HYDROGRAPHIC SURVEYS SPECIFICATIONS AND DELIVERABLES

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U.S. Department of Commerce

National Oceanic and Atmospheric Administration

National Ocean Service

Contents

1 Introduction

Contents

These technical specifications detail the requirements for hydrographic surveys to be undertaken either by National Oceanic and Atmospheric Administration (NOAA) field units or by organizations under contract to the Director, Office of Coast Survey (OCS), National Ocean Service (NOS), NOAA, U.S. Department of Commerce.

The specifications described herein are based in part on the International Hydrographic Organization's Standards for Hydrographic Surveys, Special Publication 44, Fifth Edition, February 2008, specifically for Order 1a surveys. Hydrographic surveys classified as Order 1a are intended for harbors, harbor approach channels, recommended tracks, inland navigation channels, coastal areas of high commercial traffic density, and are usually in shallower areas less than 100 meters water depth. Additional details for the specific project areas, including any modifications to the specifications in this manual, will be provided in Hydrographic Survey Project Instructions for NOAA field units and contractors or in the Statement of Work (contractors only). Field units should contact the Contracting Officer's Representative (COR), Hydrographic Surveys Division (HSD) Project Manager, or Navigation Services Division (NSD) Project Manager to ensure they are using the correct and approved version of any software mentioned in these Specifications.

1.1 Change Management

A new edition of the Hydrographic Surveys Specifications and Deliverables (HSSD) will be published in quarter two of each fiscal year by HSD Operations Branch. If a hydrographer has any questions on the interpretation of these Specifications or feels that there may be a "better way" to provide a deliverable, they should contact the HSD/NSD Project Manager or COR to discuss and clarify the issue. The Specifications will continue to evolve and can only improve with the input of all users.

Throughout the fiscal year, change requests by NOAA in-house personnel shall be made via HSSD ticket system on Hydroforum located at https://sites.google.com/a/noaa.gov/ocs-hydrography/hydro-help-desk. Change requests by contractors shall be made by contacting the COR who will update the HSSD ticket system. Hydroforum allows for a centralized location to collaborate on and manage HSSD change requests. All proposed changes will be vetted and compiled by HSD Operations Branch and presented to the Chief of HSD for final approval. Approved changes will be enacted and the new version of HSSD will be made available online at http://www.nauticalcharts.noaa.gov/hsd/specs/specs.htm and on the NOAA-internal Navigator site.

Any time in the fiscal year there is a crucial need for a HSSD revision before the new edition of HSSD is published, a Hydrographic Technical Directive (HTD) may be issued to modify the current fiscal year HSSD. The Chief of HSD will determine the necessity of an HTD and if deemed crucial, will send an HTD memorandum to all field units indicating the HSSD change, purpose, policy, effective date, and responsibilities.

1.2 Changes from March 2016

Several clerical changes have been made in the 2017 Edition of this document. Significant technical and organizational changes are summarized below:

Chapter 1 Introduction

- Section 1.2 Changes from May 2016, new location for this section
- Section 1.3 Definitions, new location for this section, clarified definition of NALL
- Section 1.4 Pre-Survey Assessment, new location for this section
- Section 1.5 Environmental Compliance, new location for this section, general BMPs transferred to Project Instructions, and reference to new sea turtle observation log
- Section 1.6 Dangers to Navigation, new location for this section, updated DTON definition, and added elevated pipeline subsection
- Section 1.7 Non DTON Seep and Pipeline Report, new section outlining how to report on seeps and exposed pipelines that are not dangers to navigation

Chapter 2 Datums

- Section 2.1 Time, new location for this section
- Section 2.2 Horizontal Datum, the horizontal datum is NAD83
- Section 2.3 Vertical Datum, new location for this section
- Section 2.3.2 Survey Platform Positioning (Control), new section

Chapter 3 Hydrographic Position Control

- Chapter 3, Hydrographic Position Control incorporates former Chapter 9, Ellipsoid-Referenced Surveys
- Section 3.1 GNSS Terminology, new section defining term usage for DGPS and ERS
- Section 3.2 Horizontal Control, updated section to clarify source of horizontal uncertainty and added information on precision
- Section 3.3 Vertical Control, updated section to reference TVU and added information on precision
- Section 3.4 Differential GNSS Reference Stations (DGPS & ERS), expanded prior section to include

additional correction systems and guidance

- Section 3.5 Ellipsoid Referenced Survey Control, new section describing requirements of survey project ERS eligibility

