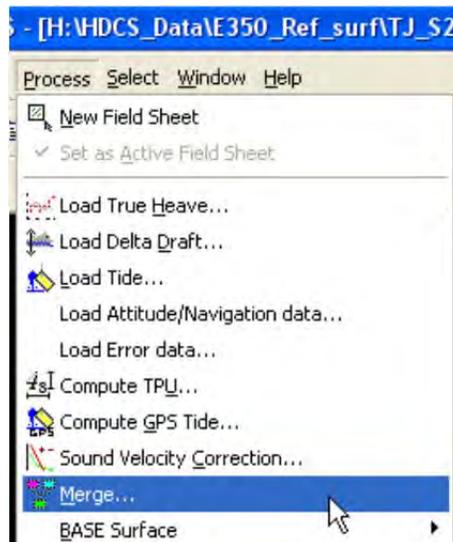
## SVC AND MERGE IN CARIS HIPS

- Select all applicable lines
- Process, SVC

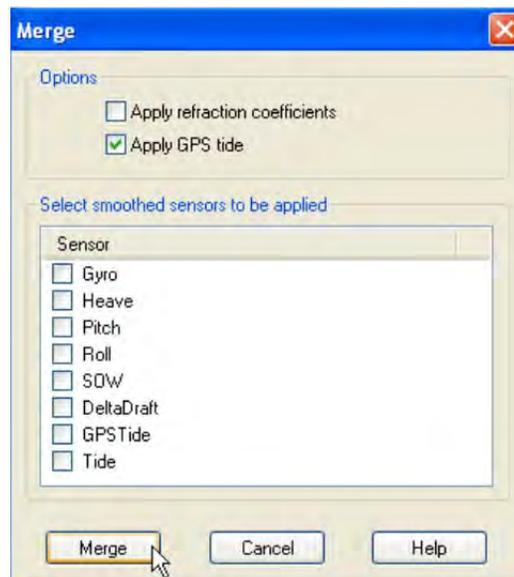


- Load the correct SVP file
- Select the appropriate profile selection method for the survey
- Apply True Heave
- Process

- With the same lines selected, Process, Merge



- Check “Apply GPS Tide”



- To go back and forth between traditional tides and using ERS/Sep model, it is necessary to:
  - Re-merge without Apply GPS Tide
  - enter in correct TPU values

## COMPUTE TPU

- Select all applicable lines
- Process, Compute TPU

Currently, CARIS does not have a process or placeholder for the separation model uncertainty, so the following is our current workaround. Input the one sigma VDatum maximum combined uncertainty value provided in the project instructions into the Tide Values: Zoning (e.g 0.10m).

- Select Error Data for the Uncertainty Source

*Note: Any data that is processed with traditional tides will have values in all four boxes and the uncertainty source from the vessel settings.*

## TRIMBLE NetR9 SETUP

Setting up new Trimble NetR9 receivers

Start with a computer (field laptop) which is set-up with appropriate subnet mask and gateway.

Turn on NetR9 receiver, press enter, press down, press enter, **Disable DHCP**, **Enter** appropriate IP address, subnet mask and gateway. **Restart** the receiver.

The computer should now connect to the receiver with the correct IP Address.

Under the security tab select **Enabled with Anonymous Access**, and give the anonymous user **File Download** capabilities. Login as the administrator (User=admin, Password=Password), **Change Password** to Admin.

The screenshot shows the Trimble NetR9 web interface. The top navigation bar includes the Trimble logo, the device ID 'CREF0001', and the 'NetR9' title with serial number 'SN: 5034K69698'. A left sidebar contains various configuration tabs, with 'Security' selected. The main content area is titled 'Security Summary' and shows 'Security: Enabled with Anonymous Access' and 'Current User: admin'. Below this is a table of users:

Username	Edit Users	File Download	File Delete	Receiver Config	NtripCaster
Anonymous User		<input checked="" type="checkbox"/>			
admin	<input checked="" type="checkbox"/>				

Start at the top and follow the screen grabs:

Ignore Receiver Status

Under Satellites

**Trimble** CREF0001 **NetR9** SN: 5034K69698

**Satellites - General Information**

Satellites Tracked:0

Total Satellites in GPS Constellation:13  
 Healthy(12): 2, 3, 4, 5, 6, 7, 8, 25, 27, 28, 29, 30  
 Unhealthy(1): 26  
 Ignore Health(32): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32

Total Satellites in GLONASS Constellation:21  
 Healthy(21): 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24  
 Ignore Health(24): 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24

Total Satellites in Galileo Constellation:2  
 Ignore Health(2): GIOVE-A, GIOVE-B

Receiver Status  
 Satellites  
 General  
 Tracking (Table)  
 Tracking (Graph)  
 Tracking (SkyPlot)  
 GPS Enable/Disable  
 GLJI Enable/Disable  
 SBAS Enable/Disable  
 Galileo Enable/Disable  
 Satellite Almanacs  
 Predicted Elevation  
 Predicted Constellation  
 Current Constellation  
 Ground Track  
 Data Logging  
 Receiver Configuration  
 I/O Configuration  
 Bluetooth  
 OmniSTAR  
 Network Configuration  
 Security  
 Firmware

**Trimble** CREF0001 **NetR9** SN: 5034K69698

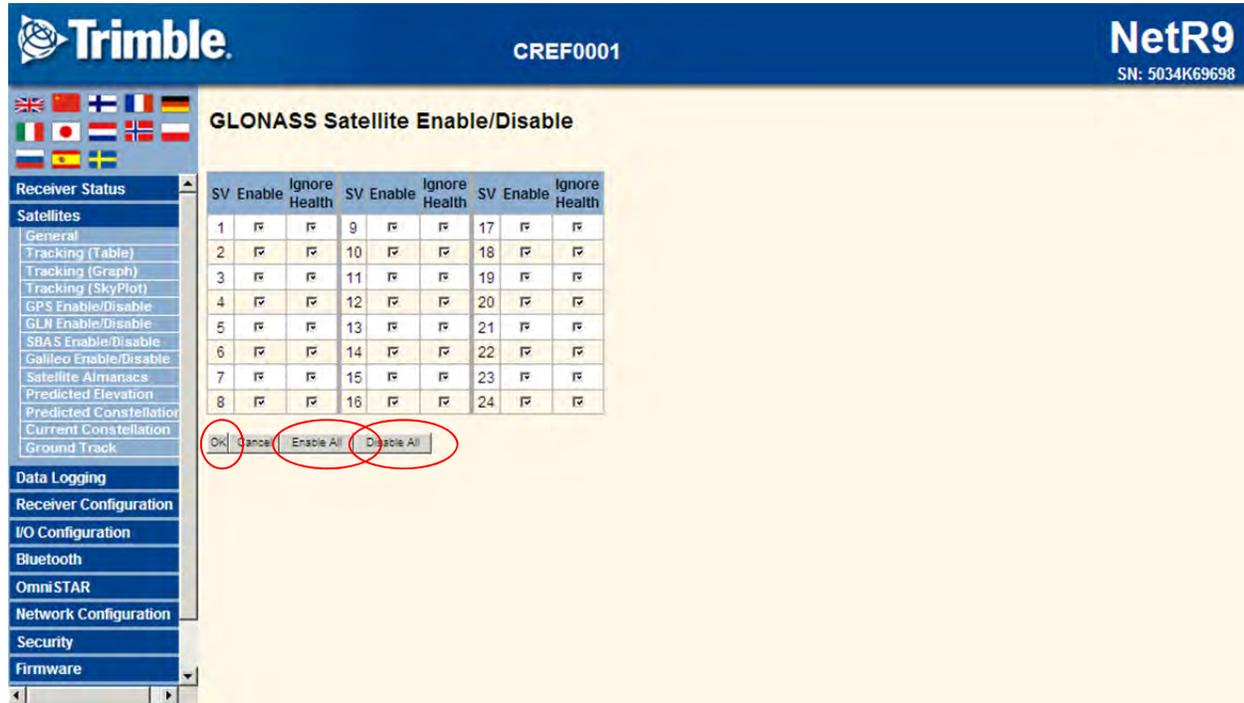
**Satellite Information**

SV	Enable	Ignore Health	SV	Enable	Ignore Health	SV	Enable	Ignore Health
1	<input type="checkbox"/>	<input type="checkbox"/>	12	<input type="checkbox"/>	<input type="checkbox"/>	23	<input type="checkbox"/>	<input type="checkbox"/>
2	<input type="checkbox"/>	<input type="checkbox"/>	13	<input type="checkbox"/>	<input type="checkbox"/>	24	<input type="checkbox"/>	<input type="checkbox"/>
3	<input type="checkbox"/>	<input type="checkbox"/>	14	<input type="checkbox"/>	<input type="checkbox"/>	25	<input type="checkbox"/>	<input type="checkbox"/>
4	<input type="checkbox"/>	<input type="checkbox"/>	15	<input type="checkbox"/>	<input type="checkbox"/>	26	<input type="checkbox"/>	<input type="checkbox"/>
5	<input type="checkbox"/>	<input type="checkbox"/>	16	<input type="checkbox"/>	<input type="checkbox"/>	27	<input type="checkbox"/>	<input type="checkbox"/>
6	<input type="checkbox"/>	<input type="checkbox"/>	17	<input type="checkbox"/>	<input type="checkbox"/>	28	<input type="checkbox"/>	<input type="checkbox"/>
7	<input type="checkbox"/>	<input type="checkbox"/>	18	<input type="checkbox"/>	<input type="checkbox"/>	29	<input type="checkbox"/>	<input type="checkbox"/>
8	<input type="checkbox"/>	<input type="checkbox"/>	19	<input type="checkbox"/>	<input type="checkbox"/>	30	<input type="checkbox"/>	<input type="checkbox"/>
9	<input type="checkbox"/>	<input type="checkbox"/>	20	<input type="checkbox"/>	<input type="checkbox"/>	31	<input type="checkbox"/>	<input type="checkbox"/>
10	<input type="checkbox"/>	<input type="checkbox"/>	21	<input type="checkbox"/>	<input type="checkbox"/>	32	<input type="checkbox"/>	<input type="checkbox"/>
11	<input type="checkbox"/>	<input type="checkbox"/>	22	<input type="checkbox"/>	<input type="checkbox"/>			

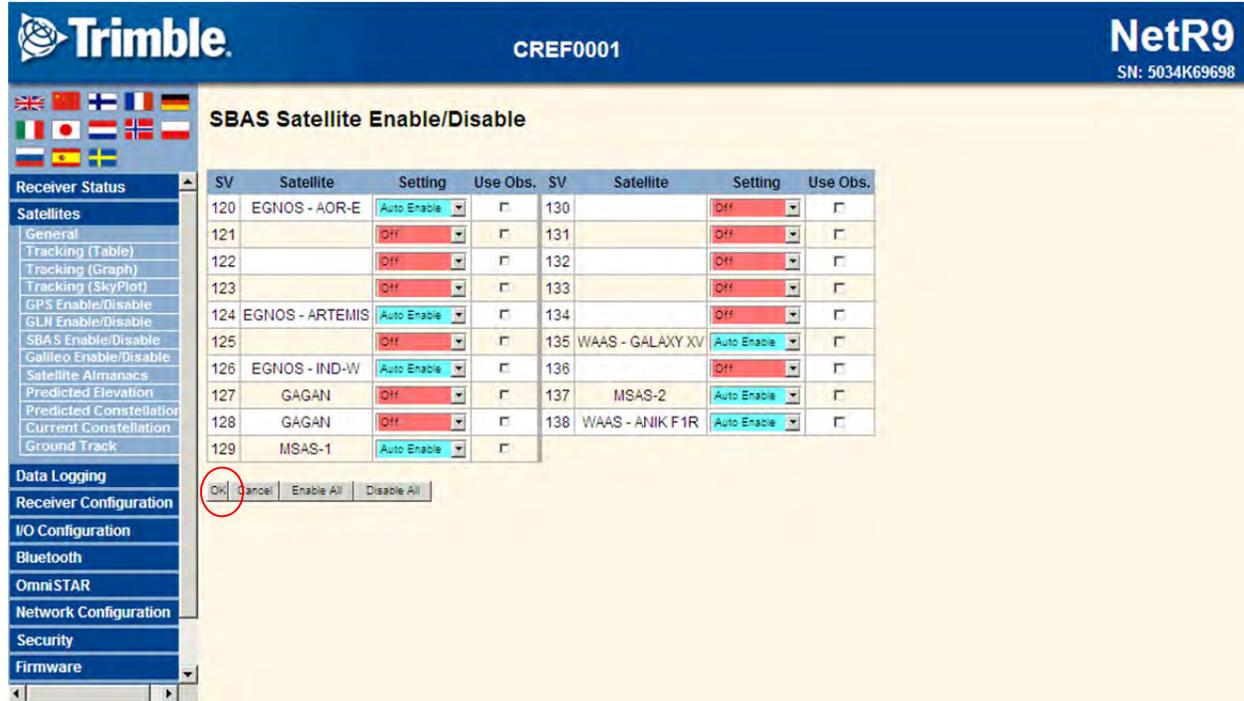
OK Cancel Enable All Disable All

Receiver Status  
 Satellites  
 General  
 Tracking (Table)  
 Tracking (Graph)  
 Tracking (SkyPlot)  
 GPS Enable/Disable  
 GLJI Enable/Disable  
 SBAS Enable/Disable  
 Galileo Enable/Disable  
 Satellite Almanacs  
 Predicted Elevation  
 Predicted Constellation  
 Current Constellation  
 Ground Track  
 Data Logging  
 Receiver Configuration  
 I/O Configuration  
 Bluetooth  
 OmniSTAR  
 Network Configuration  
 Security  
 Firmware

Click disable all, enable all, ok. This gets rid of the check boxes on ignore health.



Click disable all, enable all, ok. This gets rid of the check boxes on ignore health.



Keep Defaults



Click disable all, enable all, ok. This gets rid of the check boxes on ignore health. See NOTE made under Tracking section.



Under Data Logging

File System	Size	Available	Auto Delete
/Internal	7.744 GB	7.734 GB	100% <input type="checkbox"/> <a href="#">Format</a>
/External			<input type="checkbox"/>

Session	Schedule	Status	Enable
DEFAULT Measurements 10 Sec. Positions 5 Min.	Manual 1440 Min.	Disabled	<input type="checkbox"/>

[New Session](#)

Click on Default; Click enable, set; schedule = continuous, duration = 1440 (this equals 24 hours), Measurement Interval = 1 sec, Position interval = 5 min, Name style = SystJJJh. All other defaults okay. Press Ok

Click New Session and set the following settings; Session name = 30Min, Enable, Schedule = continuous, Duration = 30, Measurement Interval = 1 sec, Position = 5 min, Path Style = Date, Name Style = SystJJJhmm, Press ok.

Under Receiver Configuration

Enter Antenna Serial Number and Antenna Height = 1.5

Station Name = Site?

**Trimble** CREF0001 **NetR9**  
SN: 5034K69698

**Tracking**

Elevation Mask: 10  
Everest™: Enable  
Clock Steering: Enable

Type	Signal	Enable	Options
GPS	L2 - Legacy	<input checked="" type="checkbox"/>	L2 - CS and Legacy
GPS	L2 - CS	<input checked="" type="checkbox"/>	CM - CL
GPS	L5	<input type="checkbox"/>	
SBAS	L1 - C/A	<input type="checkbox"/>	
SBAS	L5	<input type="checkbox"/>	
GLONASS	L1 - C/A	<input checked="" type="checkbox"/>	
GLONASS	L1 - P	<input checked="" type="checkbox"/>	
GLONASS	L2 - C/A(M)	<input type="checkbox"/>	
GLONASS	L2 - P	<input checked="" type="checkbox"/>	
GALILEO	E1	<input checked="" type="checkbox"/>	
GALILEO	E5 - A	<input checked="" type="checkbox"/>	
GALILEO	E5 - B	<input checked="" type="checkbox"/>	
GALILEO	E5 - A/BOC	<input checked="" type="checkbox"/>	

OK Cancel

Enable GPS L5 and GLONASS L2. NOTE: enabling the logging of GLONASS and GALILEO will increase the file size. Until more testing is done it is currently not allowed to use these systems for processing. FA will log these systems in addition to GPS L5 for testing purposes for the 2011 season.

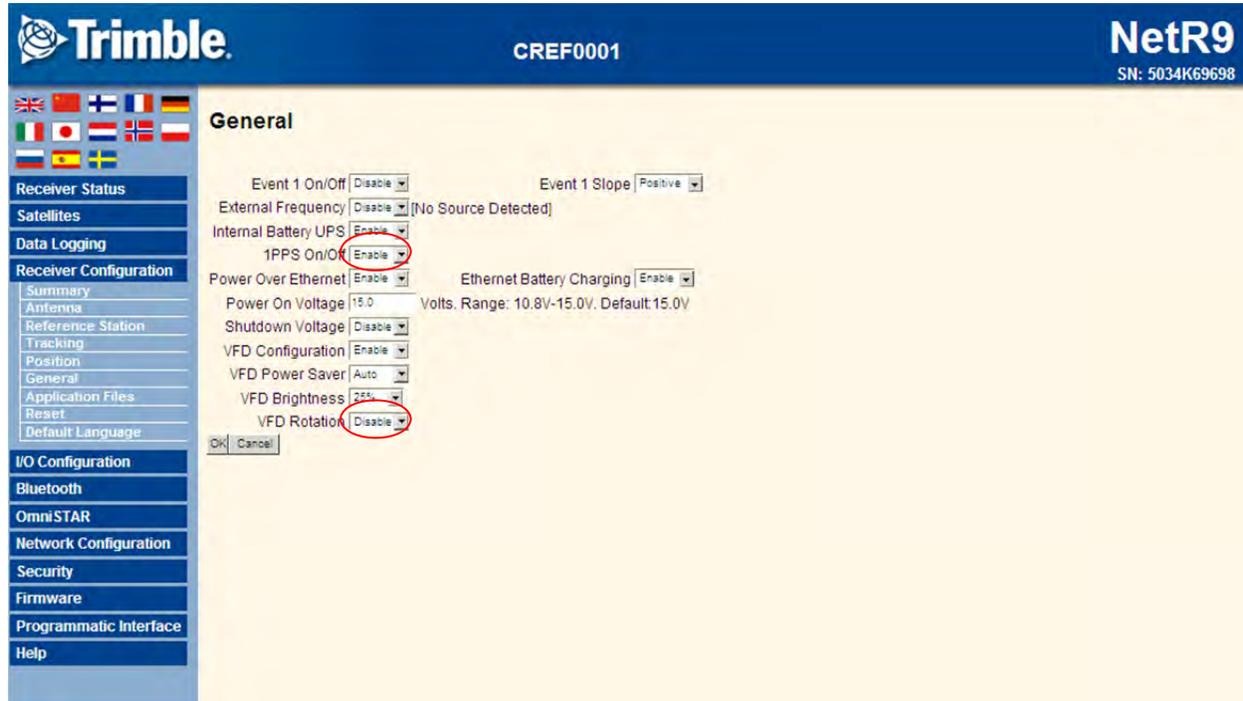
**Trimble** CREF0001 **NetR9**  
SN: 5034K69698

**Position**

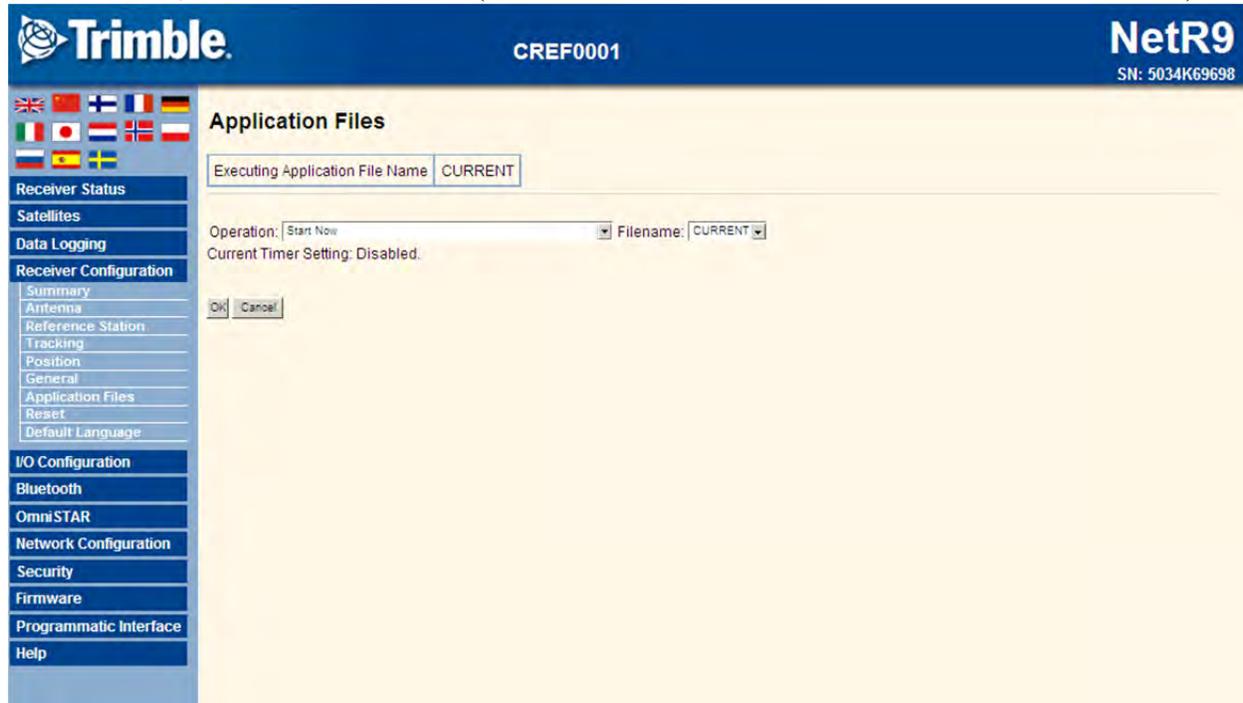
PDOP Mask: 6  
RTK Mode: Low Latency | Motion: Static  
CMR Input Filter:   
RTCM Input Filter:   
RTCM 2 Type 31 Input GLONASS Datum: PZ90  
Horizontal Precision: 0.30 [m]  
Vertical Precision: 0.30 [m]  
DGNSS Age of Correction:  
GPS: 60 [Sec]  
GLONASS: 60 [Sec]

OK Cancel

Set PDOP Mask value = 6.



Disable 1PPS, enable VFD Rotation (This will make the screen easier to read when mounted)



Keep defaults  
Under I/O Configuration


CREF0001
NetR9  
SN: 5034K69698



**I/O Configuration**

- Receiver Status
- Satellites
- Data Logging
- Receiver Configuration
- I/O Configuration**
  - Port Summary
  - Port Configuration
- Bluetooth
- OmniSTAR
- Network Configuration
- Security
- Firmware
- Programmatic Interface
- Help

Type	Port	Input	Output
TCP/IP	5017	-	RT27(1Hz)
TCP/IP	5018	-	-
TCP/IP	28001	-	-
TCP/IP	28002	-	-
NTRIP Client	-	-	-
NTRIP Server	-	-	-
NTRIP Caster 1	2101	-	-
NTRIP Caster 2	2102	-	-
NTRIP Caster 3	2103	-	-
Serial	Serial 1 (38.4K-8N1)	-	-
Serial	Serial 2 (38.4K-8N1)	-	-
Bluetooth	1	-	-
Bluetooth	2	-	-
Bluetooth	3	-	-
USB	-	-	-


CREF0001
NetR9  
SN: 5034K69698



**I/O Configuration**

- Receiver Status
- Satellites
- Data Logging
- Receiver Configuration
- I/O Configuration**
  - Port Summary
  - Port Configuration
- Bluetooth
- OmniSTAR
- Network Configuration
- Security
- Firmware
- Programmatic Interface
- Help

TCP/IP 5017 | RT17/RT27

Server: TCP10.48.19.161: 5017

Client

Output only/Allow multiple connections

UDP Mode

Authenticate, set password:

**Input/Output**

Output: RT27 (1 Hz)

**RT27**

Epoch Interval	Options
1 Hz	<input checked="" type="checkbox"/> Concise <input checked="" type="checkbox"/> Multi-System Support <input checked="" type="checkbox"/> Measurements <input type="checkbox"/> R-T Flag <input type="checkbox"/> Smooth Pseudorange <input checked="" type="checkbox"/> Positions <input type="checkbox"/> Send Raw GPS Data <input type="checkbox"/> Smooth Phase <input type="checkbox"/> Send Raw SBAS Data <input type="checkbox"/> Include Doppler
	GPS Ephemeris: When new one is available GLONASS Ephemeris: When new one is available Galileo Ephemeris: When new one is available

## **ETHERNET RADIO CONFIGURATION (to enable remote downloading of basestation data)**

### **IP Configuration via Serial**

This can also be done via the web interface but only if you already know the radio's IP.

1. With the radio off
2. Attach PORT1 on the radio to COM1 on the computer via RS232 9 pin cable
3. Open HyperTerminal and configure the session to connect on COM1
  - a. Port Settings: 19200, 8, None, 1, None
4. Power on the radio, in HyperTerminal it will first ask if you want to enter setup, type "y"
5. Next it will prompt you for a password, default password is "admin"
6. Select the IP Setup
7. Configure the station to have the following values
  - a. IP Address 10.48.19.### (see IP table)
  - b. Subnet Mask 255.255.255.0
  - c. Default Gateway 10.48.19.1
  - d. Web Port 80
  - e. Management VLAN ID 0
  - f. Data VLAN ID 0
  - g. Tagging N/A
8. After making these changes exit the interface, and reboot the radio

### **Radio Setup**

1. Confirm computer's NIC setup, IP should be in the 10.48.19.XXX subnet.
2. Open IE Browser and navigate to "http://10.48.19.###" (radio's IP)
3. Use the menu on the left side of the page to navigate to "Radio Setup"
4. Under "Operation Mode" configure the following
  - a. Network Type: Multi-Point
  - b. Modem Mode: Gateway
5. Under "Multipoint Parameters" set the "Network ID" to 250
6. Save changes
7. On radios running firmware version 2.15 you will have to do an explicit reboot as well

Operation Mode	
Network Type	Multi-Point <input type="button" value="v"/>
Modem Mode	Gateway <input type="button" value="v"/>
Transmission Characteristics	
Frequency Key	5 <input type="button" value="v"/>
Frequency Zones	<input checked="" type="checkbox"/> 902.6-903.8 <input checked="" type="checkbox"/> 904.4-905.6 <input checked="" type="checkbox"/> 906.2-906.9 <input checked="" type="checkbox"/> 907.5-908.5 <input checked="" type="checkbox"/> 909.3-909.9 <input checked="" type="checkbox"/> 910.5-911.8 <input checked="" type="checkbox"/> 912.4-913.0 <input checked="" type="checkbox"/> 913.6-914.8 <input checked="" type="checkbox"/> 915.5-916.7 <input checked="" type="checkbox"/> 917.3-917.9 <input checked="" type="checkbox"/> 918.5-919.8 <input checked="" type="checkbox"/> 920.4-921.0 <input checked="" type="checkbox"/> 921.6-922.8 <input checked="" type="checkbox"/> 923.4-924.1 <input checked="" type="checkbox"/> 924.7-925.9 <input checked="" type="checkbox"/> 926.5-927.1
Packet Size	MAX= 9 <input type="button" value="v"/> MIN= 1 <input type="button" value="v"/>
Transmit Power	10 <input type="button" value="v"/>
Retry Timeout	255
RF Data Rate	867 kbps <input type="button" value="v"/>
Compression	0 <input type="button" value="v"/>
Point-To-Point Parameters	
Transmit Rate	Normal <input type="button" value="v"/>
<a href="#">Call Book</a>	<a href="#">Click Here</a>
Multipoint Parameters	
Broadcast Repeat	3 <input type="button" value="v"/>
Slave Attempts	9 <input type="button" value="v"/> AND THEN Drop Data <input type="button" value="v"/>
Master Tx Beacon	1 Out of Every 1 <input type="button" value="v"/> Slots
Network ID	250
Repeaters	Disabled <input type="button" value="v"/>
Subnet ID	Rx= F <input type="button" value="v"/> Tx= F <input type="button" value="v"/>
<input type="button" value="Save Changes"/> <input type="button" value="Restore Factory Defaults"/> <input type="button" value="Previous Config"/>	
<input type="button" value="Reboot"/>	

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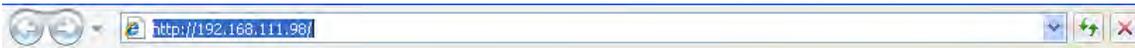
## REMOTE DOWNLOAD OF BASE STATION DATA

### Connecting to the Ethernet radio

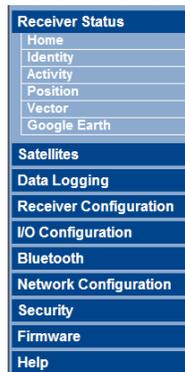
An Ethernet radio is used to communicate with the NetR5. The radio allows for communications with the base station as if it were part of the internet. Make sure the radio is connected to power and has the antenna plugged in. The radios have established a connection if the Carrier Detect (CD) light on the radio is green. Connect the computer to the radio with an Ethernet cable and start a web browser. Radio settings can be checked using the IP address of the radio in a web browser.

### Connecting to the basestation

The NetR5/R9 has a web page interface that allows for easy access through a web browser. Communications are established by typing the ip address of the base station into the address bar as shown below here:



The NetR5 website will come up with a menu on the left hand side that looks like:



This menu gives access to all the NetR5 settings and functions.

### Start / Stop Logging

Select "Data Logging" the left hand menu:

## Data Logging

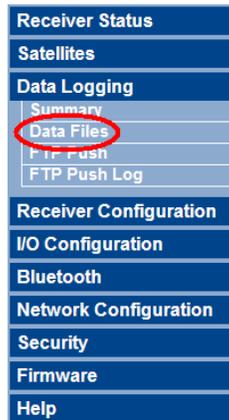
File System	Size	Available	Auto Delete	
/Internal	57.33 MB	53.37 MB	93%	<input type="checkbox"/> <input type="button" value="Format"/>
/External				<input type="checkbox"/> <input type="button" value="Format"/>

Session	Schedule	Status	Enable
DEFAULT	Always	Disabled	<input type="checkbox"/>
CANOE	Daily 14:00 720 Min.	Logging /Internal/10661260A.T01	<input checked="" type="checkbox"/>

By clicking or unclicking the check box next to the station name (CANOE in this case) under the Enable column logging is started or stopped. This session has the correct setting for the base station (elevation mask, logging rate, antenna height, etc) preset.

## Downloading Data

Under “Data Logging” on the menu select “Data Files”:



Directory: /Internal

Top Level Directory

Parent Directory

Filename	Created	Size	
			Select All <input type="checkbox"/>
			Delete Selected Files <input type="checkbox"/>
<b>10661260A.T01</b>	2009-05-06T15:39:39 GPS	2.611 MB	<input type="checkbox"/>
<b>10661250A.T01</b>	2009-05-05T18:20:03 GPS	2.133 MB	<input type="checkbox"/>

[Click here](#)

Files that are in bold can be downloaded. The file that is currently being logged cannot be downloaded until logging is stopped. To download data select the desired file. Internet Explorer will object, right click on the bar under the address bar and select “Download file...”.

### Other things of interest

When logging onto the Base Station there are several attributes to take note of and log. These include the battery level, the amount of memory and PDOP. These can all be found in the Receiver Status menu. Click Activity:

#### Satellites Tracked:10

GPS (8): 2, 4, 7, 13, 16, 20, 23, 25

SBAS (2): 135, 138

#### Data Logging:

/Internal/10661260A.T01

#### There are currently no active I/O streams

Temperature: 26.65°C

Runtime: 1 Day 05:14:29

Power Source: Port 1

Disk:	[53821KB/58708KB]	<div style="width: 91%; background-color: green; height: 10px;"></div>
Port 1:	[76% / 12.67V]	<div style="width: 76%; background-color: green; height: 10px;"></div>
Port 2:	[0% / 0.64V]	<div style="width: 0%; background-color: green; height: 10px;"></div>
Battery 1:	[92% / 8.10V]	<div style="width: 92%; background-color: green; height: 10px;"></div>
		<div style="width: 0%; background-color: green; height: 10px;"></div> 0% <span style="float: right;">100%</span>

Take note of the Disk numbers (this is the amount left). Log the voltage on Port 1 daily.

Click on the Position Tab:

<b>Position:</b> Lat: 55° 54' 8.54613" N Lon: 132° 9' 21.05874" W Hgt: 3.496 [m] Type: SBAS Datum: WGS-84	<b>Satellites Used:6</b> GPS (6): 4, 11, 20, 23, 31, 32  <b>Satellites Tracked:8</b> GPS (6): 4, 11, 20, 23, 31, 32 SBAS (2): 135, 138	<b>Velocity:</b> East: 0.02 [m/s] North: 0.01 [m/s] Up: 0.00 [m/s]
<b>Position Solution Detail:</b> Position Dimension: 3D Position Type: SBAS Motion Info: N/A Augmentation: GPS RTK Solution: N/A RTK Init: N/A RTK Mode: N/A RTK Network Mode: N/A Age of Corrections: N/A Height Mode: Normal	<b>Receiver Clock:</b> GPS Week: 1530 GPS Seconds: 334931 Offset: -0.27992 [msec] Drift: -0.18123 [ppm]	<b>1-Sigma Estimates:</b> Horizontal: 1.496 [m] East: 0.843 [m] North: 1.237 [m] Up: 2.057 [m]
	<b>Multi-System Clock Offsets</b> Master Clock System: GPS	<b>Dilutions of Precision:</b> PDOP : 2.4 HDOP : 1.4 VDOP : 1.9 TDOP : 1.4

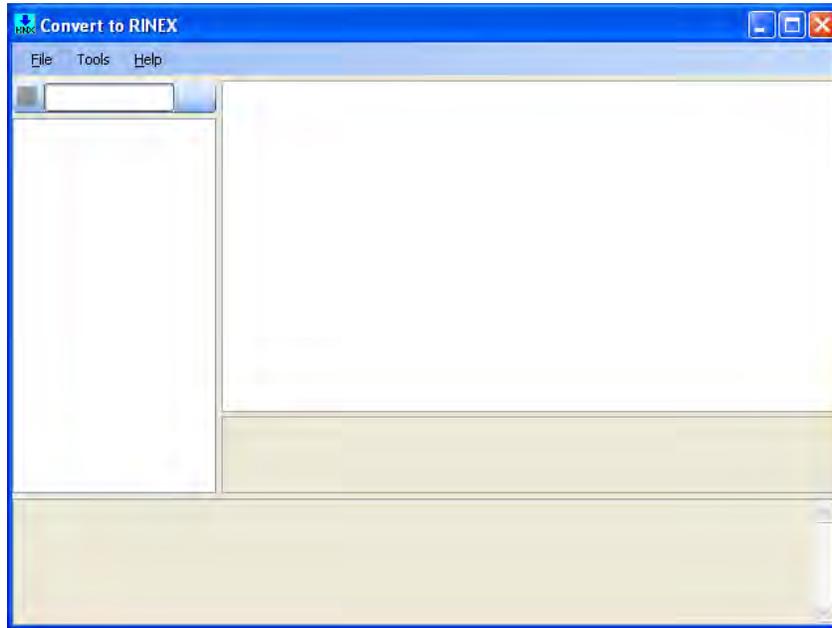
Log the PDOP and number of satellites used when beginning and ending a file.

Information on each Instrument:

Instrument	IP Address	Corresponding Instrument
Ship Radio	10.48.19.150	Ship's Network
Shore Radio 1	10.48.19.151	Bert (Trimble 1066)
Shore Radio 2	10.48.19.152	Mobile Radio
Shore Radio 3	10.48.19.153	Ernie (Trimble 1054)
Bert (Trimble 1066)	10.48.19.155	Shore Radio 1
Ernie (Trimble 1054)	10.48.19.156	Shore Radio 3

## CONVERTING TO RINEX

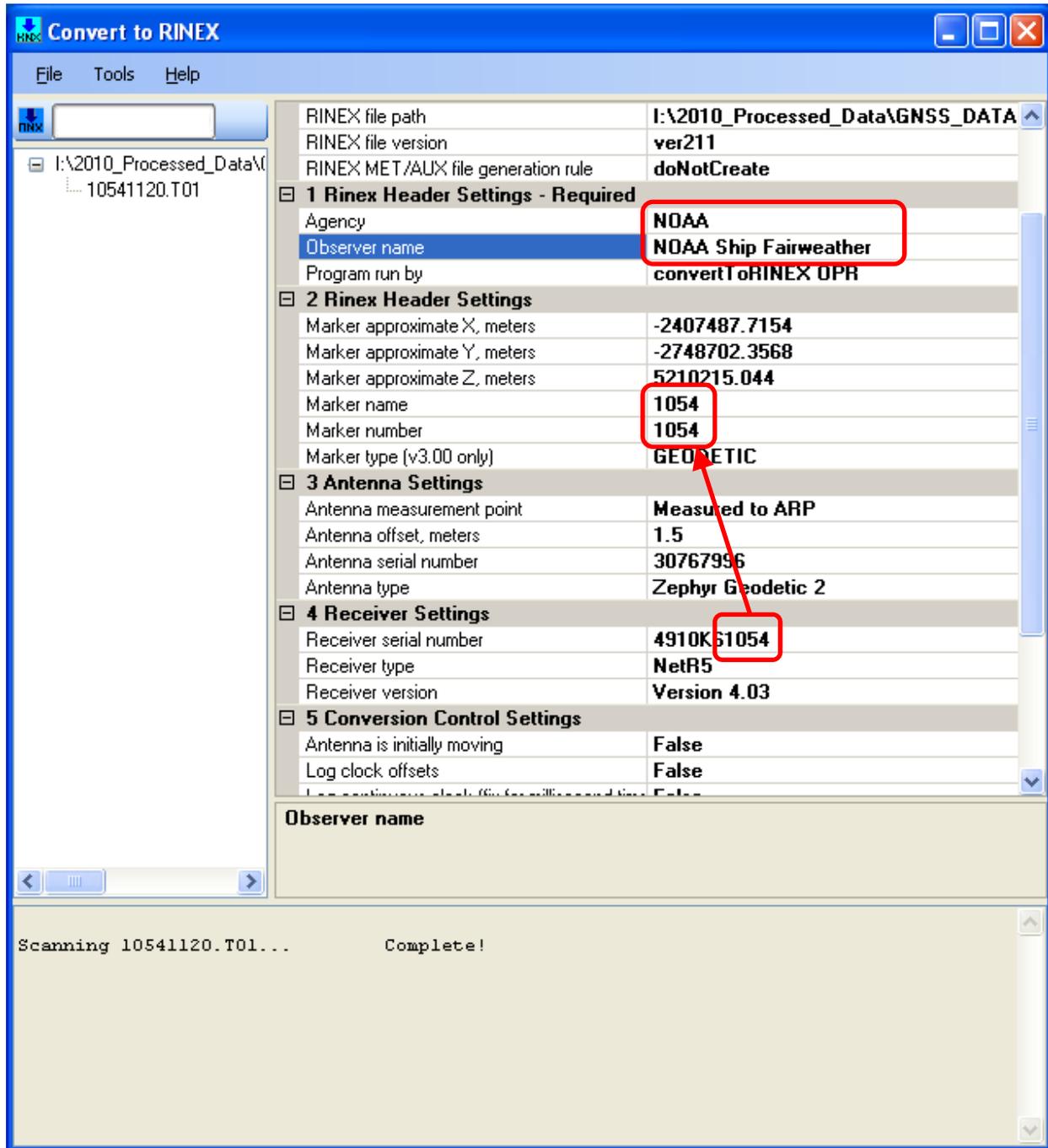
Run *Convert to Rinex* this can be found either on the desktop or on the start menu at *All Programs -> Trimble -> Convert To RINEX*



*File -> Open* to open the .t01 files which are found in  
*I:\2010\_Processed\_Data\GNSS\_DATA\[\*Project\_Name\*]\Base\_Station\_Data\[\*Base\_Name\*]*  
This will take a little bit to load, it will say Scanning...



Once loaded change the Agency and Observer name to NOAA and NOAA Ship (see the image below). Also confirm that the Marker name is the same as the last four of the serial.



Once happy click on *File -> Convert Files*, the status window will say *Converting*, again this takes a little while and will update to say “*SUCCESS!*” when done.



## SUBMITTING TO Online Positioning User Service (OPUS)

### Why Submit?

OPUS is a great tool for getting a very precise position for centimeter accuracy. We use the position calculated by OPUS to correct for inaccuracies in the acquisition platform's position. In addition, Field Procedures say we are required to obtain an OPUS solution from at least a 4 hour observation on a benchmark. We like to submit our base station position to OPUS when we first acquire data and then do a weekly submission in order to verify the position is still accurate during hydrographic acquisition. In order to obtain a precise solution, OPUS can take up to 19 days to obtain a final precise orbit because it uses a combination of seven analysis centers worldwide and these centers take several days to upload the orbit data to the International GNSS Service (IGS).

### Obtaining a Solution

After creating a RINEX file from the base station receiver raw file you may then submit the file to OPUS in order to get a precise position solution. If bandwidth is an issue, as it usually is aboard the ship, you may need to decimate and zip the RINEX file in order to get the file size smaller to achieve a reasonable upload time (a 3 mb file usually takes about 3-5 minutes to upload on the ship).

Once your RINEX file size is reasonable, got to the OPUS website at:

<http://www.ngs.noaa.gov/OPUS/>

## OPUS: Online Positioning User Service

The screenshot shows the OPUS website interface with the following steps and annotations:

1. enter your [email address](#) → Enter your email address
2. attach your [DATA file](#) of GPS obs, dual-freq. (L1/L2) only → Click browse and choose your RINEX file to upload
3. select your [antenna type](#) → Click the dropdown menu choose your antenna type
4. add your [antenna height](#) → Enter your antenna height
- 5a. customize your solution, report, and publishing [options](#) → Last step on this page, click OPTIONS
- 5b. choose a [processor](#)

Buttons for 5b: Upload to RAPID-STATIC for data > 15 min. < 2 hrs. and Upload to STATIC for data > 2 hrs. < 48 hrs.