- Section 3.6 ERS Datum Transformation Requirements, new section describing requirements for use of VDatum, ERZT, and separation models for datum transformation

Chapter 4 Tides and Water Levels Requirements

- Section 4.1.6 Error Budget Considerations, added Leveling Error, Data Processing Error, and Fixed and Bottom Mounted Pressure Gauges Error components to total tide error, also added and updated error tables

- Section 4.2.2 Water level Measurement Systems and Data Transmissions, updated section, added new image for bubbler orifice and parallel plate assembly

- Section 4.2.2.2 GPS Tide Buoys, updated section for GPS tide buoy acceptance

- Section 4.2.4 Tide Staff, new location for specifications for BMPG tide staff readings, new location for relations of station datum, orifice, and staff and pressure tide gauge record

- Section 4.2.5.1 Number and Type of Bench Marks, addition of requirement to submit obstruction diagram

- Section 4.2.6 Leveling, added orifice mounting specification for pressure sensors

- Section 4.3.2 Data Processing and Tabulation of the Tides, updated section

- Section 4.3.3 Data Editing and Gap Filling Specifications, new location for section

- Section 4.3.4 Computation of Monthly Means, new location for section

- Section 4.4 Computation of Tidal Datums and Water Level Datums, major changes to section

- Section 4.4.1 Datum Computational Procedures, new location for section, removed reference to 19 year tidal datums for subordinate stations

- Section 4.4.2 Tidal Datum Recovery, new location for this section, removed tables of tide by tide comparison and monthly mean comparison, removed bench mark sheets

- Section 4.4.3 Quality Control, new location for this section

- Section 4.5 Final Zoning and Tide Reducers, new location for this section

- Section 4.5.1 Water Level Station Summaries, new location for this section

- Section 4.5.2 Construction of Final Tidal Zoning Schemes, new location for this section

- Section 4.5.3 Tide Reducer Files and Final Tide note, new location for this section, removed reference to area anomalous to average trends and associated images

- Section 4.5.4 Tidal Constituents and Residual interpolation (TCARI), new location for this section
- Section 4.6 Data Submission Requirements, new location for this section
- Section 4.6.1 Station Documentation, removed project documentation and data checkoff list, removed final tide note and final tidal zoning chart
- Section 4.6.2 Water Level Data, added separate Pressure Sensor or Generic Data and Microwave Water Level Sensor Data formats
- Section 4.6.6 CO-OPS Final Deliverables and Timelines, new section
- Section 4.7 Guidelines and References, new location for section, addition of CO-OPS Specifications and Deliverables

Chapter 5 Depth Soundings

- Section 5.2.1.2.3 Designated Soundings, added clarification for use of designated soundings including an emphasis on hydrographer's discretion, modified 1/2 TVU to 1 TVU, and included deeper soundings incorporated into the grid for flier definition
- Section 5.2.2.2 Object Detection Coverage Option B, changed density requirement
- Section 5.2.2.3 Complete Coverage Option B, changed density requirement
- Section 5.2.2.4 Set Line Spacing Option A, changed density requirement
- Section 5.2.2.5 Trackline Specifications, added reference to Appendix K: DR Memo and DR Summary Template
- Section 5.2.3.1 Instrument Error Corrections, changed echosounder comparisons from weekly to per project
- Section 5.2.3.3 Speed of Sound Corrections, updated section, removed the 95 percent of depth requirement for sound speed profiles, removed independent confidence check requirement
- Section 5.2.3.5 Error Budget Analysis for Depths, added Vertical Datum Error
- Section 5.2.3.6 Uncertainty Budget Analysis for Depths, updated introduction paragraph of section
- Section 5.2.4.3 Crosslines, updated crossline guidance and added an example image

Chapter 6 Acoustic Backscatter

- Section 6.1.3.1 Confidence Checks, added requirement for time of confidence check recorded in acquisition/processing log
- Section 6.2.2.2 Acquisition Parameters, added guidance for backscatter coverage