From the figure above follow these steps:

1. Enter your email address
2. Browse and select your RINEX file, this is your .100 file

3. Select your antenna type from the dropdown, for FA this will either be the Trimble antenna (TRM55971.00 Zephyr GNSS Geodetic Model 2) or the Ashtech antenna (ASH701975.01AGP Geodetic IV, Rev. A with groundplane)
4. Enter your antenna height. This will usually be 1.5 meters, which is what you set your tripod height to.
5. Click the OPTIONS button. This will take you to the following page

#### 4. Extended Output

Additional information on the OPUS solutions, including the numerical portion of the g-files, is provided in Extended Output.

Standard output is fine.  Yes, I'd like extended output.

#### 5. Draft XML Output

You may request output in xml format. The xml output will be appended to your e-mailed report.

No, Thank you.  Yes, I'd like xml output.

Click "Yes" for both Extended Output and Draft XML Output

#### 6. Submit to Project

OPUS now allows authorized users to submit files to a previously defined project where a project is an effort involving many receivers, operating at several locations within a specified time frame and whose data is to be mutually processed as a network. OPUS is used to provide preliminary solutions for each data file submitted, evaluate the data quality, and assign the data to the appropriate project. The assigned project manager can then process any combination of sessions from the project as a network.

To submit this data file to a project, enter the password assigned by the project manager for the appropriate project.

Project Name

#### 7. Set User Profile

OPUS allows the antenna type, antenna height, SPC code, selected base stations and extended option choices that you have just identified to be assigned to the email address that you have entered. These entries & selections will be saved and used for your subsequent OPUS submissions, saving time for multiple or repetitive submissions using the same equipment and options configuration. When your profile is set, you will only need to enter your email address and your data file and then upload. Your profile will automatically supply the saved entries. When you data is finished uploading, the upload page will display your profile entries.

To change and reset your profile, complete all the main page entries to gain access again to the options page. You may also elect to delete your profile. (Hint: You might use different email aliases to identify different equipment and processing configurations that you frequently use.)

Set/Reset my profile.  Delete my profile.

#### 8. Submit to Data Base

OPUS allows qualified users to submit results for publication in the NGS Data Base.

Yes, publish.  No, don't publish.

Click STATIC

Leave all numbered sections as is except for 4. Extended Output and 5. Draft XML Output. Choose "Yes" for both of these and they will be included in the OPUS solution emailed to you. At the bottom section 8. Choose "STATIC" if your observation was more than 2 hours. This will give you a more precise solution.

After choosing "STATIC" you should receive a pop-up window stating that your file is being uploaded. Once it is uploaded, it will take some time for OPUS to create a solution. Check your email in about 15 minutes and you should receive a solution. Once you do, open the email and save all the text as your OPUS solution. The solution will give you useful information like your antenna name, antenna height, start and stop times of the observation, and most importantly, your latitude, longitude, and ellipsoid height (this position is what you will input for your base station coordinates in POSPAC when processing true heave data).

From opus <opus@NGS.noaa.gov>  
 Sent Wednesday, July 21, 2010 3:59 pm  
 To Albert.Davison@noaa.gov  
 Subject OPUS solution : 1054200\_concat\_dec.10o 000046305  
 Attachments 1054199v.10o.xml 13K

FILE: 1054200\_concat\_dec.10o 000046305

antenna type  
and height

NGS OPUS SOLUTION REPORT  
 =====

observation start  
and stop time

All computed coordinate accuracies are listed as peak-to-peak values.  
 For additional information: <http://www.ngs.noaa.gov/OPUS/about.html#accuracy>

USER: albert.davison@noaa.gov  
 RINEX FILE: 1054199v.10o

DATE: July 21, 2010  
 TIME: 23:59:27 UTC

SOFTWARE: page5 0909.08 master2.pl 0810233  
 EPHEMERIS: 10r15930.eph [rapid]  
 NAV FILE: hndc1990.10n  
 ANT NAME: TRM55971.00  
 ARP HEIGHT: 1.3

START: 2010/07/18 21:44:00  
 STOP: 2010/07/19 23:59:00

OBS USED: 771/0 / 78/66 : 98%  
 # FIXED AMB: 296 / 301 : 98%  
 OVERALL RMS: 0.011(m)

latitude, longitude,  
and ellipsoidal height

REF FRAME: NAD\_83(CORS96)(EPOCH:2003.0000) ITRF00 (EPOCH:2010.5465)

X:	-2606610.795(m)	0.008(m)	-2606611.776(m)	0.008(m)
Y:	-609104.779(m)	0.005(m)	-609103.754(m)	0.005(m)
Z:	5769830.520(m)	0.014(m)	5769830.949(m)	0.014(m)

LAT:	65 15 29.96293	0.003(m)	65 15 29.94755	0.003(m)
E LON:	193 9 9.68554	0.005(m)	193 9 9.59143	0.005(m)
W LON:	166 50 50.31446	0.005(m)	166 50 50.40857	0.005(m)
EL HGT:	8.233(m)	0.016(m)	8.925(m)	0.016(m)
ORTHO HGT:	4.404(m)	0.016(m)	[NAV088 (Computed using GEOID09)]	

associated RMS  
values

	UTM COORDINATES	STATE PLANE COORDINATES
	UTM (Zone 03)	SPC (5008 AK 8)
Northing (Y) [meters]	7238507.767	1254365.086
Easting (X) [meters]	413738.910	460419.043
Convergence [degrees]	-1.67783609	-0.76953979
Point Scale	0.99969110	0.99991917
Combined Factor	0.99968981	0.99991789

US NATIONAL GRID DESIGNATOR: 3WVN1373838507(NAD 83)

BASE STATIONS USED

PID	DESIGNATION		LATITUDE	LONGITUDE	DISTANCE(m)
DL6423	AB11 NOME_ANVILAK2006	CORS ARP	N643352.198	W1652224.356	104162.6
DL6675	AB18 KOTZEBUE_AK2007	CORS ARP	N665130.119	W1623648.521	261834.1
DL6684	AC07 BUCKLAND_AK2007	CORS ARP	N655740.665	W1611711.714	267931.5

NEAREST NGS PUBLISHED CONTROL POINT

UW4186	CON PT SPENCER CONT TWR 1950	N651545.450	W1665104.374	512.3
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### Submitting to the OPUS Database

You first must register with OPUS in order to submit to their database. To register go to their main page: <http://www.ngs.noaa.gov/OPUS/> and click on their “View” tab

[published marks](#) | **register to publish** | today's marks: [Static](#) [Rapid-Static](#)

1. Your Agency: \* ... select your agency here  
 yours not listed?

2. Your Email: \*  (e.g., jsmith@survey.com)

3. Terms of use:  I accept these terms.

[NOAA privacy policy](#)

---

### publishing requirements

<p><b>high-quality OPUS solution:</b></p> <ul style="list-style-type: none"> <li>• &gt; 4 hour duration</li> <li>• &gt; 70% observations used</li> <li>• &gt; 70% ambiguities fixed</li> <li>• &lt; 0.04m horizontal peak-to-peak</li> <li>• &lt; 0.08m vertical peak-to-peak</li> <li>• &lt; 0.03m RMS</li> <li>• IGS precise or rapid orbits (available next day)</li> <li>• see <a href="#">using OPUS</a></li> </ul>	<p><b>descriptive metadata:</b></p> <ul style="list-style-type: none"> <li>• quality <a href="#">survey mark</a></li> <li>• photos of mark &amp; equipment</li> <li>• mark details (name, type, stability)</li> <li>• description to aid mark recovery</li> <li>• preview <a href="#">mark description form</a></li> <li>• &amp; <a href="#">help file</a> for form elements</li> </ul>	<p><b>field procedures:</b></p> <ul style="list-style-type: none"> <li>• fixed height tripod recommended</li> <li>• brace tripod with sandbags or chain</li> <li>• verify antenna height and plumb</li> <li>• calibrate your tripod or tribrach height &amp; plumb</li> <li>• <a href="#">antenna type</a> properly identified</li> <li>• <a href="#">antenna height</a> &gt; 0.1 m</li> <li>• more suggestions at <a href="#">HARN guidelines</a></li> </ul>
--	---	---

---

[published marks](#) | **register to publish** | today's marks: [Static](#) [Rapid-Static](#)

Scroll down the page and complete the following steps:

1. Select your agency from the dropdown menu, this should be National Oceanic and Atmospheric Administration
2. Enter your email address
3. Read the “Terms of use” and check the accept terms button
4. Once complete, click the “Register” button

**WHAT HAPPENED:**

Success!

Thank you for registering your e-mail as a publisher in the NGS database.

Your e-mail and agency information will be displayed as shown below on any datasheet published by you.

CONTRIBUTED BY

[test](#)

 [National Oceanic and Atmospheric Administration](#)

**WHAT TO DO NOW:**

1. Follow requirements and procedures listed below the [register to publish](#) form.
2. Publish your solutions by invoking [OPUS](#) option #8, "Submit to Database"
3. Retrieve published solutions at [OPUS view tab](#)
4. To withdraw or amend your registration, contact [OPUS administrator](#).

If your registration was successful, you should see the information above and you are now registered with OPUS DB.

Now you are ready to submit. Go through the same process as above for obtaining a solution with the email you used to register with OPUS DB. The only difference is that on the OPTIONS page, under section 8, click on the "Yes, publish" button and then click "STATIC".

## 8. Submit to Data Base

**OPUS allows qualified users to submit results for publication in the NGS Data Base.**

Yes, publish.  No, don't publish.

Click on "Yes, publish".  
Then click **STATIC**

STATIC

RAPID STATIC

After your RINEX file finishes uploading, you should get the step 2 of 4 page, "Identify your Mark".

## Step 2 of 4: Identify your Mark

An OPUS solution report is now being prepared. When complete, it will be e-mailed to you.

---

**PUBLISHING**

\* Confused? [New and recovered marks are described here.](#)

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**OPUS ENTRIES**

e-mail address: <a href="mailto:albert.davison@noaa.gov">albert.davison@noaa.gov</a>	Selected Antenna: <a href="#">ASH701975.01AGP</a>
Uploaded File Name: <a href="#">92372292.100</a>	Antenna Height(m): <a href="#">1.5</a>

---

**OPTIONS**

State Plane Code: <a href="#">AUTO</a>	User Selected Base Stations: <a href="#">NONE</a>
Extended Output: <a href="#">YES</a>	User Excluded Stations: <a href="#">NONE</a>
Submit to NGS Database: <a href="#">YES</a>	User Selected Project Name: <a href="#">NONE</a>
Geoid Model: <a href="#">Geoid09</a>	

From the page above, double check your OPUS entries and click on one of the publishing options, New Mark, Recovered Mark, or Abort. In most cases you will be describing a new mark so you can click the button marked, “Describe New Mark”. If any of your OPUS entry information is incorrect, you can click the “Abort” button and start over. Once you click on “Describe New Mark” you should get the page below, “Step 3 of 4: Describe New Mark”.

## Step 3 of 4: Describe New Mark

for data file: 9237229s.10o

R E Q U I R E D	<b>Designation:</b>	<input type="text" value="946 9541 A"/>		
	<b>Stamping:</b>	<input type="text" value="9541 A 2010"/>		
	<b>Type:</b>	<input type="text" value="D = Disk"/>	<input type="text" value="DB = Bench mark disk"/>	
	<b>Setting:</b>	<input type="text" value="35 = Mat foundation or concrete slab other than pavement"/>		
		<b>specific setting(optional):</b> <input type="text"/>		
	<b>Descriptions:</b>	<p>From Nome, AK via sea proceed 202 deg.T from Nome Harbor for 6nm then due W for 21nm, then NW for 50nm to a point abeam of King Island, then <u>NNE</u> for 55nm, then W for 6nm, and finally S for 2.3nm. The closest landing point on the island is the north shore of the helicopter pad, the breakwater of which is <u>riprap</u>. The benchmark is a disk set flush in the concrete of the <u>NNW</u> corner of the village helicopter pad. It is set into the poured concrete border of the landing pad (about 1m wide).</p>		
		(describe the mark, witness ties, etc., to enable future recoveries. Max. characters=500) <input type="text" value="489"/>		
	<b>Close-up photo:</b>	<input type="text" value="W:\Control\HorCon\Projects\2010\OPR-R365-FA-"/>	<input type="button" value="Browse..."/>	
	<b>Horizon photo:</b>	<input type="text" value="W:\Control\HorCon\Projects\2010\OPR-R365-FA-"/>	<input type="button" value="Browse..."/>	
	O P T I O N A L	<b>Stability:</b>	<input type="text" value="B = Monument will probably hold position well"/>	
<b>Magnetic:</b>		<input type="text" value="N = No magnetic material"/>		
<b>Application:</b>		<input type="text" value="Choose Special Application"/>		
<b>Antenna S/N:</b>		<input type="text"/>		
<b>Receiver S/N:</b>		<input type="text"/>	<b>Model</b> <input type="text"/>	<b>Firmware</b> <input type="text"/>
		<input type="button" value="Continue"/> <input type="button" value="Abort"/>		

Make sure to fill in all required fields:

- **Designation:** This is a user-friendly identifier, unique for the area and usually descriptive of the mark stamping and/or location. For tidal benchmarks, you can find the designation under the tides COOPS submission under “Bench Mark Descriptions” in the W drive.
- **Stamping:** Is the unique lettering, if any, manually added to the mark by the original marksetter. For tidal benchmarks, you can find this in the “Bench Mark Descriptions”.

- **Type:** This describes the surveyed object. For our purposes, the most likely type is a “D=Disk”. When you choose disk, you will then be given a dropdown to the right of “Type” which you need to identify the type of disk. In most cases this will be “DB=Bench mark disk”.
- **Setting:** This is the structure to which the mark is affixed. This can sometimes be found in the “Bench Mark Descriptions” described above. The most common will be:
  - 2 = Object driven into ground
  - 66 = In rock outcrop or ledge
  - 80 = In a boulder
- **Descriptions:** Describe new marks by noting distances and directions to local witnesses (posts, trees, curbs, etc.) along with any other salient features (recommended approach, hazards, etc.). This will help future surveyors recover and assess the suitability of your mark. In most cases you can find a suitable description in the “Bench Mark Descriptions” described above.
- **Close-up photo:** Use the browse button to select a close up photo of the mark



- **Horizon photo:** Use the browse button to select a horizon photo of the mark



For optional fields, make sure to fill in at least stability and magnetic:

- **Stability:** This is your best estimate of the mark's ability to maintain a long-term, constant position relative to other local features. Consider the setting quality, soil type, threats from construction or traffic, etc.
- **Magnetic:** Copper, brass, aluminum, and stainless steel are not magnetic. Alloys containing iron, cobalt or nickel are magnetic. Use a magnet to test. Most of the marks we recover are not magnetic.

Once this is complete, click on the “Continue” button.

You should then see a page which states, “Almost Done...”. At this point check for an email from OPUS. In the body of the email, you should be prompted to click on a link to verify that the information you provided is correctly presented. Click on this link.

## Step 4 of 4: Approve your Datasheet

Please carefully review your datasheet below, then select an action:

<div style="border: 1px solid black; padding: 2px; display: inline-block;"><b>PUBLISH</b></div> Add to NGS database	<div style="border: 1px solid black; padding: 2px; display: inline-block;"><b>EDIT</b></div> Change my description	<div style="border: 1px solid black; padding: 2px; display: inline-block;"><b>ABORT</b></div> Discard my solution
--	---	--

A reminder: Please share only quality data from marks of PERMANENT PUBLIC INTEREST.  
 Although OPUS will enforce some quality limits, it will not identify all errors.  
 YOUR PROFESSIONAL DISCRETION is necessary to maintain the integrity of this archive.

You should be sent to the “Step 4 of 4: Approve your Datasheet” page. From this page, you can either publish, edit, or abort your submission. If you feel your submission is complete and correct, click on the “PUBLISH” button.

OPUS will then review your submission and if accepted, will publish the database submission on their website. You can check to see if your submission has been published by click on the “View” tab from the OPUS main page. You can then click on one of the many ways you can retrieve datasheets. The most common would be by “email of submitter”. Once it is published it should look similar to the following:

## SURVEY DATASHEET (Version 1.0)

**PID:** BBCC45  
**Designation:** 946 9541 A  
**Stamping:** 9541 A 2010  
**Stability:** Monument will probably hold position well  
**Setting:** Mat foundation or concrete slab other than pavement  
**Description:** From Nome, AK via sea proceed 202 deg.T from Nome Harbor for 6run then due W for 21run, then NW for 50run to a point abeam of King Island, then NNE for 55run, then W for 6run, and finally S for 2.3run. The closest landing point on the island is the north shore of the helicopter pad, the breakwater of which is riprap. The benchmark is a disk set flush in the concrete of the NNW corner of the village helicopter pad. It is set into the poured concrete border of the landing pad (about 1m wide).  
**Observed:** 2010-07-27T22:28:00Z  
**Source:** OPUS - page5 1009.28



**Close-up View**

<b>REF_FRAME:</b> NAD_83(CORS96)	<b>EPOCH:</b> 2003.0000	<b>SOURCE:</b> NAVD88 (Computed using GEOID09)	<b>UNITS:</b> m	<b>SET PROFILE</b>	<b>DETAILS</b>
<b>LAT:</b> 65° 45' 30.51839" ± 0.018 m <b>ELL HI:</b> 8.718 ± 0.034 m <b>X:</b> -2577428.090 ± 0.005 m <b>Y:</b> -503164.318 ± 0.013 m <b>Z:</b> 5792949.800 ± 0.039 m <b>ORTHO HI:</b> 6.618 ± 0.058 m		<b>UTM 2 SPC 5009(AK 9)</b> <b>NORTHING:</b> 7294516.249m 1310260.245m <b>EASTING:</b> 593740.030m 547950.469m <b>CONVERGENCE:</b> 1.86602113° 0.95408208° <b>POINT SCALE:</b> 0.99970757 0.99992814 <b>COMBINED FACTOR:</b> 0.99970620 0.99992677			

**CONTRIBUTED BY**

[albert.davison](#)  
 National Oceanic and Atmospheric Administration



**Horizon View**

Map
Satellite
Hybrid

946 9541 A ✕

Get directions: [To here](#) (nearest road)

POWERED BY Map data ©2010 Geocentre Consulting, Google - [Terms of Use](#)

Congratulations, you have now successfully submitted a mark to the OPUS database for all to see.

## USING POSPAC MMS TO COMPUTE VESSEL OFFSETS

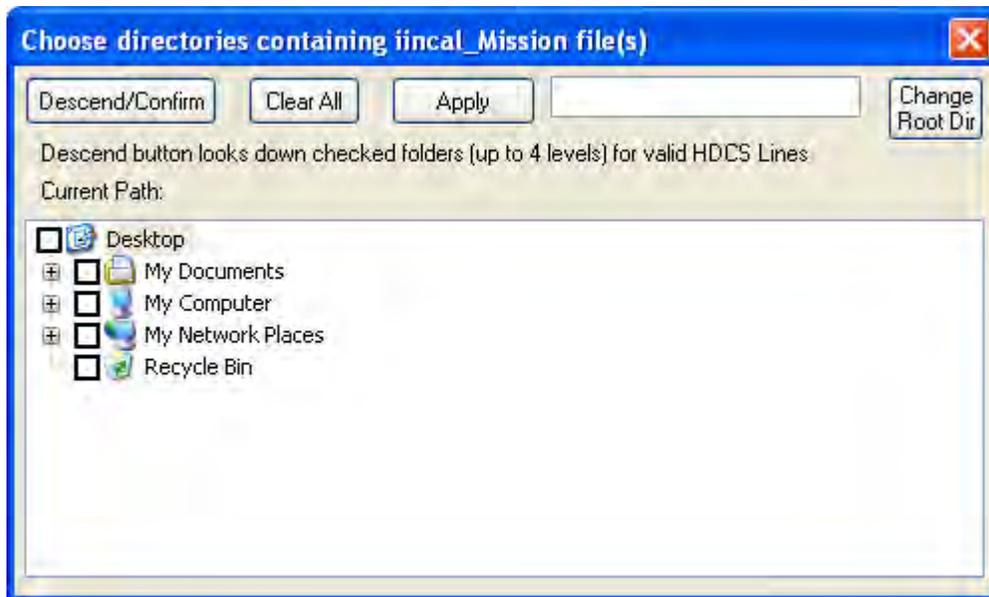
It is possible to post-process the POSMV files recorded during the GAMS calibration to refine offsets between the IMU reference point and the primary antenna phase center. The GAMS calibration data is used because in general it is the most dynamics that a vessel will see. This helps resolve the offsets quickly in post processing and to a higher degree of confidence.

### Processing

The general idea is to process the POSMV data multiple times at the 10cm confidence level. Each time inputting the resulting calibrated installation parameters as the initial lever arm offsets for the following run. This is repeated until the resulting offsets vary by only millimeters.

Process the SBET in POSPac and QC the solution.

To get statistically robust final values for the calibrated installation parameters there is a macro that runs in Pydro. Open Pydro, on the menu bar select Misc → Run Macro. Select CalcPOSMViincalLeverArmStats.py



Navigate to and check the project name, click descend/confirm, this will find the “Proc” folder. Then click Apply, it will look like nothing happened. In the background behind the Pydro window is the command prompt associated with Pydro the macro will have output the data in this window.

```

C:\Program Files\Pydro\Source>echo off
Pydro version 9.10 (r2824) No updates available.
No update to perform
0
initialize geotrans engine : 0
Microsoft Windows XP 9.10 (r2824)
License: 0294c0ab026f318325 exp:2/2011
Read Registry: HKEY_LOCAL_MACHINE\SOFTWARE\CARIS\HIPS\6.1
Loading layout data from: default.p1
==> W:\Control\HorCon\Projects\2009\OPR-P357-FA-09 Kachemak Bay\POSPAC\H12089_2
28\2009_228_S220\Mission 1\Proc\iincal_Mission 1.out
- Stats computed from last 10 minutes of file:
  xMean,yMean,zMean = -11.849,0.889,-13.171
  xStd,yStd,zStd = 8.17e-004,2.95e-004,5.07e-004

```

Note the values and standard deviations. Repeat these steps. Input these new values to the lever arm.

#### Example offset processing for vessel 2805

	X	Y	Z
Start	-0.806	-0.682	-3.623

	Trailing 10 minute average					
	X	X Std	Y	Y Std	Z	Z Std
Run 1	-0.787	0.000689	-0.73	0.000215	-3.153	0.000758
Run 2	-0.788	0.000692	-0.73	0.000198	-3.138	0.0013
Run 3	-0.788	0.000692	-0.73	0.000197	-3.137	0.00133

## ELLIPSOIDALLY REFERENCED DYNAMIC DRAFT MODEL (ERDDM)

### Analysis Using the Pydro macro ProcSBETDynamicDraft

#### Step One: Establish desired tide package in Pydro: (a) Discrete Zoned Tides or (b) TCARI

##### 1 (a) If you have Discrete Zoned Tides (ZDF + .TID(s))

From Pydro's main menu, *Tides > Load Zoning Data (.ZDF)*

*Tides > CO-OPS Office Tools > Download Zoned Tide Stations*

- Pydro console window will echo a "trying to download stations" list

- If you have problems, or you don't otherwise have internet access, you can consult with HSD and your HSTP representative to obtain a stations file for your ERDDM analysis. Such a station file is loaded "manually" via *Tides > CO-OPS Office Tools > Load Zoned Tide Stations*

<OR>

##### 1 (b) If you have TCARI Tides

From Pydro's main menu, *Tides > Load TCARI Data (.tc)*

#### Step Two: (a) Examine discrete or TCARI zones and (b) load/view water levels

##### 2 (a) To see the ZDF or TCARI zones in a Chart Window

*Window > Show/Hide > Display Properties* (or F3 key if Pydro window frame has focus)

- Plotting tab: Check "Tides" in Auto Draw & Middle Button Mouse Draw

- Press the Zoom to Chart Overview (Globe toolbar button) on Chart Window, then Middle Button on mouse to refresh the display--drawing zones

<AND>

##### 2 (b) To load water level data for both discrete and TCARI zones in a Chart Window

*Tides > Load WL Data* or *Tides > Download WL Data*, for the applicable to ERDDM data acquisition

- QC WL data via *Tides > Show WL Graphs*

**Step Three: Analyze the ERDDM data via the Pydro macro**

**3 Misc > Run Macro** - browse/select *ProcSBETDynamicDraft.py* (should be present in the default directory in the dialog: <Pydro install path>/Lib/site-packages/HSTP/Pydro/Macros)

- Browse to select ERDDM POSProc SBET file--either binary (.out) or ASCII (.txt) will work
- Enter year-doy of start of ERDDM data
- Enter start/ end times [units are seconds-of-GPS-week]; it defaults to the min/max of the SBET file
- The data analysis graphs and dynamic draft table appropriate for use in CARIS HIPS will pop up shortly thereafter

**Notes:**

- While both binary (.out) and ASCII (.txt) POSProc SBET data files may be used, height uncertainty data is not available in the binary files. If you want to use the POSProc height uncertainty, export SBET data to ASCII and process that with the ProcSBETDynamicDraft.py
- The tide correction may take some time, especially in the case of 200 Hz (undecimated) SBET data. The Console Window that accompanies Pydro will show progress, counting through the number of tide look-ups performed. Left at 200 Hz, an dynamic draft calibration SBET file may require on the order of one million tide "corrector" look-ups.
- Figure 1 Ellipsoid Height [m] vs. time is for entire SBET file data; i.e., to help ascertain start/end times to clip the SBET data for all subsequent analysis and plots. Note that this height plot is uncorrected for tide; compare to subsequent graphs which are tide corrected. You may have to select the Figure 1 tab on the Windows system task bar to make it visible on your Desktop.
- Figure 2 Altitude [m] is corrected for tide and records are per start/end clipping. The two standard deviation value from this figure should be entered into the HVF TPU section for delta draft.
- Figure 3 is the resulting speed vs. draft appropriate for use in a CARIS HIPS HVF.

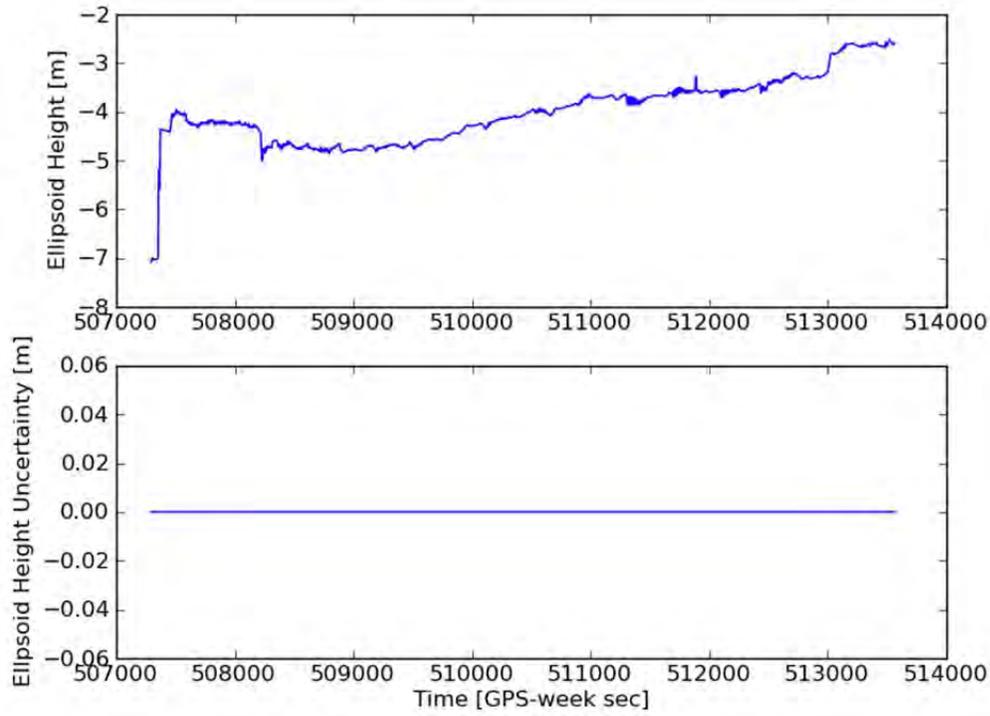


Figure 1

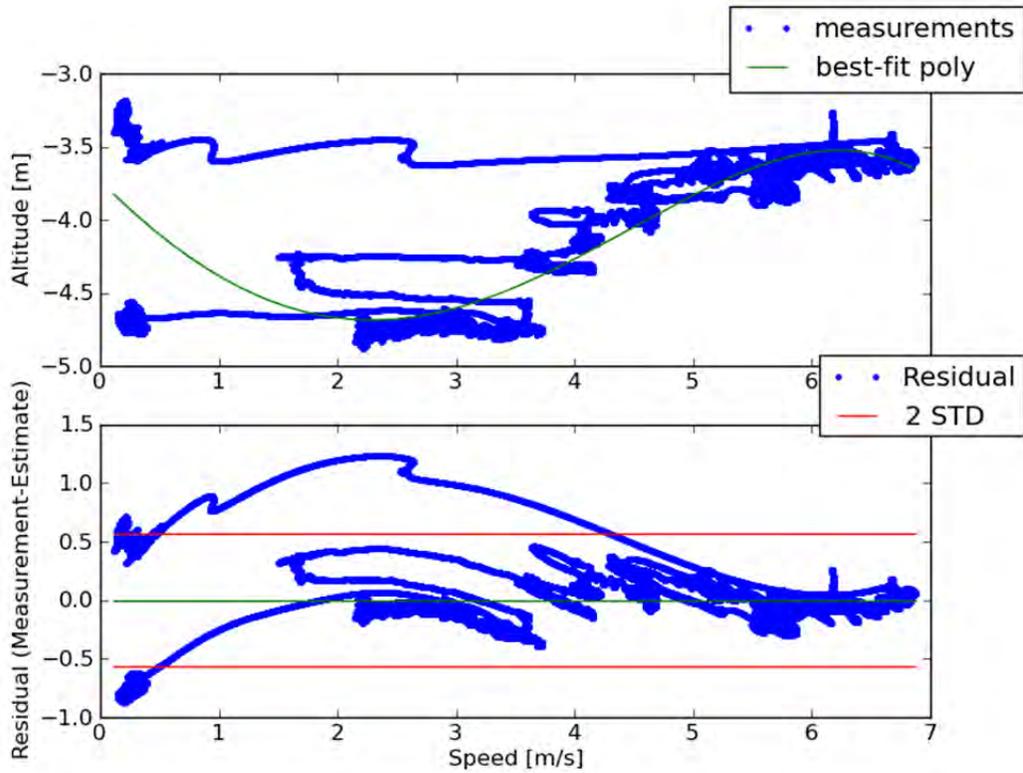


Figure 2 - NO TIDES; 4th-order fit, nominal two-times standard deviation +/-0.6m

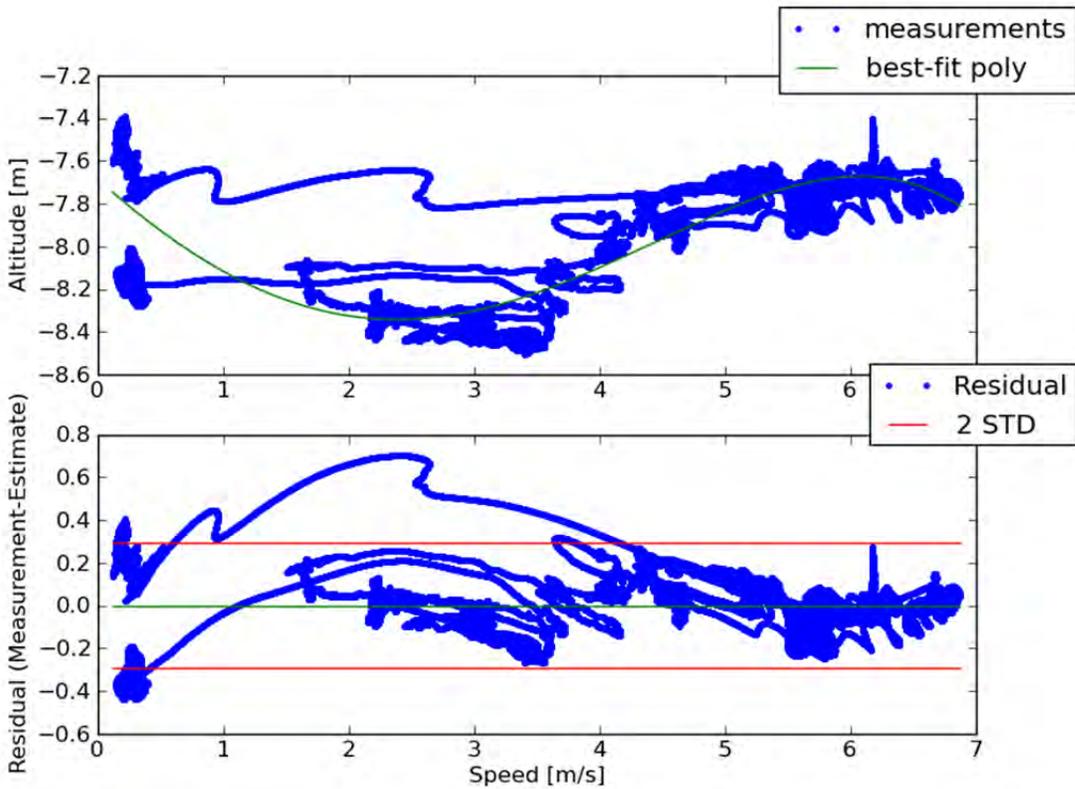


Figure 2 - YES TIDES; 4th-order fit, nominal two-times standard deviation +/-0.3m

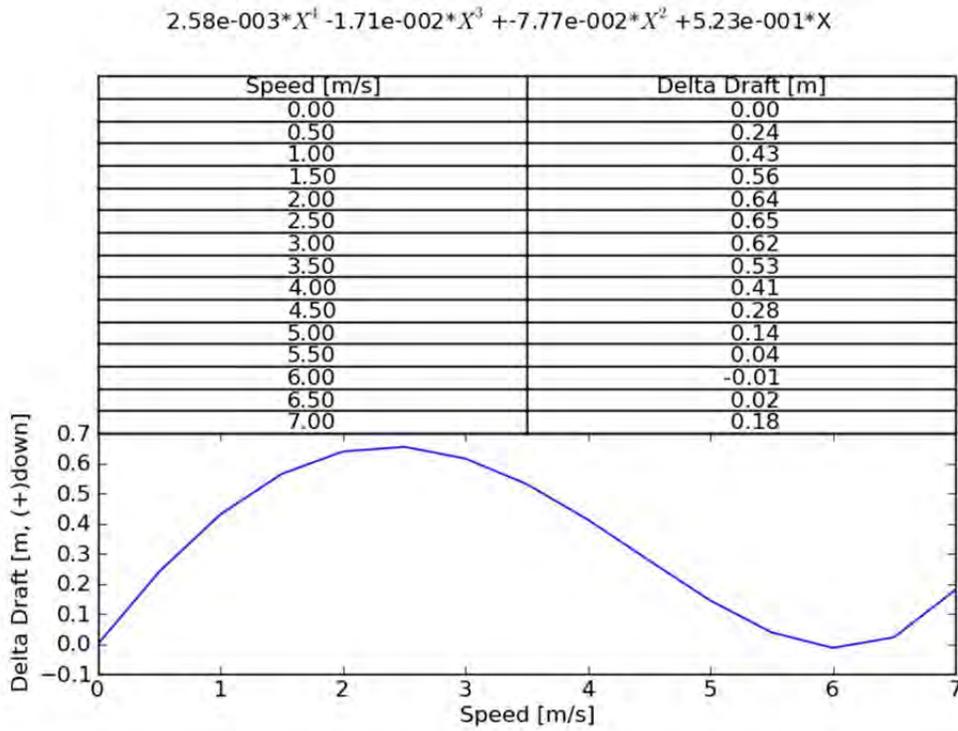


Figure 3 - YES TIDES; 4th-order fit, dynamic draft table

## **ELLIPSOIDALLY REFERENCED ZONED TIDES**

An alternative option in areas lacking a published VDatum model is to relate "traditional" zoned water levels to the ellipsoid. This is done by measuring the height of the GPS antenna to the water line. Then a SEP is created by adding this ellipsoidally-referenced water line measurement to the zoned water level "corrector." The SEP is then applied to the ellipsoidally-referenced hydrography to reference it to chart datum. ERS-ERZT data may be readjusted at a later date when VDatum coverage becomes available. Additional tools and documentation will be made available via a Hydrographic Technical Directive later this year.

## HORCON / VERCON OBSERVATION LOG

<b>DATE:</b>	<b>SESSION:</b>	<b>PROJECT NAME:</b>	
<b>WX CONDITIONS:</b>		<b>SITE NAME:</b> _____	<b>SITE PHOTO(S):</b> Y / N
<b>OBSERVER(S):</b>		<b>SITE TYPE:</b> HORZ. / VERT. / ATON / BM / NEW / _____	
<b>DN:</b>		<b>RECEIVER #:</b> _____	<b>FIXED HEIGHT? Y / N</b>
<b>4 CHAR. SITE ID:</b>		<b>ANTENNA #:</b> _____	<b>SPACER? Y / N</b>
<b>SESS. FILE NAME:</b>		<b>ANT. MEASUREMENTS                      ANT. CONSTANTS</b>	
<b>ELEV. MASK:</b> _____ degrees		<b>ANT. SLANT HEIGHT (S)</b>	<b>ANT. RAD. (R)</b>
<b>RECORDING INTERVAL:</b> _____ sec.s		<b>START</b>	<b>STOP</b>
		_____ m	_____ m
		_____ ft	_____ ft
		_____ m	_____ m
<b>OBSERVATION TIMES AND STATUS</b>			
RECEIVER TIME (UTC)	PDOP	LOCAL TIME	# of SV's
START:			
STOP:			
<b>INSTRUCTIONS:</b>		<i>Office Check by:</i>	
		<b>HI to ARP=</b> $((\text{SQRT}(\text{S}^2 - \text{R}^2) - \text{C}))$ <b>(m)</b>	
<b>SITE SKETCH/LOC./NOTES:</b>			
<b>OBSTRUCTION DIAGRAM</b>		<b>MONUMENT RUBBING / DESCRIPTION</b>	

**ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS**

**I. Instructions for Fixed-Height Tripods:**

Measure & record the fixed-height tripod length (A) and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) (B)

$$\text{Antenna.Height} = H = A + B$$

**II. Instructions for Slip-Leg Tripods:**

**1. Measure the Slant Height (S)**

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm				
Before, inch				
After, cm				
After, inch				
Note: cm= inch x (2.54)		Overall average, cm		

S = \_\_\_\_\_ cm

**2. Record the Antenna Radius (R) and the Antenna Constant (C)**

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

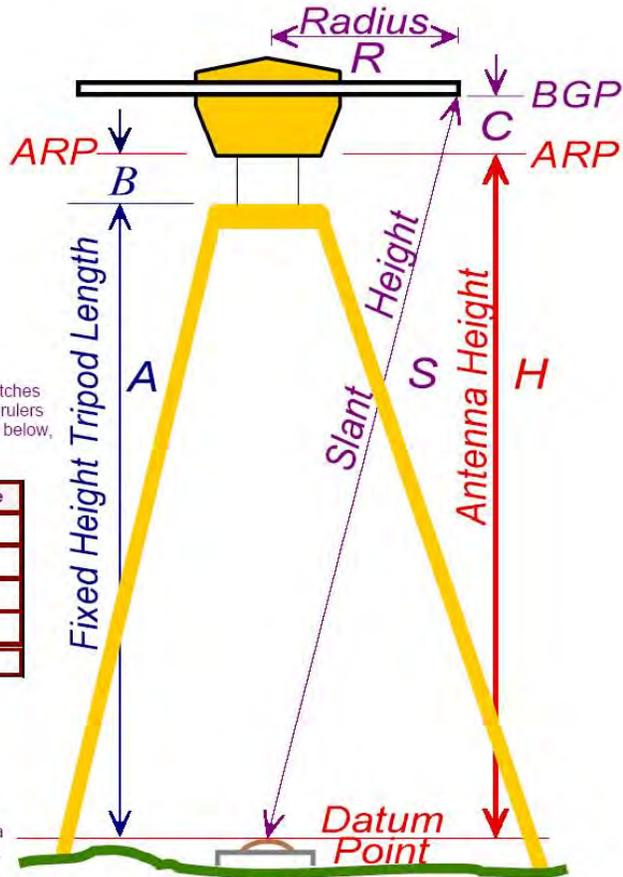
R = \_\_\_\_\_ cm

C = \_\_\_\_\_ cm

**3. Compute Antenna Height (H)**

Use the following Pythagorean equation:

$$\text{Antenna.Height} = H = ((\sqrt{S^2 - R^2}) - C)$$



Contents:

- 1| Background
- 2| Creation of Checksums
- 3| Verification of Checksums
- 4| Reporting Results

## 1| Background

A checksum or hash sum is a fixed-size datum computed from an arbitrary block of digital data for the purpose of detecting accidental errors that may have been introduced during its transmission or storage. The integrity of the data can be checked at any later time by recomputing the checksum and comparing it with the stored one.

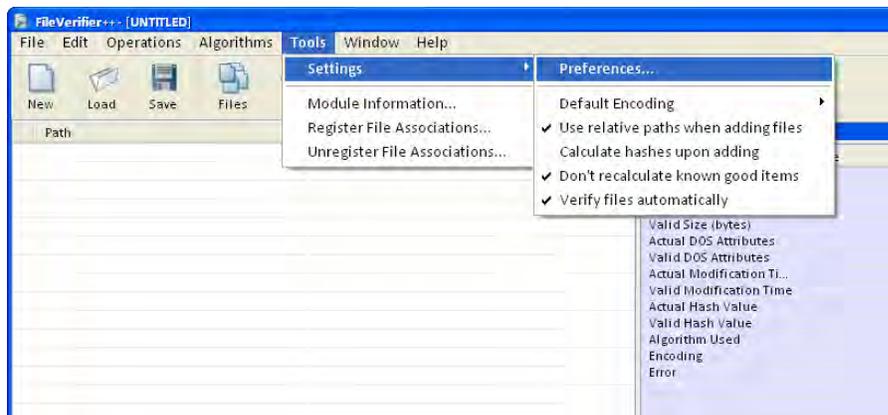
NOAA field units shall create MD5 checksums for all digital data submitted to the processing branches. This SOP outlines the procedure for creating, verifying, and reporting the results of the verification process using the program FileVerifier++.