Chapter 7 Features

- Section 7.2.2 Junctions, new section defining junctions and junction overlap requirements
- Section 7.3 Final Feature File, clarifies that DTONs shall be submitted in FFF with position and elevation reflecting the application of final correctors
- Section 7.3.1, Assigned Features, added reference to investigation requirement attribute, added guidance for assigned submerged rocks, and added guidance for features assigned as Unassigned and For Info Only.
- Section 7.3.2 New Features, added that departures to this section shall be addressed in the DR.
- Section 7.3.4 Feature Disprovals, added reference to investigation requirement attribution and that field unit may consult with Project Manager/COR if a feature disproval requirement is unclear
- Section 7.3.5 Aids to Navigation, updated section to include that all ATONs are now assigned with guidance in the investigation requirement attribute as to action required and inclusion in FFF
- Section 7.4 Designated Soundings, updated the purpose for designating soundings
- Section 7.5.1 S-57 Attribution, clarification of required S-57 attribution in tables: edits to SORIND, SORDAT, OBSTRN, PILPNT, COALNE, SLCONS, LNDARE, and LNDELV
- Section 7.5.2 NOAA Extended Attributes, updated 'descrp' attribute requirement, removed images requirement for OBSTRN foul area

Chapter 8 Deliverables

- Section 8.1.1.1 Weekly Progress Reports, added naming convention to weekly progress reports and updated horizontal datum to NAD83
- Section 8.1.1.2 Monthly Progress Reports, updated section to reflect provided monthly report template
- Section 8.1.4 Descriptive Report, added XML DR schema link, added note not to discuss potentially cultural or historically significant features in DR, updated junction discussion requirement, removed requirement for chart comparison with RNCs, updated ATON discussion requirement, provided reference to investigation requirement in section D.2, added Separation Model folder to the, renamed, Water Levels Appendix I
- Section 8.2.3 Data Acquisition and Processing Logs, updated section: removed System Status Annotations, First Position/Last Position Annotations, Special Annotations, and Annotation Methods
- Section 8.3.1 Media, clarified that field units are responsible for off-site backups of raw data until official acceptance, updated data delivery location to Hydrographic Branch listed in the Project Instructions
- Section 8.3.2 Bathymetric Data, removed reference to CARIS HIPS and SIPS versions prior to version 9, clarified deliverable for non-CARIS users, and updated references to data directory structure (Appendix J)
- Section 8.3.4 Backscatter Deliverables, updated data directory folder

- Section 8.3.5 ERS Data Deliverables, updated ERS deliverable requirements including delivery of the separation model

- Section 8.3.6 Other Data, added option for all zero vessel file, added reference to new VesselConfig folder

Chapter 9

- Removed this Chapter and incorporated the information into Chapter 3

Appendices

- Appendix G: NOAA Extended Attributes Schema, new location for appendix

- Appendix I: Removed letter transmitting for NOAA raw data submission

- Appendix J: Data Directory Structure, renamed Tides and Water Levels folder to “Water Levels," renamed Bathymetry_&_SSS to "Sonar_Data," updated Preprocess and Processed folders, removed NOAA off site backup directory structure

- Appendix K: DR Memo and DR Summary Templates, new appendix with templates

- Appendix L: Marine Mammal and Turtle Observation Logs, renamed section, and added sea turtle observation log

1.3 Definitions

1.3.1 Hydrographer

The term “hydrographer” as used through this document, refers to: (a) the chief of party or officer in charge, when the survey is being conducted by NOAA field units, or (b) the contractor where the work is being performed for NOAA under contract.

1.3.2 Navigable Area Survey

All modern NOAA hydrographic surveys are Navigable Area Surveys, unless explicitly stated otherwise in the Hydrographic Survey Project Instructions. Navigable Area Surveys are basic hydrographic surveys with a restricted inshore limit of coverage.

The shoreline depicted on NOAA’s nautical charts approximates the line where the average high tide, known as Mean High Water (MHW), intersects the coast and includes the attached cultural features that are exposed at MHW. In addition, nearshore natural and man-made features such as rocks, reefs, ledges, foul areas, aids to navigation, and mooring facilities are typically included in the colloquial definition of “shoreline.” NGS Remote Sensing Division (RSD) is responsible for acquisition and compilation of shoreline data, which it provides directly to MCD for nautical chart updates. However, NOAA’s hydrographic field parties may be tasked with verifying that shoreline details are adequately and accurately depicted in source data sets and the corresponding nautical charts.

The inshore limit of hydrography and feature verification for Navigable Area Surveys is the Navigable Area Limit Line (NALL), unless stated otherwise in the Hydrographic Survey Project Instructions. By default, the NALL is defined as the most seaward of the following:

1. The surveyed 4-meter depth contour. Note that in the cases where the 4-meter depth contour surrounds a feature (unless explicitly assigned as For Info Only, Section 7.3) disconnected from the contiguous mainland coastline (e.g. offshore islet or rock), the feature shall be investigated utilizing appropriate hydrographic techniques and included in the Final Feature File (Section 7.3).

2. The line defined by the distance seaward from the observed MHW line[1] which is equivalent to 0.8 millimeters at the scale of the largest scale nautical chart covering any portion of the survey area (e.g., for a 1:80,000 scale chart, this line would fall 64 meters seaward of the MHW line)[2]

3. The inshore limit of safe navigation for the survey vessel, as determined by the Chief-of-Party in consultation with his or her field personnel. If kelp, rocks, breakers, or other hazards make it unsafe to approach the coast to the limits specified in 1 and 2 above, the NALL shall be defined as the shoreward boundary of the area in which it is safe to survey.

In rare instances, the Chief-of-Party may determine that the NALL lies inshore of the limits defined in 1 and 2. For example, this could be the case in confined waters such as harbors or passes which are inshore of the NALL as defined above, but are regularly utilized by vessels depending on NOAA chart products for safe passage. It could also occur in deep water ports where modern bathymetry is required along wharf faces. In these cases, the Chief-of-Party shall consult with the Chief, HSD Operations Branch or COR, prior to dedicating significant survey resources to these areas.

Also, on some occasions the hydrographer may be tasked with investigation of specific items (e.g., Chart Evaluation File items or USCG Aids to Navigation) which fall inshore of the NALL as defined by criteria 1 and 2 above. The hydrographer may also encounter unassigned natural or anthropogenic features inshore of the NALL which are such exceptionally prominent aids to visual navigation that accurate positions for depiction on nautical charts are required. In these cases, the hydrographer shall proceed inshore of the NALL to accomplish investigation of these features, so long as this can be accomplished safely and in accordance criterion 3 above. Note that the hydrographer is not required to extend bathymetric coverage inshore of the NALL when investigating features with vertical extents above MLLW.

The hydrographer shall discuss in the Descriptive Report all areas where NALL definition deviated from the default criteria. Note that offshore surveys which do not approach the coast will end at their assigned survey limits.

Working near shore is inherently dangerous, and all field units are reminded that safety shall always be the primary consideration when conducting operations. Verification of near shore features 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 should defer near shore operations until conditions are favorable.

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[1] For the purposes of this section "observed MHW line" means the approximate mean high water line estimated visually by the hydrographer from the survey launch.

[2] For surveys which cross a chart scale boundary (e.g., a portion of the survey area is covered at large scale, while the remainder is covered at a smaller scale), the MHW offset for the entire survey shall be based on the largest scale chart covering any portion of the survey area. (Contact the HSD/NSD Project Manager or COR for clarification if required.) Note that the chart scale referenced by this requirement is determined individually for each survey, not for an entire project, i.e., different surveys in the same project may have different maximum chart coverage scale, and thus different MHW offsets for the purpose of NALL determination.

1.4 Pre-Survey Assessment

The Chief of Party / Lead Hydrographer shall complete an informal pre-survey assessment before survey acquisition commences. This assessment shall review and validate the survey requirements in the Project Instructions / Statement of Work (e.g., acquisition method, grid resolution, survey limits, feature verification, etc.) based on conditions observed on the survey grounds and any contact with local stakeholders. Any concerns with the adequacy or appropriateness of the survey requirements as specified in the Project Instructions/Statement of Work shall be brought to the attention of the HSD/NSD Project Manager or COR for clarification or adjustment as soon as possible after the completion of this assessment.

1.5 Environmental Compliance

The Endangered Species Act (ESA) requires Federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat. Consultation with National Marine Fisheries Service (NMFS) and/or the Fish and Wildlife Service is required when a Federal action may affect listed species or critical habitat.

The Office of Coast Survey (OCS) consulted with the NMFS to assess how OCS hydrographic surveying operations and related activities may impact these ESA-listed species and critical habitats. NMFS concluded that OCS hydrographic surveying operations and related activities "*may affect, but [are] not likely to adversely affect*" these resources, if certain Best Management Practices (BMPs) are followed. These BMPs are also broadly protective of marine mammals generally (all marine mammals are protected under the Marine Mammal Protection Act).

The BMPs to be followed during an OCS project (and transits to the project areas) will be communicated to the field units through the Survey Project Instructions.