This SOP is intended to be used with FileVerifier++ version 0.6.3.5830W or later.

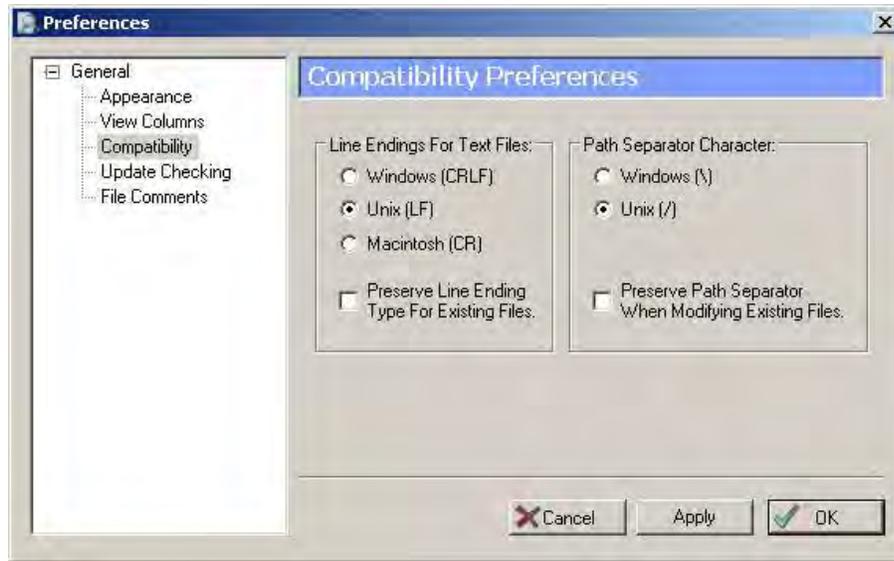
## 2| Creation of Checksums

To create checksums, first copy all the digital data to be submitted to the processing branch to the submission drive. Once all the data has been copied, create a MD5 checksum file with Unix Line Endings, Unix Path Separator Characters and a custom MD5 file comment using the following procedure:

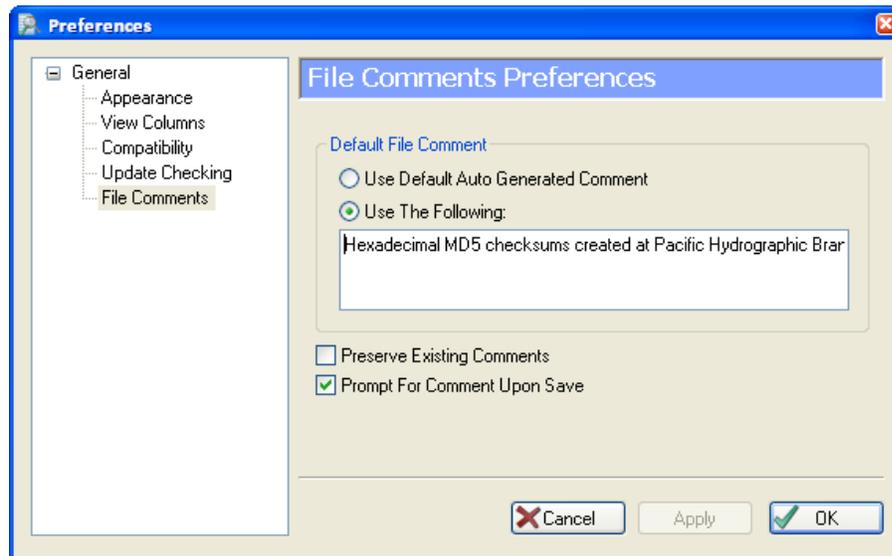
1. Open FileVerifier++ by opening the fv.exe file from Windows Explorer
2. If this is the first time you have run the program, go to Tools ->Settings->Preferences



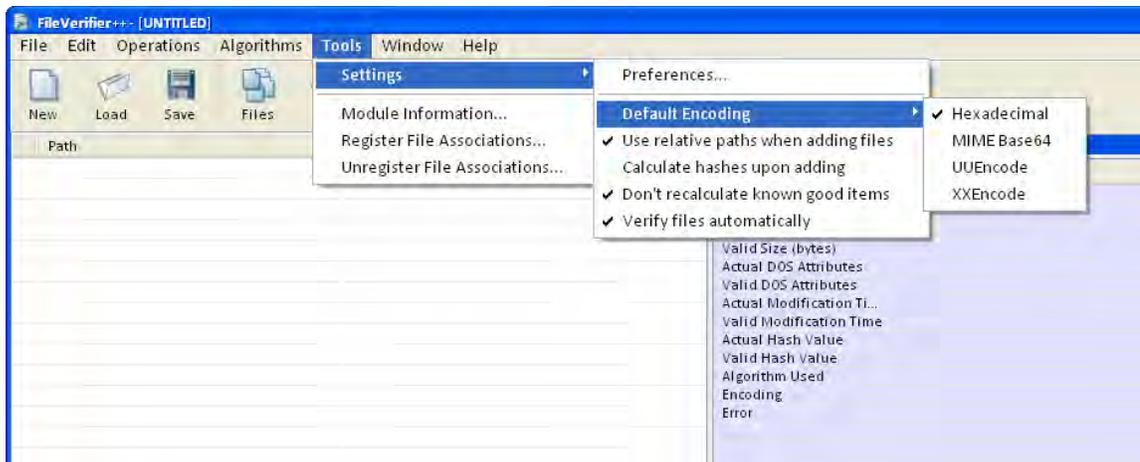
- a. Under General ->Compatibility change
  - i. Line Endings for Text Files to Unix (LF)
  - ii. Path Separator Character to Unix (/)



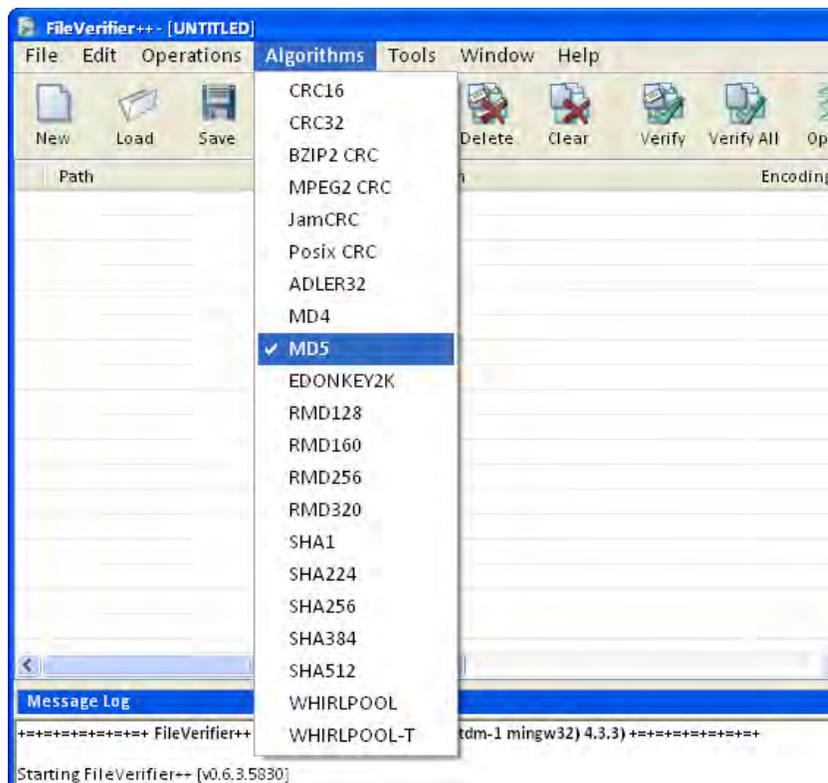
- b. Under General->File Comments change
  - i. Default File Comment to “Hexadecimal MD5 checksums created at {insert field unit name here} on YYYY-MM-DD”
  - ii. Check Prompt For Comment Upon Save



- c. Under Tools->Settings->Default Encoding-> Select “Hexadecimal”
- d. Under Tools->Settings->Select “Use relative paths when adding files”

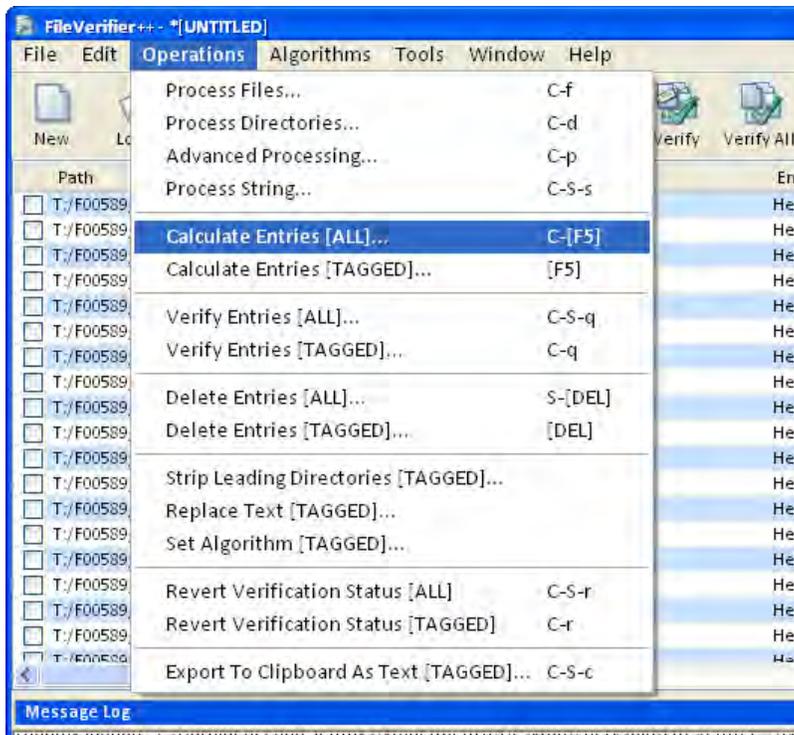


e. Under Algorithms-> Select “MD5”

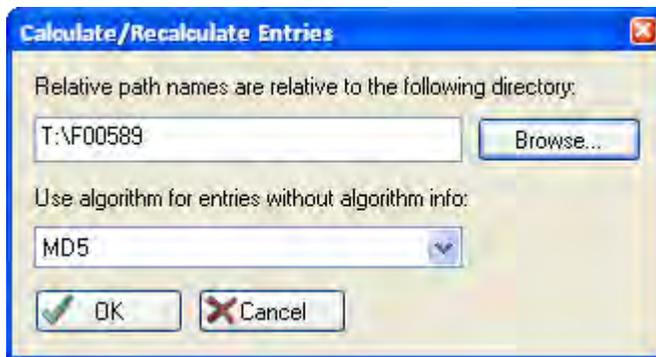


3. Once you have all your settings correct, you can add the files to be checksummed
  - a. Select the “Dirs” button and browse to the H12345 folder on the submission drive
  - b. Under Operations-> Select “Calculate Entries [ALL]...”

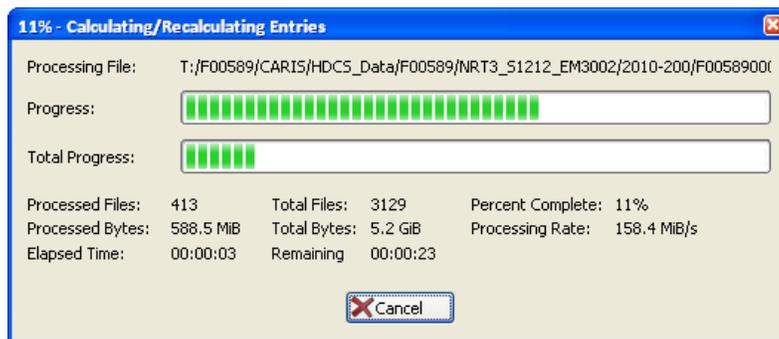




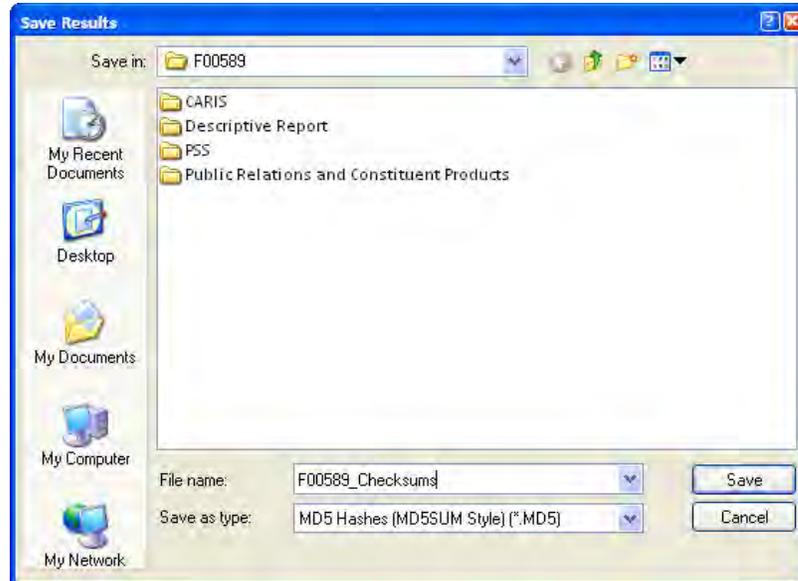
- c. Enter the base path of the submission folder (ex. T:\H12345) in the Relative path names entry dialog and click okay



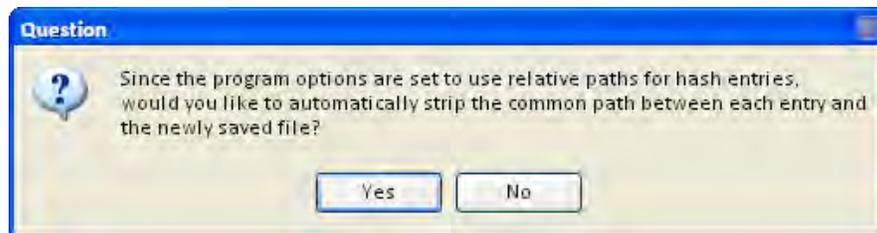
- d. The process will begin and you will get a status bar telling you how far along you are



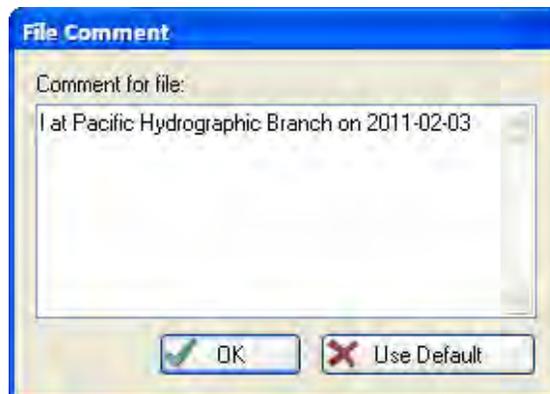
- e. When it is finished, click on the “Save” button
- i. Give the checksum file a name using the naming convention HXXXXX\_Checksums.MD5 and place it in the base folder (ex T:\H12345)
  - ii. Save as “MD5 Hashes (MD5SUM Style) (\*.MD5)”



- iii. Answer “Yes” to the question about relative path stripping



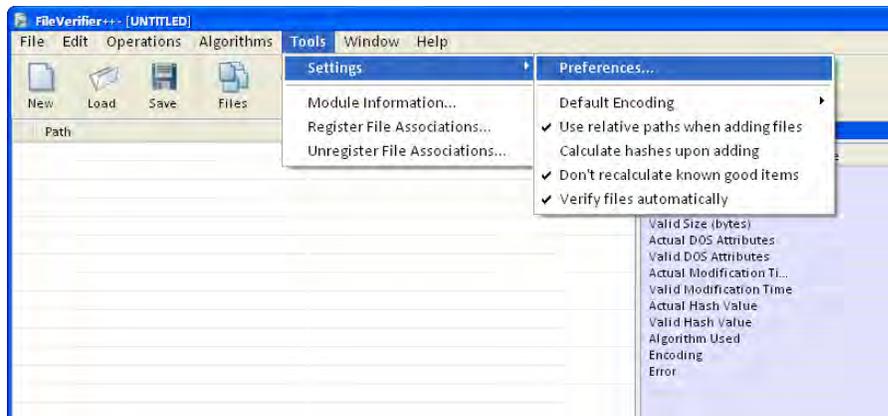
- iv. Modify the date in the comments to the current date



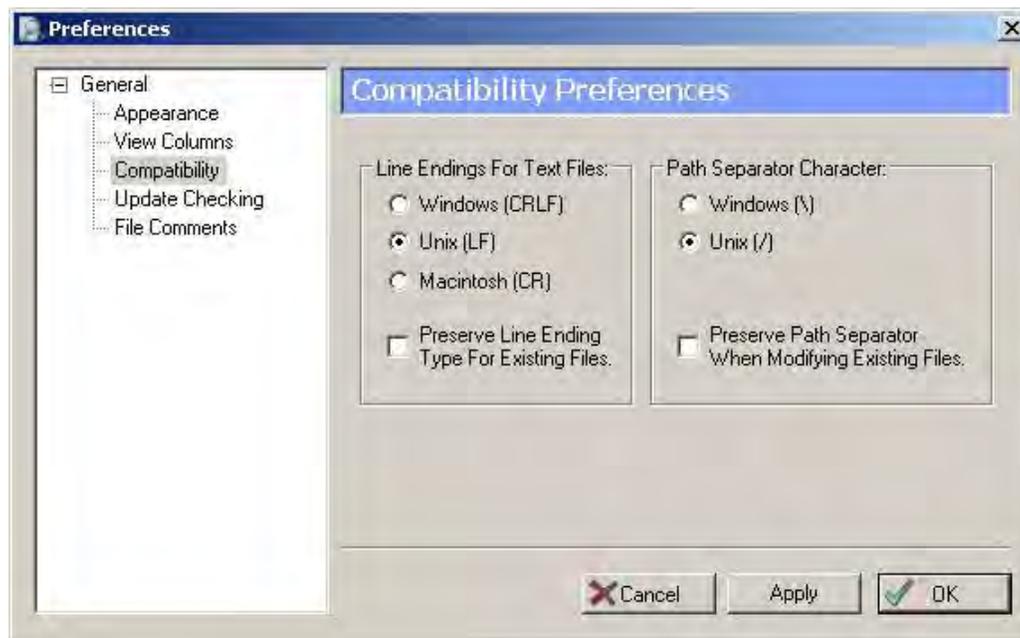
### 3| Verification of Checksums

To verify checksums, first copy all the submitted digital data to the network drive where it will be stored. Then verify that the data has not been altered by loading the checksum file and comparing the checksums of the files as they currently exist to how they existed on the ship using the following procedure:

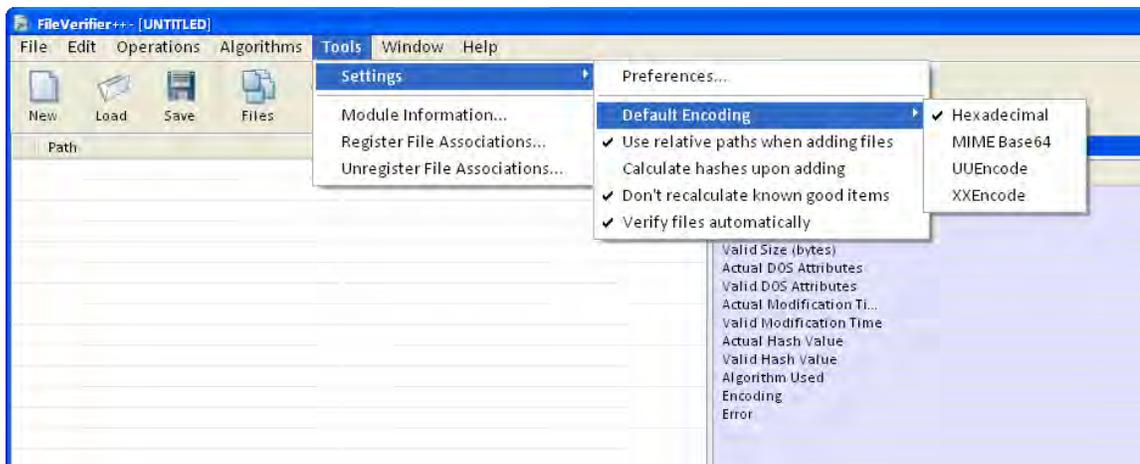
1. Open FileVerifier++ by opening the fv.exe file from Windows Explorer
2. If this is the first time you have run the program, go to Tools ->Settings->Preferences