Environmental Compliance Requirements and Deliverables

All NOAA Field Units shall provide a list of all trained marine mammal observers (e.g. all officers, deck, and survey personnel) who are required to view the Marine Species Awareness Training video provided by HSD/NSD Project Manager or COR as a DVD or viewed at https://www.youtube.com/watch?v=KKo3r1yVBBA (produced by the U.S. Navy). The viewing of this video is considered sufficient to declare a crew member a "trained observer." The observation of marine mammals should be conducted in conjunction with both ship and small boat operations and the Marine Species Awareness Training must be completed prior to the start of the field season. A list of trained marine mammal observers and the date each observer viewed the training video (including new personnel who arrive mid-project) shall be included in the DR Appendix II folder and provided to the OCS Environmental Compliance Coordinator, (ocs.ecc@noaa.gov) with a CC to the HSD/NSD Project Manager or COR, as appropriate.

Marine mammal observations shall be recorded in the provided PDF form (included in the Project Instructions and shown in Appendix K, for reference). Digital photographs of observations shall be taken, if possible. The marine mammal observation log and associated photographs shall be submitted to pop.information@noaa.gov and ocs.ecc@noaa.gov (with a CC to the HSD/NSD Project Manager or COR) at the end of each project.

Sea turtle sightings shall be recorded in the provided PDF form (included in the survey project instructions and shown in Appendix L, for reference) for each project and shall be sent (with a CC to ocs.ecc@noaa.gov and the HSD/NSD Project Manager or COR) to:

- Larisa Avens on the East Coast (larisa.avens@noaa.gov)
- Jeff Seminoff on the West Coast (jeffrey.seminoff@noaa.gov)

- George Balazs in Hawaii and Pacific Islands (george.balazs@noaa.gov)

In the event of unauthorized incidental "take," the field unit shall contact the HSD/NSD Project Manager or COR, immediately. For the purposes of these specifications, "take" is defined as "*to harass, hunt, capture, kill, harm, pursue, shoot, wound, trap, or collect, or attempt to engage in any such conduct, any ESA-listed species or marine mammal.*"

1.6 Dangers to Navigation

As soon as practicable after discovery, the hydrographer shall submit a Danger to Navigation (DTON). Timeliness is a critical issue in reporting DTONs. The hydrographer should ensure that the discovery of a potential DTON is reported immediately to the appropriate authority. Further, should additional dangers be discovered during the processing of the survey, they shall be immediately reported.

1.6.1 Definition

A danger to navigation is considered to be any natural feature (e.g., shoal, boulder, reef, rock outcropping) as well as any cultural feature (e.g., wreck, obstruction, pile) which, during the course of survey operations was found by the hydrographer to pose an imminent danger to the mariner or to be inadequately charted as described below. Potential dangers shall be evaluated in the context of the largest scale nautical chart of the area and with detailed knowledge of vessel traffic in the area including usual and seasonal routes. All features with depths of 11 fathoms (66 feet) or less in navigable waters may be considered potential dangers to navigation and subject to reporting.

Dangers to Navigation may include:

- Natural or cultural features, either submerged or visible, that pose an imminent danger to surface navigation based on hydrographer's knowledge of the survey area, vessel traffic, and existing cartographic product
- Uncharted or inadequately charted clearances for bridges and overhead cables or pipelines
- Uncharted aid to navigation, unless temporary in nature or repositioned frequently (Section 7.3.5)
- An aid to navigation located off station, is damaged to the extent that it does not serve its intended purpose or its characteristics are incorrectly charted (Section 7.3.5)
- Elevated pipelines (Section 1.6.2)

Once all dangers to navigation are identified by using the criteria above, they must be reviewed in context with the largest scale chart covering the survey area. DTONs should not cause undue clutter in relation to other soundings or features on the chart. When multiple distinct features are located within 4 mm of each other, as depicted on the largest scale chart of the area, then the most significant DTON located within the 4 mm radius shall be submitted as a single danger to navigation.

Dangers that are too complex to be adequately identified as discrete features shall be depicted as area features. For example, widespread shoaling would be represented as a selection of the shoalest depths with a selection interval of 4 mm at the largest chart scale.

If there are no charted depths in the survey area, consult with the HSD/NSD Project Manager or COR, to develop DTON selection criteria appropriate to the navigational use of the area.

1.6.2 Elevated Pipelines

Exposed pipelines that are less than 1 m from bottom sediment shall be reported following the Non DTON Seep

and Pipeline workflow detailed in Section 1.7. Pipelines that are elevated at least 1 m off the bottom between depths of 0 and 20 m and 10% off the bottom in depths deeper than 20 m may pose a hazard to surface navigation and may be considered a DTON.