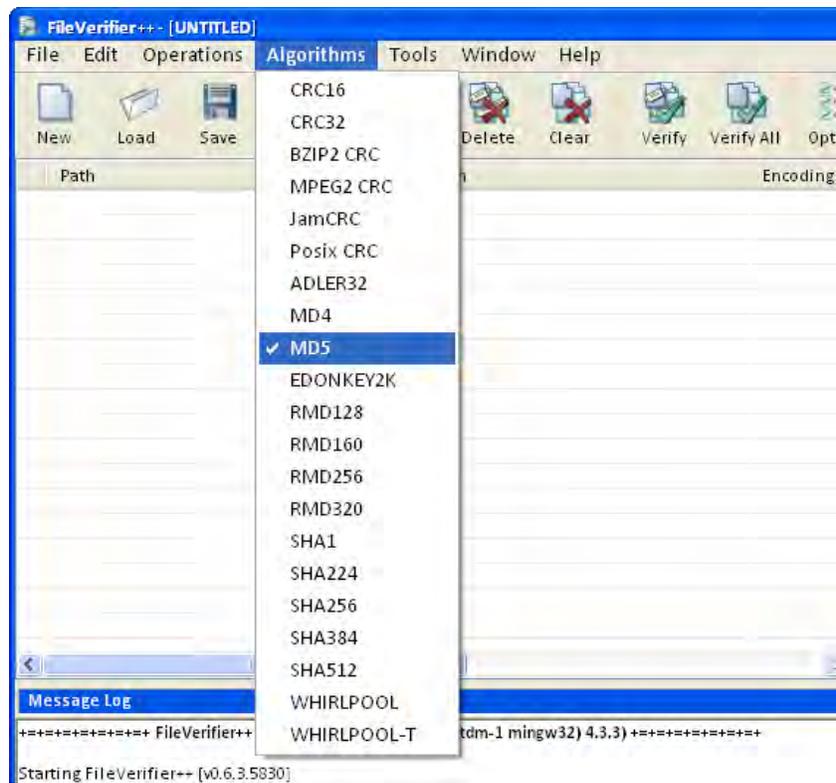
- a. Under General ->Compatibility change
  - i. Line Endings for Text Files to Unix (LF)
  - ii. Path Separator Character to Unix (/)



b. Under Tools->Settings->Default Encoding-> Select "Hexadecimal"

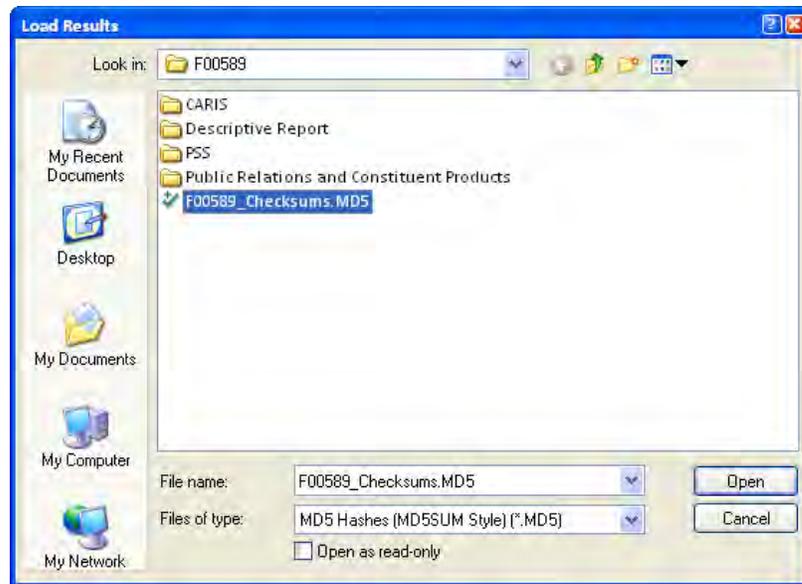


c. Under Algorithms-> Select "MD5"

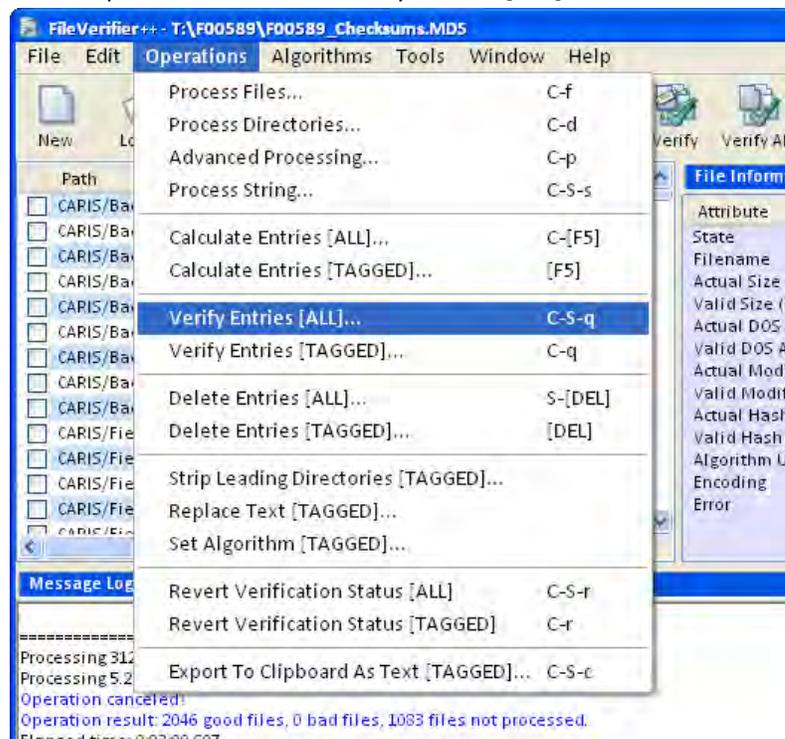


3. Open the MD5 Checksum file by clicking on the "Load" button

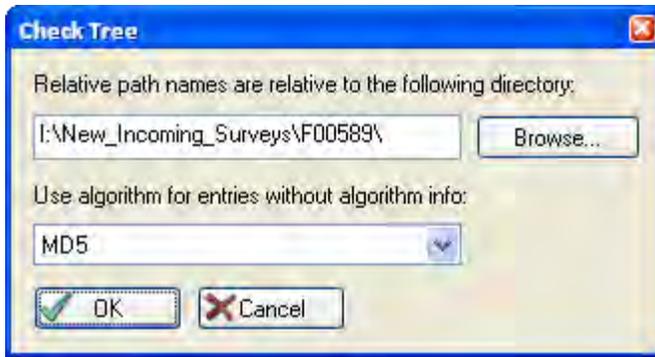




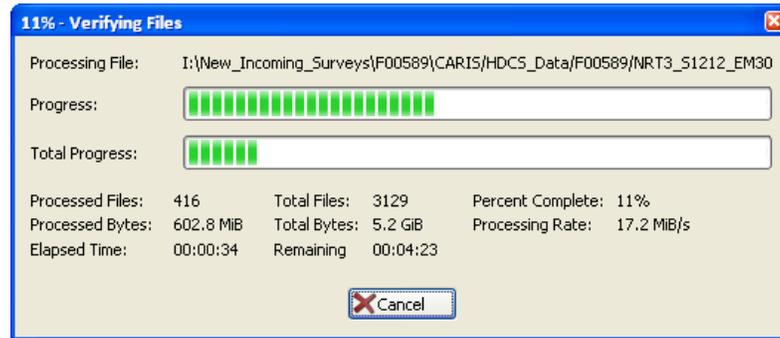
- a. If you have "Verify files automatically" selected in the Tools->Settings menu, the comparison will begin automatically.
- b. If not, under Operations-> Select "Verify Entries [ALL]..."



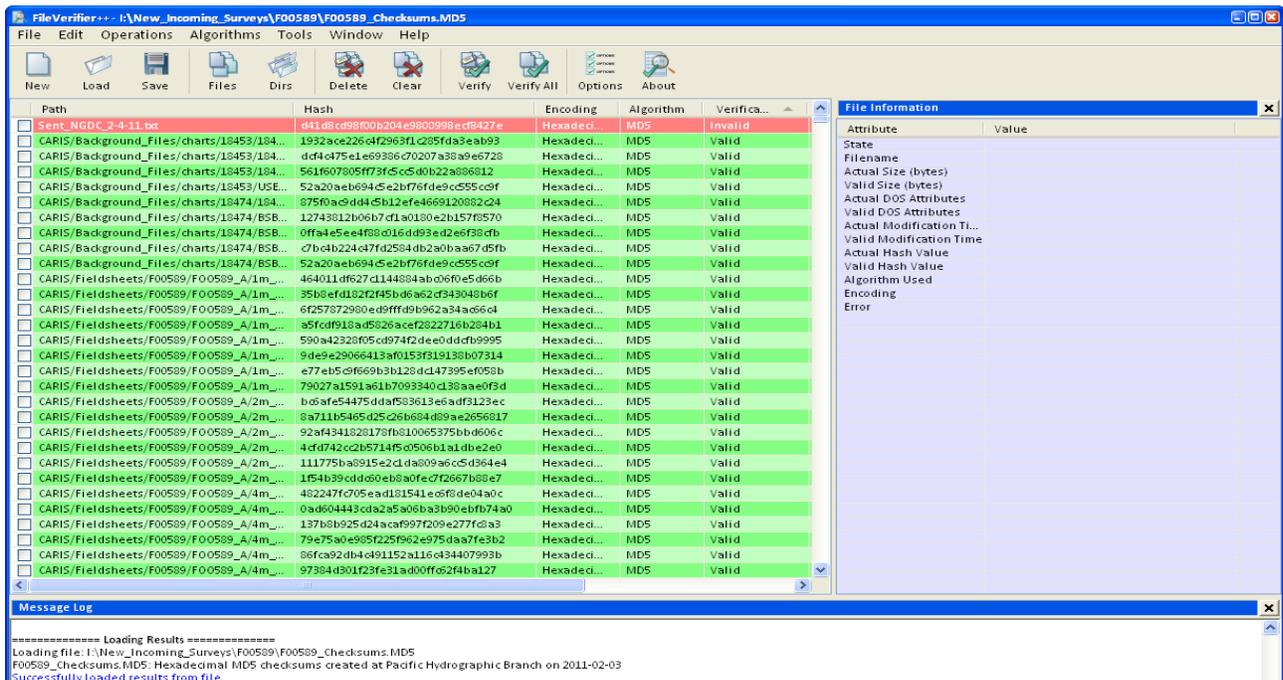
- c. The Relative path names entry dialog should already be pointing to the current root folder but if not, point to it now and click OK.



d. The process will begin and you will get a status bar telling you how far along you are



4. When the verification process is complete, sort the columns by "Verification". If any files have been altered or deleted between the field unit and the processing branch network they will show up as Invalid and be colored red. These files will need to be re-transmitted from the field unit to the processing branch.



- If all files have valid checksums then a report shall be created noting this

## 4| Reporting Results

If you have successfully verified all files in the submission, report the results of the verification using the following procedure:

- Select the Loading Results and Verifying Files text from the Message Log window

The screenshot shows a table of files with their MD5 checksums and a message log window below it. The table has columns for file paths, checksums, and verification status. The message log window shows the following text:

```

Loading module: C:\Documents and Settings\grant.froelich\Desktop\Checksum\FileVerifier+-\fv-0.6.3.5830W\Modules\whirlpool.dll

===== Loading Results =====
Loading file: I:\New_Incoming_Surveys\F00589\F00589_Checksums.MD5
F00589_Checksums.MD5: Hexadecimal MD5 checksums created at Pacific Hydrographic Branch on 2011-02-03
Successfully loaded results from file.

===== Verifying Files =====
Processing 3129 files.
Processing 5.2 GiB total.
Operation result: 3129 good files, 0 bad files, 0 files not processed.
Elapsed time: 0:04:17.770
Average processing rate: 20.5 MiB/s.
  
```

At the bottom of the message log window, there is a summary bar showing: 3129 Files, 1 File Selected, MD5.

- Copy the text to a new text file in the submission root folder which is named with the naming convention HXXXXX\_Checksum\_Results.txt

The screenshot shows a Notepad window titled "F00589\_Checksum\_Results.txt - Notepad". The text inside the Notepad window is identical to the text shown in the message log window above:

```

===== Loading Results =====
Loading file: I:\New_Incoming_Surveys\F00589\F00589_Checksums.MD5
F00589_Checksums.MD5: Hexadecimal MD5 checksums created at Pacific Hydrographic Branch on 2011-02-03
Successfully loaded results from file.

===== verifying Files =====
Processing 3129 files.
Processing 5.2 GiB total.
Operation result: 3129 good files, 0 bad files, 0 files not processed.
Elapsed time: 0:04:17.770
Average processing rate: 20.5 MiB/s.
  
```

## Standard Shorthand for Features

Notes made in Remarks or Recommendations fields should be concise and use approved shorthand:

att	attached	mlw	mean lower low water
bdk	bedrock	mbes	multibeam echosounder
bch	beach	mnt	maintained
bkwr	breakwater	N	north
blldrs	boulders	nain	not addressed inshore of NALL
brg	bearing	nall	navigable area limit line
ch	channel	ntd	noted
chd	charted	ofsh	offshore
cir	circle	ort	oriented
conn	connected	par	parallel
cov	covers	pos	position
c/u	covers/ uncovers	pt	point
dbn	daybeacon	pvt	private
dia	diameter	rk	rock
dis	disproval	rng	range
DP	detached position	shl	shoal
dup	duplicate	sig	significant
E	east	sl	shoreline
ext	extent	sndg	sounding
fr	features	S	south
fl	flashing	subm	submerged
flt	floating	swm	seaward most
fm	fathoms	vbes	vertical beam echo sounder
ft	feet	vfd	verified
GC	Geographic Cell	W	west
ht	height	wtr	water
hp	high point		
hw	high water		
inshr	inshore		
invst	investigation		
klp	kelp		
ldg	ledge		
ldr	lidar		
lmt	limit		
lt	light		
ltd	lighted		
lw	low water		
m	meter		
mhw	mean high water		



**NOAA**

**NATIONAL OCEANIC AND  
ATMOSPHERIC ADMINISTRATION**  
UNITED STATES DEPARTMENT OF COMMERCE

SOP

## Total Vertical Uncertainty Quality Check

SOP

Megan Greenaway
Manager / Process Owner Approval

### Revision History

Date	Revision Description (Reason/What)	Updated by
04/22/2013	Initial Release	Megan Greenaway

### CONTENTS

1. OVERVIEW .....	2
2. WORK INSTRUCTIONS .....	2
2.1 Create TVU QC Layer.....	2
2.2 Review the TVU QC Layer .....	4
3. REFERENCE DOCUMENTS.....	4

## 1. OVERVIEW

The Total Vertical Uncertainty Quality Check (TVU QC) is a simple way to identify nodes in the submitted grid that have estimated uncertainties that exceed the NOAA specifications. The NOAA uncertainty standards are based on IHO S-44 standards for hydrographic surveys. Specifically, the TVU QC layer compares the estimated uncertainty of the depth estimate to the allowable uncertainty of the depth estimate node by node.

There are multiple methods to identify the nodes that have estimated uncertainties that exceed the NOAA specifications. The best practice is to use the ratio method which visualizes the ratio of the uncertainty at a node to the maximum allowed IHO uncertainty for each node via a computed layer in CARIS. This TVU QC layer scales with depth and demonstrates what fraction of the total allowable error budget is consumed by the estimated uncertainty. In addition, only one new CUBE child layer is required for each IHO Order (1 or 2).

## 2. WORK INSTRUCTIONS

The Compute Layer function is used in CARIS HIPS & SIPS or CARIS BDB to create a new custom attribute layer from one or more existing layers. The hydrographer should use the Finalized surface because this surface will identify areas where either the uncertainty or the standard deviation exceeded the maximum allowable error and the greater of these two values is used in addition to having the Uncertainty scaled to a 95% CI, whereas unfinalized surface Uncertainties are reported at the 68% CI.

The IHO Order specifications change with depth. Use the following guidelines for determining the IHO Order specification:

- IHO Order 1 for 1m, 2m, 4m, and 8m surfaces.
- IHO Order 2 for 8m, 16m, and 32m surfaces.

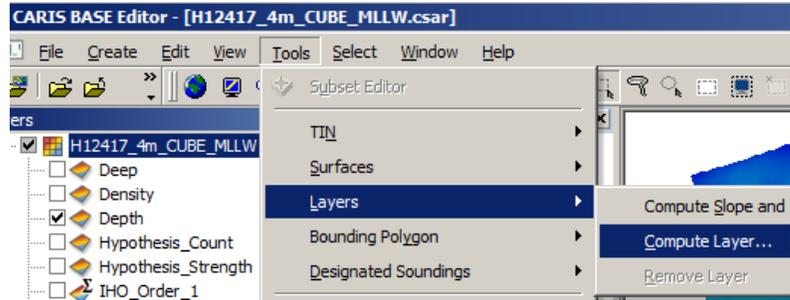
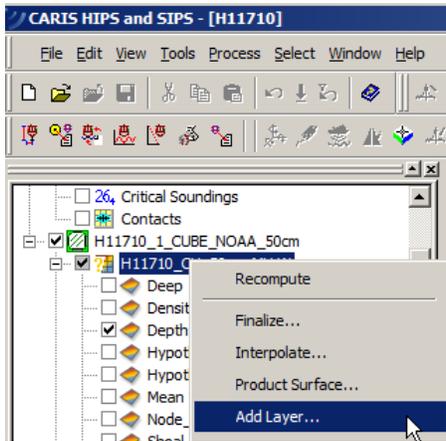
Note: Two layers should be created for 8m surfaces for evaluation: IHO-1 layer 72-100m and IHO-2 layer 100-160m.

### Ratio Method

#### 2.1 Create TVU QC Layer

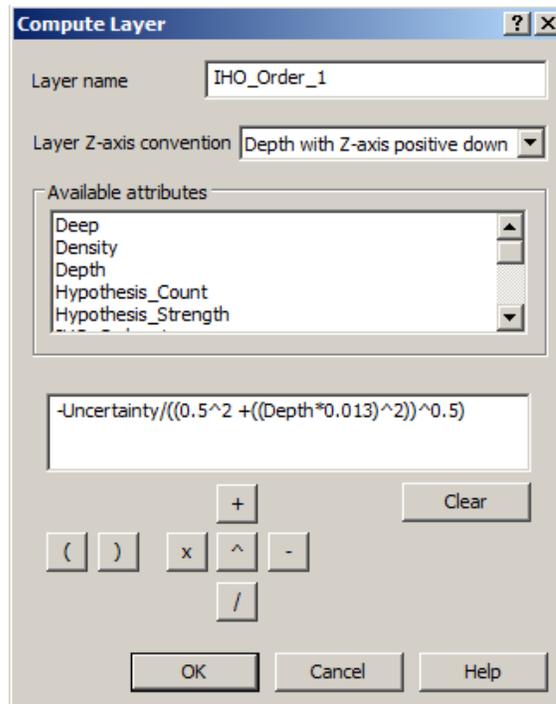
- a. Select the parent layer of the surface in the Layers window.
- b. Open Compute Layer Window:
  - i. HIPS & SIPS -> Right-click and select 'Add Layer'
  - ii. BDB -> Select Tools->Layers->Compute Layer.

See next page for images.



- c. Enter the Layer Name (e.g. IHO\_Order\_1) using the IHO guidelines above.
- d. Select the Layer Direction from the drop down list (i.e. depth positive down or height positive down).
- e. Enter the appropriate equation using the table below in to the Attributes field:

IHO Order	Surfaces	Equation
Order 1	1m, 2m, 4m, 8m	$-\text{Uncertainty}/((0.5^2 + ((\text{Depth} * 0.013)^2))^0.5)$
Order 2	8m, 16m, 32m	$-\text{Uncertainty}/((1.0^2 + ((\text{Depth} * 0.023)^2))^0.5)$



- f. Click OK.