In water depths between 4 and 40 m, pipelines elevated a significant height from the seafloor shall be reported via email to the HSD/NSD Project Manager or COR and Navigation Manager with the appropriate information regarding the elevated pipeline. The Navigation Manager will contact the relevant regulatory authority for that region (e.g., USACE or MMS) and inform them of the hazardous situation regarding the noted pipeline and follow up with the Hydrographic Branch with the status of the reburial effort. If reburial does not occur or is not expected, the Hydrographic Branch will submit the elevated pipeline as a DTON with all relevant information and MCD will chart the DTON as an obstruction, linear obstruction with caution area, or other symbol as appropriate to the size of the elevated pipeline section and scale of the chart. The Navigation Manager shall continue to contact USACE, MMS, or the pipeline owner periodically until it has been established that the pipeline has been reburied or that reburial will not take place. The field unit shall document this correspondence in Section 8.1.4 D of the DR for the affected survey. Copies of all correspondences shall be included in DR Appendix II.

1.6.3 USACE Channel DTONs

If surveying within a USACE maintained channel, the hydrographer shall conduct a comparison of survey depths with the DRVAL1 attribute found in the ENC's DRGARE feature object in all maintained channels. When survey soundings or obstructions located in the channel are found to be shoaler than the controlling depth of that channel then the hydrographer shall immediately report these results to the HSD/NSD Project Manager or COR. The HSD/NSD Project Manager or COR will inform the Navigation Manager, who will to address the issue with the USACE, USCG, and communicate the findings to the local Pilots. The field unit shall document this correspondence in Section 8.1.4 D of the DR for the affected survey. Copies of all correspondences shall be included in DR Appendix II.

1.6.4 DTON Submission

NOAA field units shall submit all DTONs via e-mail directly to Marine Chart Division's (MCD) Nautical Data Branch at e-mail address ocs.ndb@noaa.gov, with courtesy copies to HSD/NSD Project Manager or COR, Operations Branch Chief and to the Chief of the appropriate Hydrographic Branch.

NOAA field unit DTON recommendations shall be submitted as follows using Pydro software:

1. A PDF letter in the format shown in Appendix D.
2. An XML file of the Pydro DTON report.
3. Screen Captures of Side Scan Sonar images, Multibeam images or chartlets (if applicable) of the DTON.

These files shall be submitted as a .zip file.

Contractors shall submit all DTONs via e-mail to the HSD/NSD Project Manager or COR and the appropriate Hydrographic Branch stated in the Hydrographic Survey Project Instructions (ahb.dton@noaa.gov or phb.dton@noaa.gov).

Contractor DTON recommendations shall be submitted as follows:

An S-57 .000 feature file attributed in accordance with Section 7.5 Feature Attribution. Filenames shall contain only letters, numbers, and underscores; no spaces nor special characters other than an underscore. In addition, the following NOAA attributes shall be populated as follows:

a. Special Feature Type (sftype)=DTON
b. Images (images) shall include associated images such as chartlets, Multibeam and side scan imagery of the danger (see Appendix D)
c. Observed Time (obstim) – observed time in the format YYYYMMDDThhmmss.

The Hydrographic Branches will review the DTON .000 feature file, import the .000 file into Pydro, and create the .xml file. A letter and .xml file will then be forwarded to the Nautical Data Branch at ocs.ndb@noaa.gov.

MCD will process the Danger to Navigation Reports and send the information to the USCG for inclusion in the Local Notice to Mariners. Within three days of DTON report submission, MCD's Nautical Data Branch (NDB) will send an email (i.e. DREG registration email) to the field unit (NOAA in-house surveys) or the originating Hydrographic Branch and associated Contractor and HSD/NSD Project Manager or COR confirming that DTON data has been received and released from NDB to the Production Team. 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 released from NDB to the Production Team. MCD will notify the submitting party of any changes made to the Dangers to Navigation Report by return e-mail.

The Hydrographic Branches will submit any DTON detected during office processing to MCD as stated above. If the Hydrographic Branch is submitting a DTON that changes an earlier DTON submitted by a field unit, please explain the change in the cover letter.

A copy of the DTON recommendation files (i.e. DTON Reports) and the DTON verification e-mail from NDB (e.g. the DREG registration e-mail, which the contractors receive as courtesy copies from the Hydrographic Branch) shall be included in the Appendix II Supplemental Survey Records and Correspondence folder of the DR. See Appendix J Descriptive Report Appendices below. DTON features shall remain in the .000 Final Feature File (Section 7.3).

1.6.5 Charted Feature Remove Request (Anti-DTON)

Charted features, particularly "Position Approximate" wrecks and obstructions that are located in major shipping corridors, should be expeditiously removed from the chart if adequately disproved (Section 7.3.4). The Charted Feature Removal Request is similar to a Danger to Navigation Report, except it is used to remove a charted feature that represents a hazard, which does not exist, rather than add a newly found hazard. This process should be used sparingly, usually by responding to a request from local pilots or other authorities that a charted feature is a hindrance to operations. If removal of a feature is not time critical, do not use the Charted Feature Removal Request (Anti-DTON).

If local authorities request the hydrographer to investigate a feature that has not been assigned, contact HSD/NSD Project Manager or COR for a determination of the search criteria. Once the hydrographer meets the search criteria and determines the feature does not exist, they should prepare the Charted Feature Removal Request and follow the same submission procedure and format requirements as Dangers to Navigation. See Appendix D for an example of a Danger to Navigation Report. Contractors shall submit Charted Feature Removal Request through the same process as a DTON request (i.e. via appropriate Hydrographic Branch for verification).

1.7 Non-DTON Seep and Pipeline Report

Seeps and exposed pipelines that do not pose a danger to navigation (Section 1.6) shall be reported via e-mail to the HSD/NSD Project Manager or COR and the e-mail shall be included in DR Appendix II. The body of the e-mail

should include the location of the seep/exposed pipeline (latitude/longitude), distance from charted feature, date and time of observation, depth (if appropriate) and an image. The HSD/NSD Project Manager or COR will submit the seep/pipeline information to the Navigation Manager who will then contact Bureau of Ocean Energy Management (BOEM)/Bureau of Safety and Environmental Enforcement (BSEE)/US Coast Guard (USCG), as appropriate.

Sample e-mail text follows:

Subject: H12345: Possible Seep 1
Body: A NOAA Contractor surveying in the Gulf of Mexico has discovered a possible seep. The feature has a form and morphology typical of ascending gas or bubble plumes and was found at latitude XXX/longitude XXX on January 1, 2017 at 0902 UTC. This feature is X meters from the (un)charted BSEE wellhead.

2 Datums

Contents

2.1 Time

Coordinated Universal Time (UTC) will be used for all time records.

Note that "GPS time" (i.e., time used in the U.S. Global Positioning System - GPS and other Global Navigation Satellite System - GNSS) is not the same as UTC.

2.2 Horizontal Datum

All horizontal positions shall be referenced to the North American Datum of 1983 (NAD83) 2011 realization 2010 (NAD83(2011)2010.0), or later. When using the Universal Transverse Mercator (UTM) projection the hemisphere and zone definition most appropriate to the data coverage shall be used. A consistent horizontal datum must be used throughout a survey project for everything that has a geographic position or for which a position is to be determined. Data used for comparisons, such as charts, junctional surveys, and prior surveys, must be referenced or adjusted to NAD83 for parity.

The only exception for the NAD83 datum requirement is that the S-57 Final Feature File (Section 7.3) will be in the WGS84 datum to comply with international S-57 specifications.

2.3 Vertical Datum

2.3.1 Charted Soundings and Heights

With some limited exceptions, sounding data shall be referenced to Mean Lower Low Water (MLLW). Heights of bridges and overhead cables shall be referenced to Mean High Water (MHW).

Exceptions to the use of MLLW as a sounding datum will fall into one of three categories. In non-tidal coastal areas, sounding data will be reduced to Low Water Datum (LWD) which is Mean Sea Level (MSL) - 0.5 ft. On the Great Lakes, all sounding data is reduced to the current International Great Lakes Datum (IGLD). In areas charted to 'Special Datums' such as Columbia River Datum, Hudson River Datum, Mississippi River Datum, etc., the sounding data is reduced accordingly.

2.3.2 Survey Platform Positioning (Control)

On-datum positioning specifications are divided into two categories, differentiated by the hydrographic survey methodology to achieve vertical referencing: (1) horizontal control plus vertical measurements relative to the "static" sea surface and (2) ellipsoid referenced survey three-dimensional control. The hydrography of category (1) is corrected to chart datum through water level reducers as discussed in Chapter 4, Tides and Water Levels Requirements. The hydrography of category (2) is transformed to chart datum through an ellipsoid separation (SEP) model. See Chapter 3, Hydrographic Positioning, for specifications.