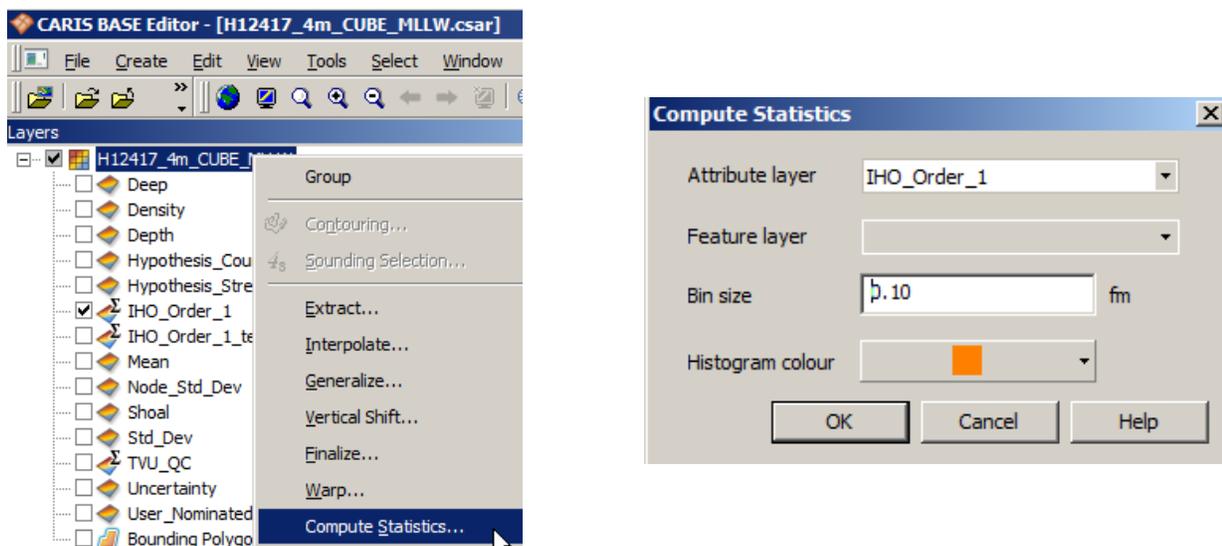
## 2.2 Review the TVU QC Layer

The results from the ratio method visually demonstrate if and by how much the estimated uncertainties have exceeded the NOAA specifications. The properties of the TVU QC layer can be modified to improve visualization. Specifically the user should use the most appropriate Colour Map file or create a Colour Range template. If using a Colour Range template the values which do not require further examination are from -1 to 0 and the values which do require further examination are from -100 to -1, however the ranges should be broken down into finer collections so the user can take advantage of showing the fraction of allowable error budget.

The TVU QC layer should be examined not only for the 95% confidence level but also for spatial indicators such as different uncertainty behavior between lines, patterns and/or clusters of non-compliant nodes which may indicate a systematic error, TPU model error, or noisy data.

The TVU QC layer is one tool for evaluating the TVU. The hydrographer should use the TVU QC layer in conjunction with other tools such as a distribution (e.g. histogram) plot, the Python “Standards Compliance Evaluation” tool by Weston Renoud, spreadsheets and the CUBE layers.

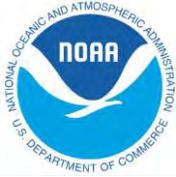
Histograms can be created in CARIS using the Compute Statistics function. Select the parent layer of the surface -> Right Click -> Compute Statistics. Select the IHO\_Order\_1(or2) layer and a bin size.



## 3. REFERENCE DOCUMENTS

This document is in alignment with the following regulatory/guidance documentation:

- Field Procedures Manual
- Hydrographic Survey Specifications and Deliverables



**NOAA**

**NATIONAL OCEANIC AND  
ATMOSPHERIC ADMINISTRATION**  
UNITED STATES DEPARTMENT OF COMMERCE

SOP

## TCARI for Notebook Features

SOP

Megan Greenaway
Manager / Process Owner Approval

### Revision History

Date	Revision Description (Reason/What)	Updated by
04/18/2013	Initial Release	Megan Greenaway

### CONTENTS

1. OVERVIEW .....	2
2. WORK INSTRUCTIONS .....	2
2.1 Export the features .....	2
2.2 Generate TCARI .tid file .....	3
2.3 Correct the features for tide .....	3

## 1. OVERVIEW

CARIS Notebook may be used to apply tide correctors to point features. However, if a TCARI tide method is required then Pydro must be used to create the compatible tide file. This SOP describes how Pydro is used to create a CARIS “single station” tide file (.tid) that is a 1:1 ratio with the feature records.

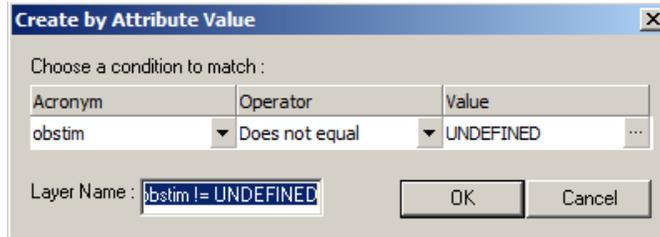
## 2. WORK INSTRUCTIONS

### CARIS Notebook:

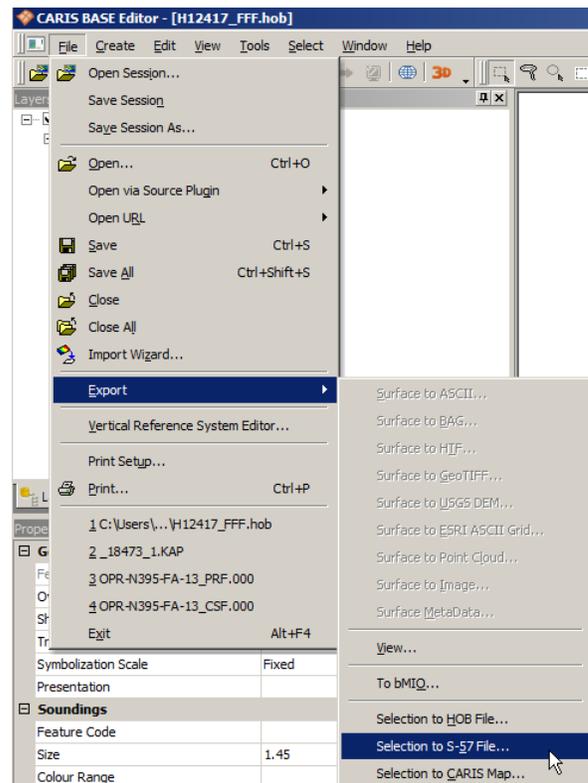
#### 2.1 Export the features

Export the features that need to be tide corrected to S-57 .000 (or GML) format. This file will be used by a utility in Pydro as a "navigation" file to create the .tid file.

- a. Perform a feature selection in Notebook. The utility in Pydro uses the NOAA extended attribute "obstim" in computing the tide records. To select features with the “obstim” attribute populated (i.e. not equal to null), right click and Create Layer by Attribute Value with the following:

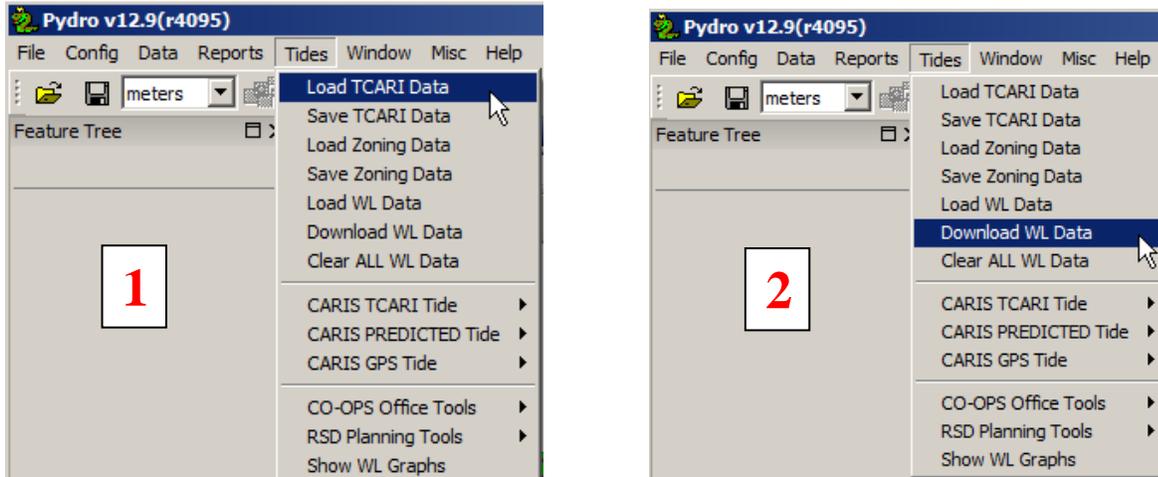


- b. File->Export->To S-57 (or GML will also work).

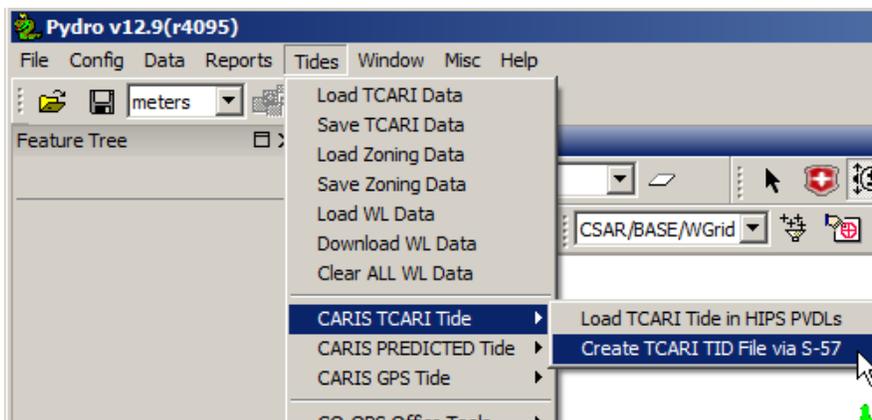


**Pydro:****2.2 Generate TCARI .tid file**

- a. Load the desired TCARI project data. No other data needs to be loaded/inserted into the Pydro Survey Session (PSS) to use the utility.



- b. Select Tides->CARIS TCARI Tide->Create TCARI TID File via S-57, and select the S-57 file from step 1). (Note: there are menu options to opt for PREDICTED tides as generated by TCARI; if you want predicted tides rather than TCARI tides, use that menu option.)

**CARIS Notebook:****2.3 Correct the features for tide**

- a. Perform a feature selection in Notebook, using the same query from step 1)
- b. Go to Tools->Load Tide ->Single tide station observations: browse and select the .tid file created in step 2).

# SSS Contacts to \$CSYMB

02/27/2014

## Overview

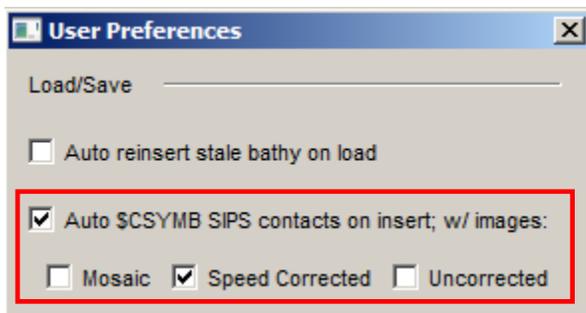
This SOP outlines the procedures for NOAA field units to translate CARIS SIPS side scan sonar contacts to Cartographic Symbols (\$CSYMB) in a .000 format for further analysis in CARIS BDB. This is the most efficient method because Pydro automatically creates the \$CSYMB features, attaches the CARIS SIPS images to the \$CSYMB feature and packages the images in to a single zipped folder which can be extracted to the Multimedia folder.

## CARIS HIPS & SIPS

- Pick and attribute contacts.

## Pydro

- Config -> User Preferences
- Toggle ON “Auto \$CSYMB SIPS contacts on insert; w/ images” and the appropriate SSS contact image (Mosaic, Speed Corrected, or Uncorrected). All three can be exported but this will create three copies of each image.



- Insert SSS Lines which contain contacts
  - Data -> Insert HIPS/SIPS Line Features
    - Select Lines with SSS contacts to insert
    - Apply
- Export SSS Contacts to .000
  - Data -> Export -> S-57 Features to ISO 8211 (.000)
  - Use “Default” as Filter
  - Name .000 \$CSYMB file
  - Intended Usage = Harbor (5)

## WinZip

- Unzip new SSS contact image folder - Pydro automatically zips all images which are correlated to SSS contacts. The zip file is written to the same folder as the .000 file. Unzip the image file to your Multimedia folder.

## CARIS

- Open SSS contact \$CSYMB .000 file for analysis with surfaces and Final Feature File.

## Appendix I

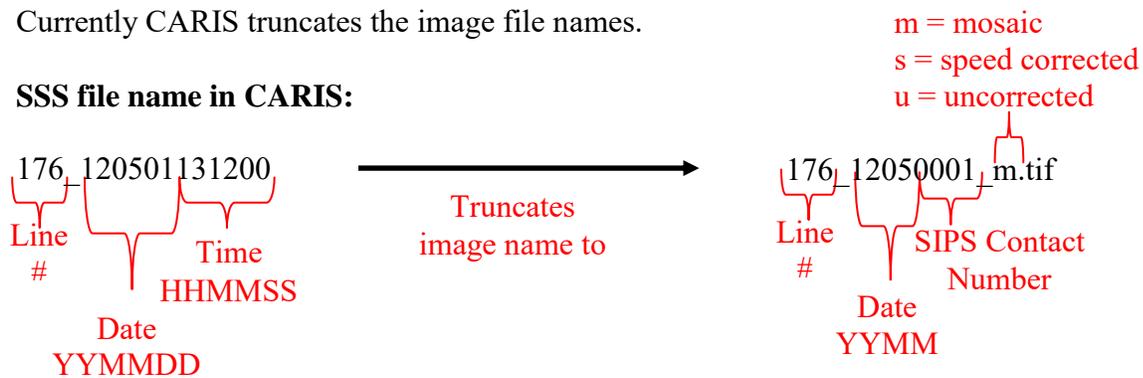
Attribute Mapping from CARIS SIPS to \$CSYMB:

SIPS Contacts	\$CSYMB
HDCS file name (i.e. 100% or 200%)	SORIND (PVDL)
Hydrographer Initials	INFORM
Date	SORDAT
Observed Time	obstim
Remarks	remrks
Contact Type	NINFOM
Images	Images*
N/A – added in Pydro	Primary/Secondary = Pending
Contact Number	Userid
Contact Height	Contact Height

### \*Images File Name:

Currently CARIS truncates the image file names.

### SSS file name in CARIS:



NOTE: The month and year remain and the SIPS contact number is added (e.g. 0001, 0002, etc.). The day and time are truncated.



**Input**

Source Selection

**Tide**

Measure 0 (m)

Zoning 0 (m)

**Sound Speed**

Measured 0 (m/s)

Surface 0 (m/s)

**Uncertainty Source**

Source Realtime

Position Realtime

Sonar Realtime

Heading Realtime

Pitch Realtime

Roll Realtime

Vertical Delayed Heave

Tide Realtime

**Sweep parameters**

Peak to peak heave 0 (m)

Maximum Roll 0.0

Maximum Pitch 0.0

**Maximum Pitch**

The Pitch offset of the transducer boom.

OK

Cancel

Help

# Field Procedures Manual

National Oceanic and Atmospheric Administration, Office of  
Coast Survey

2014

## Chapter 5 Appendices:

Digital Data Submission Checklist  
Hydro Survey QC Checklist  
Hydro Survey Review Checklist  
Fixed ATON Report

Please Note:

The Standard Operating Procedure's (SOP's) within the FPM Appendices are in the process of being transferred to the "Documents" section of the Hydroforum and the SOP's will reside in both places for the remainder of the 2014 field season.

# Digital Data Submission Checklist

OPR-A###-FA-##  
HXXXXX Survey X

## CARIS

### Background Files

\_\_\_\_\_ Any background files to be submitted with the survey

### Fieldsheets

\_\_\_\_\_ HXXXXX (Non-Finalized BASE Surfaces)

\_\_\_\_\_ HXXXXX\_2m\_0to40 Naming convention: HXXXXX\_Resolution(m)\_DepthRange

\_\_\_\_\_ HXXXXX\_5m\_30to70

\_\_\_\_\_ HXXXXX\_10m\_50to120

\_\_\_\_\_ HXXXXX\_20m\_100to200

\_\_\_\_\_ HXXXXX\_35m\_180to350

\_\_\_\_\_ HXXXXX\_Final\_Combined (Finalized & Combined BASE Surface)

### HDCS\_Data

\_\_\_\_\_ HXXXXX (processed CARIS HDCS data)

\_\_\_\_\_ Critical Soundings

\_\_\_\_\_ VesselConfig (only vessels that apply to this survey)

\_\_\_\_\_ DeviceModel.xml (DeviceModel used for processing this survey)

### Notebook Files

\_\_\_\_\_ HXXXXX\_Original\_Composite\_Source.hob

\_\_\_\_\_ HXXXXX\_Composite\_Source.hob OR HXXXXX\_Updates\_Ntbk.hob

\_\_\_\_\_ HXXXXX\_Updates\_Pydro.hob

\_\_\_\_\_ HXXXXX\_Disprovals.hob

### Preprocess

\_\_\_\_\_ ISIS (raw XTF data and True Heave from ISIS)

\_\_\_\_\_ SVP\_raw (raw SV data from Velocwin)

\_\_\_\_\_ Trimble (raw data from TerraSync & exported SHP files from GPS PathFinder)

### SVP (processed CARIS SVP data files separated by vessel)

\_\_\_\_\_ 1010

\_\_\_\_\_ 1018

\_\_\_\_\_ S220

### Tide

\_\_\_\_\_ Observed, Verified or Smooth .tid & .zdf (only tide files applied to data at time of submission)

\* No Sessions submitted at this time

## DESCRIPTIVE REPORT

### Report Body

\_\_\_\_\_ HXXXXX\_Descriptive\_Report.doc

\_\_\_\_\_ HXXXXX\_Title\_Sheet.pdf

\_\_\_\_\_ HXXXXX\_Cover\_Sheet.pdf

\_\_\_\_\_ Digitally Signed Approval Memo

### Appendices

#### I. DTON Report(s)

\_\_\_\_\_ HXXXXX\_DTON.xml (XML of DTONS exported from Pydro)

\_\_\_\_\_ HXXXXX\_DTON\_Report.pdf (report produced in Pydro)

\_\_\_\_\_ HXXXXX\_DTON\_email.txt (copy of submission email)

\_\_\_\_\_ other email correspondence related to DTONS including MCD confirmation

**II. Survey Feature Report**

\_\_\_\_\_ HXXXXX\_Survey\_Feature\_Report.pdf (report produced in Pydro)

**III. Final Progress Sketch & Survey Outline**

\_\_\_\_\_ HXXXXX\_Survey\_Outline.tab & final Progress Sketch files

**IV. Tides & Water Levels**

\_\_\_\_\_ Official smooth tide note issued by CO-OPS to identify files used for final correctors

**Request for Tides**

\_\_\_\_\_ HXXXXX.pdf (Smooth Tides Request & Abstract Times of Hydro)

\_\_\_\_\_ HXXXXX.mif/mid files

**V. Supplemental Survey Records & Correspondence**

\_\_\_\_\_ HXXXXX\_Correspondence.xxx (digital copies of emails, request & correspondence)

**Separates**

**I. Logs**

**Acquisition & Processing**

\_\_\_\_\_ HXXXXX\_1010\_8101\_Log.xls

\_\_\_\_\_ HXXXXX\_1010\_8101\_Log.xls

\_\_\_\_\_ HXXXXX\_S220\_8111\_Log.xls

\_\_\_\_\_ HXXXXX\_S220\_8160\_Log.xls

**Detached Positions**

\_\_\_\_\_ HXXXXX\_Pydro\_Feature\_Log.xls

\_\_\_\_\_ HXXXXX\_DPForms.pdf (Scanned DP forms)

\_\_\_\_\_ HXXXXX\_Boat\_Sheets.pdf (Scanned boat sheets)

**II. Sound Speed Data**

Not Applicable, submitted by Project with the DAPR

**III. Hydrographic Survey Letter Instructions**

\_\_\_\_\_ Letter Instructions, changes and amendments for the project

**IV. Checkpoint Summary & Crossline Comparisons**

\_\_\_\_\_ Checkpoint Summary & Crossline Comparisons

**Public Relations and Constituent Products**

\_\_\_\_\_ Include all products that were provided to constituents or used for PR

**PSS** (Pydro Preliminary Smooth Sheet)

\_\_\_\_\_ HXXXXX.PSS

\_\_\_\_\_ Photos (Non-SSS contact images associated with Pydro features, named w/unique identifier )

**HXXXXX Contents**

\_\_\_\_\_ Survey data included in transmittal list text file

_____	size
_____	number of files
_____	number of folders

Command prompt H: (to go to drive) cd (can use rt click paste to put in path to folder)
---

# Hydrographic Survey Quality Control Checklist

Survey: HXXXXX Project: OPR-XXXX-FA Survey PIC: \_\_\_\_\_

## SURVEY PLANNING

Completed:

INITIAL

DATE

- \_\_\_\_\_ Read and Understand the project Instructions
  - \_\_\_\_\_ Letter Instructions
  - \_\_\_\_\_ Standing Instructions
- \_\_\_\_\_ Start filling in Survey Log
  - \_\_\_\_\_ pertinent Chart scales listed
- \_\_\_\_\_ Shoreline Prep
  - \_\_\_\_\_ Shoreline files prepped
  - \_\_\_\_\_ Boat sheets produced
  - \_\_\_\_\_ TIF/TFWs opened and checked in TerraSync
  - \_\_\_\_\_ Initial TIF/TFWs produced for MBES launches in Isis
- \_\_\_\_\_ Cross Lines
  - \_\_\_\_\_ Plan to run crosslines early, prior to MS if possible
  - \_\_\_\_\_ Plan to obtain 10%
  - \_\_\_\_\_ Atleast 5% collected
- \_\_\_\_\_ Multibeam Polygons produced and updated
  - \_\_\_\_\_ DO NOT send multibeam boats inshore of the eight meter curve until shoreline has been run in area
  - \_\_\_\_\_ Initially create SHIP & LAUNCH polygons only - Launch polygons can be driven by any Cox'n
  - \_\_\_\_\_ NEAR\_SHORE & HIGH\_WATER\_ONLY polygons not created until shoreline has been run in area
  - \_\_\_\_\_ Discuss NEAR\_SHORE & HIGH\_WATER\_ONLY areas with FOO/CST - run by experienced Cox'ns only
  - \_\_\_\_\_ Polygons converted to shp format and put in R/Transfer and on Launch hard drive
- \_\_\_\_\_ Bottom Samples Prepped
  - \_\_\_\_\_ Bottom Sample chartlet/boat sheet produced
  - \_\_\_\_\_ Create a tif/tfw of your bottom sample sites
  - \_\_\_\_\_ TIF/TFWs opened and checked in TerraSync

## DAILY CHECKS

Completed:

INITIAL

DATE

- \_\_\_\_\_ Quality Control of Survey Data
  - \_\_\_\_\_ Review BASE surfaces
  - \_\_\_\_\_ Review data in subset mode for SV error, tide problems, holidays & noise
  - \_\_\_\_\_ Check coverage and update polygons
  - \_\_\_\_\_ Check for immediate DTONs and notify FOO
  - \_\_\_\_\_ Immediate DTONs submitted
- \_\_\_\_\_ Review Acquisition and Processing logs
  - \_\_\_\_\_ Check for issues/problem data in both Acquisition and Processing sections
  - \_\_\_\_\_ Make sure the SV application method is documented (e.g. NIDWT-4hrs)
  - \_\_\_\_\_ Note if True Heave could not be applied & document in DR
- \_\_\_\_\_ Track issues in HXXXXX\_Survey\_Log.doc
  - \_\_\_\_\_ Note which vessels were used for the day (especially useful for shoreline boats)
  - \_\_\_\_\_ Document special circumstances/problems, HVF changes & deviations from DAPR
  - \_\_\_\_\_ Issues explained in DR

## FIELD PROCESSING

Completed:

INITIAL

DATE

- \_\_\_\_\_ Pydro Processing
  - \_\_\_\_\_ All DPs/GPs & Bottom Samples imported
  - \_\_\_\_\_ Features reviewed, flagged, S57 attributed and CartoAction selected
  - \_\_\_\_\_ Remarks/Recommendations completed

- \_\_\_\_\_ Pictures labeled correctly, in one folder, & inserted in PSS
- \_\_\_\_\_ AWOIS investigations completed
- \_\_\_\_\_ .mbd file inserted in Pydro
- \_\_\_\_\_ Database updated in AWOIS editor, with investigation methods and remarks
- \_\_\_\_\_ Tide and SVP correctors applied where necessary
- \_\_\_\_\_ HXXXXX\_Pydro\_Feature\_Log completed
- \_\_\_\_\_ Feature .xml's exported using Pydro Tree Templates

\_\_\_\_\_ Notebook Processing

- \_\_\_\_\_ All Pydro features imported
- \_\_\_\_\_ Features reviewed with DP forms and boat sheet
- \_\_\_\_\_ Address all data including CFF, Chart, Lidar, and new items
  - \_\_\_\_\_ All remarks fields completed or state "Unable to Verify"
  - \_\_\_\_\_ Unverified items flagged with Marker Text
  - \_\_\_\_\_ Photos, not associated with a Pydro feature, added to features in Ntbk in a marker note
  - \_\_\_\_\_ Notebook Photos are stored in PSS\Photos\Notebook Photos

\_\_\_\_\_ Verify Sound Velocity Files

- \_\_\_\_\_ Compare SVP files listed in digital acquisition logs with files on I: drive – all should match
- \_\_\_\_\_ Review cast profiles in HIPS SVP Editor
- \_\_\_\_\_ Display SV cast positions in CARIS to check for gross error
- \_\_\_\_\_ Check file management on H: and I: drives
- \_\_\_\_\_ Query data to make sure only master concatenated files (*HXXXXX\_VSSL.svp*) were applied
  - \_\_\_\_\_ If *HXXXXX\_VSSL.svp* is not applied to lines, then discussed in DR
  - \_\_\_\_\_ SV acquisition/processing deviations from the DAPR are noted in the DR.

\_\_\_\_\_ Updated Shoreline TIF/TFWs created and sent out to field before any near shore MBES run

\_\_\_\_\_ Examine Range Displayed CUBE surfaces (make sure that CUBE surfaces have Depth Ranges in name)

\_\_\_\_\_ Coast Pilot review & write up with edits completed

**POST ACQUISITION**

**Completed:**

\_\_\_\_\_ INITIAL

\_\_\_\_\_ DATE

\_\_\_\_\_ Review of CARIS Data

- \_\_\_\_\_ Re-insert all HDCS lines (not DPs) into HXXXXX\_QC session
- \_\_\_\_\_ Review data using CARIS Subset Editor (include looking at rejected and BASE child layers)
  - \_\_\_\_\_ Subset tiles created for review process
  - \_\_\_\_\_ Data checked for systematic errors (Std deviation child layer especially useful)
  - \_\_\_\_\_ Flyers cleaned out, where it affects appropriate surface for that depth
  - \_\_\_\_\_ Contours & Soundings generated from finalized/compiled surface (CARIS FS Editor)
- \_\_\_\_\_ Review all examined soundings (to designate, mark outstanding, or reaccept)
- \_\_\_\_\_ Designate soundings in areas where surface does not accurately represent the bottom
  - \_\_\_\_\_ # of Designated Soundings
- \_\_\_\_\_ Data issues discussed in DR if present

\_\_\_\_\_ Smooth Tides Request (\*.mif/mid and times of Hydro)

- \_\_\_\_\_ All data inserted in Pydro for correct Times of Hydrography
- \_\_\_\_\_ Request with letter, times, & mif/mid generated and saved in Appendix III
- \_\_\_\_\_ E-mail CST & FOO when complete

\_\_\_\_\_ Survey Outline

- \_\_\_\_\_ Produced & saved in Appendix III
- \_\_\_\_\_ E-mail CST & FOO when complete

\_\_\_\_\_ DTONs (Dangers to Navigation)

- \_\_\_\_\_ Select DTONs
  - \_\_\_\_\_ soundings marked outstanding in CARIS
  - \_\_\_\_\_ inserted in Pydro as CARIS Line Feature
- \_\_\_\_\_ Notify FOO that they are ready for review
- \_\_\_\_\_ DTONs chosen by CO should be marked Designated in Pydro or CARIS
- \_\_\_\_\_ Use the Pydro Report function to generate a DTON Report
- \_\_\_\_\_ E-mail CST, FOO & CO when selection and report are complete

\_\_\_\_\_ Submittal e-mail/DTON Report saved in PSS folder

\_\_\_\_\_ Additional (Observed, Verified or Smooth) Tides Applied

- \_\_\_\_\_ Tide file reviewed & checked for gaps/flyers (txt in Notepad, .tid in Caris Tide Editor)
- \_\_\_\_\_ Apply zoned file to all HDCS lines
- \_\_\_\_\_ Apply zoned file to all DPs
- \_\_\_\_\_ Data remerged in CARIS after tides have been re-applied.
- \_\_\_\_\_ Recompute BASE surfaces

\_\_\_\_\_ Complete H#####\_Data\_Log (file is in Separates\Logs)

- \_\_\_\_\_ MBES MS tab complete, query Main Scheme lines only
  - \_\_\_\_\_ Count data files on H: and I: drives
  - \_\_\_\_\_ Number of raw files matches number of HDCS lines, and matches total # of survey lines
- \_\_\_\_\_ Compare queries to daily acquisition logs to check for discrepancies
- \_\_\_\_\_ Tide correctors applied are correct and most current (observed, verified or smooth)
- \_\_\_\_\_ Master SV files applied for all vessels (or as noted in DR)
- \_\_\_\_\_ Vessel speeds meet object detection requirements for relevant depths
- \_\_\_\_\_ MBES XL tab complete, query Crosslines only
- \_\_\_\_\_ MBES DEV tab complete, query Development lines only (generally lines run over AWOIS items)
- \_\_\_\_\_ Features Query completed in H#####\_Data\_Log
  - \_\_\_\_\_ Compare fields of matching colors
- \_\_\_\_\_ Statistics tab reviewed and box copied to DR
- \_\_\_\_\_ Problems/discrepancies investigated

\_\_\_\_\_ Pydro Review

- \_\_\_\_\_ All features resolved
- \_\_\_\_\_ DP forms match features in PSS
  - \_\_\_\_\_ Scanned into a single .pdf and saved in DP Log folder
- \_\_\_\_\_ Use DP editor to ensure correct vessels were selected for all data
- \_\_\_\_\_ Apply necessary correctors (tides) to DPs and merge data
- \_\_\_\_\_ DPd for height items - additional processing complete
  - \_\_\_\_\_ copy attributes from Pydro to Ntbk feature (watlev etc)
  - \_\_\_\_\_ change UWTRC in Pydro to \$CSYMB
  - \_\_\_\_\_ if smooth tides delivered, copy smooth tide height of feature to Ntbk, update DR
- \_\_\_\_\_ Remarks/Recommendations completed
- \_\_\_\_\_ Disprovals marked Report, contain search methods in Remarks & have a recommendation
  - \_\_\_\_\_ Chart GPs produced if necessary
- \_\_\_\_\_ Changes to MHW (including islets) marked Report
  - \_\_\_\_\_ include description paragraph in Remarks and have a recommendations
- \_\_\_\_\_ AWOIS items finalized
- \_\_\_\_\_ Features Report produced and saved in Appendix I

\_\_\_\_\_ Notebook Review

- \_\_\_\_\_ Features compared to Pydro session
- \_\_\_\_\_ Remarks reviewed for consistency & completeness (All features must have a remark!)
- \_\_\_\_\_ S57 attribution correct and complete

\_\_\_\_\_ Descriptive Report

- \_\_\_\_\_ Digital images of limits and junctions produced and inserted
- \_\_\_\_\_ Fill in Statistics in Data\_Log & add the box to DR using paste special as picture
- \_\_\_\_\_ Dates of survey match- DR, Cover Sht, Title Sht, Sm Tide Req, Raw Isis & Trimble folders
- \_\_\_\_\_ Check that the General & Sub-Locality for survey in DR, Cover Sht, & Title Sht matches LIs
- \_\_\_\_\_ Add LI date signed added to DR, if LI changes affect your survey add verbage to that affect
- \_\_\_\_\_ Cross-line comparisons completed and documented
  - \_\_\_\_\_ Required quantity of XLs met. If not, addressed in DR.
- \_\_\_\_\_ Junction comparisons completed and documented
- \_\_\_\_\_ Prior surveys were reviewed because of special issues
  - \_\_\_\_\_ Issues explained in the DR
- \_\_\_\_\_ Chart comparisons completed and documented
  - \_\_\_\_\_ Chart edition & date corrected through included in DR
  - \_\_\_\_\_ Notice to Mariners checked for recent updates
- \_\_\_\_\_ Special circumstances, problems, HVF changes, deviations from DAPR documented

- \_\_\_\_\_ Shoreline processes described
- \_\_\_\_\_ Separates reviewed & complete
- \_\_\_\_\_ Acquisition logs checked
- \_\_\_\_\_ True Heave applied and how SV applied noted (nearest in time etc.)
- \_\_\_\_\_ Coverage requirements were met (use finalized surfaces to assess coverage)
- \_\_\_\_\_ If not, addressed in DR.
- \_\_\_\_\_ Run the interpolation/triangulation to assess holidays
- \_\_\_\_\_ For holidays larger than 3 nodes across
  - \_\_\_\_\_ corresponding MBES backscatter sidescan was examined
  - \_\_\_\_\_ were any navigationally significant items found in backscatter?
  - \_\_\_\_\_ Discuss in DR, if necessary
- \_\_\_\_\_ Accuracy requirements were met (use IHO error calculator)
- \_\_\_\_\_ If not, addressed in DR

**SUBMISSION** **Completed:**

\_\_\_\_\_ INITIAL \_\_\_\_\_ DATE

- \_\_\_\_\_ Data Checked & Ready for Review
  - \_\_\_\_\_ Any HVF changes or alterations are discussed in DR
  - \_\_\_\_\_ H#####\_ QC session ready
    - \_\_\_\_\_ If multiple fieldsheets are necessary, naming includes resolution & geographic identifier
    - \_\_\_\_\_ Surfaces include depth threshold ranges and resolutions in name
      - \_\_\_\_\_ cov or bot\_dep in name, if bottom depiction srfc's used in addition to coverage srfc's
    - \_\_\_\_\_ Finalize surfaces with depth thresholds applied; to produce critical soundings
      - \_\_\_\_\_ Use finalized surfaces to assess that coverage requirements were met
      - \_\_\_\_\_ Adjust overlap if necessary, there should be no gaps between surfaces
    - \_\_\_\_\_ Produce a combined surface from finalized surfaces
      - \_\_\_\_\_ produce soundings & contours from combined surface
    - \_\_\_\_\_ Open and save to session the best chart(s) for the survey area
    - \_\_\_\_\_ Make combined surface transparent, so that chart shows through
  - \_\_\_\_\_ PSS data is not Stale or Outdated
  - \_\_\_\_\_ Shoreline session contains all files named properly & located in Notebook Files folder on I: drive
  - \_\_\_\_\_ Create & Examine Fledermaus session from compiled surface, save to Survey Files/Fledermaus
- \_\_\_\_\_ Descriptive Report Components
  - \_\_\_\_\_ Approval Memo, Cover & Title sheets copied from templates, completed and saved in DR folder
  - \_\_\_\_\_ Appendices completed as necessary
  - \_\_\_\_\_ Separates completed as necessary
  - \_\_\_\_\_ Three-hole punch hard copies of DP forms & boat sheets and put them in a folder with a label
- \_\_\_\_\_ File Management
  - \_\_\_\_\_ File management SOP consulted
    - \_\_\_\_\_ Fieldsheet folder contains only deliverable fieldsheets, all others removed
  - \_\_\_\_\_ All files accounted for and in correct location
  - \_\_\_\_\_ Content of all submission folders (CARIS, DR, Field Products, & PSS folders) checked
    - \_\_\_\_\_ Complete, suitable, and non deliverable items removed
- \_\_\_\_\_ Notification e-mail to CST & FOO that survey is ready for review
- \_\_\_\_\_ All data and DR submitted for Review and Approval

**POST-APPROVAL** **Completed:**

\_\_\_\_\_ INITIAL \_\_\_\_\_ DATE

- \_\_\_\_\_ Digitally sign approval memo and put in Descriptive\_Report\Report\_Body\Approval\_Sheet folder

# Hydrographic Survey Review Checklists

Survey: \_\_\_\_\_

Project: \_\_\_\_\_

**QC REVIEW** QC Reviewer: \_\_\_\_\_ **Completed:** \_\_\_\_\_  
INITIAL DATE

**Bold** underlines require date and initials when item is completed.

## 1. Survey Data and Documentation Familiarization

### ***QC Check reviewed***

\_\_\_\_\_ Quality Control Checklist done by sheet manager is complete and reviewed

### ***Descriptive Report reviewed***

\_\_\_\_\_ Check that the cover sheet, title sheet and the DR information correspond with Letter Instructions (eg. Locality, Registry #, etc.)

\_\_\_\_\_ Base Surface and Field sheet Table

\_\_\_\_\_ Date for Letter Instructions in DR is correct

\_\_\_\_\_ Review survey feature report

\_\_\_\_\_ Statistics

\_\_\_\_\_ Review Appendices

\_\_\_\_\_ Review Separates

### ***Logs reviewed***

\_\_\_\_\_ Digital Acquisition & Processing Logs

\_\_\_\_\_ Pydro Feature Log

\_\_\_\_\_ Data Log

\_\_\_\_\_ Feature Query reviewed, appropriate features were exported to Notebook

\_\_\_\_\_ Check Statistics & Dates of Survey

\_\_\_\_\_ DR, Cover Sht, Title Sht & Sm Tide Req should match raw (PREPROCESS) data, including Trimble

\_\_\_\_\_ Survey Log

## 2. Data Quality

### ***MBES - CARIS HIPS & SIPS***

\_\_\_\_\_ HDCS data, fieldsheets, and base surfaces open in CARIS and are not outdated

\_\_\_\_\_ BASE Surfaces contain least Depth, Uncertainty, and Standard Deviation attributes

\_\_\_\_\_ Proper corrector files applied to data

\_\_\_\_\_ Tide

\_\_\_\_\_ SVP

\_\_\_\_\_ Sound Velocity

\_\_\_\_\_ Evaluate profiles

\_\_\_\_\_ View positions

\_\_\_\_\_ Tide files: If smooth tides have been applied:

\_\_\_\_\_ Evaluate tide file in CARIS tide editor (no gaps or spikes in data)

### ***Features***

#### *PYDRO*

\_\_\_\_\_ Verify PYDRO information matches DP form

\_\_\_\_\_ Remarks/Recommendations are appropriate and not confusing

\_\_\_\_\_ Verify S-57 attribution

\_\_\_\_\_ Verify PYDRO flags

\_\_\_\_\_ All features are resolved

\_\_\_\_\_ Verify all AWOIS items have been addressed

#### *CARIS Notebook*

\_\_\_\_\_ Verify all features have been addressed

\_\_\_\_\_ Verify S-57 attribution

\_\_\_\_\_ Review features with BASE Surface

#### *CARIS HIPS*

\_\_\_\_\_ Verify DPNE lines have the correct Tide file applied and are Merged

\_\_\_\_\_ Verify DPES lines have SV applied, the correct Tide file applied and are Merged

### ***DTONs***

\_\_\_\_\_ Verify DTONs

\_\_\_\_\_ DTON Report in DR matches DTONs in PYDRO

**3. Data Accuracy**

**Systematic Errors**

- \_\_\_\_\_ BASE Surfaces reviewed for sound velocity, tide, roll bias or timing bias, etc.
- \_\_\_\_\_ Have errors been documented in the DR

**Coverage and Object Detection**

- \_\_\_\_\_ Coverage and accuracy requirements were met

**BASE Surfaces**

- \_\_\_\_\_ Verify CARIS BASE Surfaces are threshold by depth and are of appropriate resolution
- \_\_\_\_\_ Verify the Finalized/Combined CARIS BASE Surface
- \_\_\_\_\_ Verify all significant shoals, DTONs and designated soundings have been examined

**Designated Soundings**

- \_\_\_\_\_ Review all to ensure appropriate sounding selected (eg. not outerbeam or noise)

**Subset Review**

- \_\_\_\_\_ Review 10% of survey in subset mode (include looking at rejected data)

**Quality Control**

- \_\_\_\_\_ Required percentage of crosslines have been conducted
- \_\_\_\_\_ Crosslines represent a sample of the entire survey area
- \_\_\_\_\_ Examine 10% of crossline junctions
- \_\_\_\_\_ Areas that exceed allowable errors discussed in DR
- \_\_\_\_\_ Contours & Depths checked
- \_\_\_\_\_ Chart comparisons reviewed
- \_\_\_\_\_ Ensure chart edition and date corrected through included in DR

<b>FINAL REVIEW</b>	Final reviewer: _____	<b>Completed:</b>	_____ INITIAL      DATE
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- \_\_\_\_\_ Final Review completed
- \_\_\_\_\_ Data and DR are approved
- \_\_\_\_\_ Descriptive Report & Appendices reviewed
- \_\_\_\_\_ Survey Feature Report reviewed
- \_\_\_\_\_ Pydro/Notebook Sessions reviewed
- \_\_\_\_\_ Data reviewed in Fledermaus

<b>CO REVIEW</b>	<b>Completed:</b>	_____ INITIAL      DATE
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- \_\_\_\_\_ Data review
- \_\_\_\_\_ DR review
- \_\_\_\_\_ Signed Approval Memo



FIXED AIDS FOR USCG I-ATONIS

US Coast Guard District		State	Locality		Reporting Unit		
OPR Project No.	Survey Number	Datum		Make & Model of Positioning Equipment		From Date	To Date
LIGHT LIST NUMBER	AID NAME	LATITUDE dd-mm-ss.sssN	LONGITUDE ddd-mm-ss.sssW	HORIZONTAL ACCURACY @ 95% CONFIDENCE LEVEL	HORIZONTAL POSITION METHOD* (see footer)	LARGEST SCALE CHART AFFECTED	I-ATONIS Date
12345	Example Purpose Only GPS	48-50-30.332	065-55-45.789	0.8 meter	Post Process GPS	17345	
New	Example Purpose Only Photo	48-50-30.333	065-55-45.790	2.5 meter	Photogrammetry	17345	

**Additional Comments:** (This space is for additional narrative on problematic ATONs. Examples are: ATON is not serving its intended purpose, difficulties encountered while positioning, or horizontal accuracy issues. For ATONs positioned using Detached Positioning state whether or not the new position is better than what is currently charted. Include light list number. **This form DOES NOT replace requirements for DTON reports.**)

\* Horizontal Position Method: e.g. DGPS only, Post Processed GPS, Detached Position, photogrammetric