3 Hydrographic Positioning

Contents

3.1 GNSS Terminology

Terminology used in GNSS (Global Navigation Satellite System) based technologies is somewhat confusing and shall not be relied-upon alone to certify a given approach for use in hydrographic positioning. Differential GNSS is the general positioning technique wherein two or more receiver-antenna pairs are used to position an unknown point relative to a known point. Precise Point Positioning (PPP) GNSS is a "single receiver" technique that achieves better performance than standalone, non-differential GNSS; however, certain PPP techniques do employ relative positioning aspects to improve precision.

The term DGPS is used herein to refer to the specific class of techniques in differential GPS/GNSS that achieve meter-level positioning. The U.S. Coast Guard (USCG) Nationwide (coastal) DGPS and the Federal Aviation Administration Wide Area Augmentation (FAA WAAS) are examples of service providers of this technology, both of which are capable of meeting horizontal positioning standards for NOAA hydrographic surveys.

Ellipsoid referenced survey (ERS) 3-D control capable of meeting the more stringent vertical positioning requirements requires an improvement in GNSS positioning control over that afforded by meter-level DGPS. ERS work leverages the family of methods known as kinematic GPS/GNSS (KGPS) and those specialized PPP techniques that better resolve precision.

3.2 Horizontal Control

The NOS specification for hydrographic surveys requires the Total Horizontal Uncertainty (THU) in position of soundings shall not exceed 5 m + 5% of the depth, with a confidence level of 95%. The portion of the total uncertainty budget allotted to survey platform (vessel) position depends upon how accurately the sounding is positioned relative to the vessel.

THU for soundings obtained by single-beam echosounders may usually be assumed to equal the uncertainty in the horizontal positioning of the vessel transducer (i.e., vessel navigation uncertainty plus uncertainty in transducer offsets).

For swath-based (e.g., multibeam) surveys the position of a sounding is usually located some appreciable distance oblique to the vessel position. Total uncertainty must account for beam forming precision of the echo-sounding system, depth of water and water column variability (speed of sound), accuracy of motion compensation (heave,

roll, pitch, heading errors and timing latency), etc.

Recorded horizontal positions, including values reported in survey records and deliverables, shall retain a precision of at least decimeters; i.e., for positions records in:

- decimal degrees: 6 decimal places
- degrees and decimal minutes: 4 to 5 decimal places
- degrees, minutes and decimal seconds: 2 to 3 decimal places
- projected coordinates (meters): 1 decimal place

3.3 Vertical Control

NOS specification for total allowable vertical uncertainty (TVU) for reduced soundings is detailed in Section 5.1.3, Uncertainty Standards. No intrinsic maximum allowable uncertainty is prescribed for the component attributed to survey platform vertical positioning. The hydrographer shall regard all of the uncertainties which affect vertical positioning, to ensure that the net error does not exceed the allowable limit set for TVU. Because TVU is much more stringent than THU, even more emphasis must be placed on the accounting of the factors which form total uncertainty. See Section 5.2.3, Corrections to Echo Soundings and Uncertainty Assessment, for additional information.

Recorded vertical positions in the ERS, including values reported in survey records and deliverables, shall retain a precision of centimeters, commensurate with that required for depths as discussed in Section 5.1, General Standards for Depth.

3.4 Differential GNSS Reference Stations (DGPS & ERS)

The National Spatial Reference System (NSRS) is realized through the NOAA Continuously Operating Reference Station (NOAA CORS) network. The position of unknown non-CORS differential GNSS sites utilized for hydrographic control shall be established and verified through the National Geodetic Survey (NGS) Online Positioning User Service (OPUS) tie to the NSRS. Non-CORS in general include differential networks maintained by state and other municipalities, as well as commercial and private systems.

Non-CORS differential sites shall utilize existing NOAA, USACE, etc. permanent benchmarks as far as practicable, rather than opting for a temporary mark; ideally, historic tidal benchmarks shall be used, although that is expected to be the exception rather than the rule. The hydrographer shall conduct a certification on non-CORS to ensure that no multipath or other site specific problems exist. The reference position of non-CORS antenna installations shall be verified at least once per week while the site is utilized for survey operations. Verification may be achieved by repeated OPUS sessions to demonstrate that the difference between adopted and check positions are within the error budget allotted per THU (Section 3.2).

Many large-scale differential correction systems, such as the USCG DGPS, FAA WAAS, and certain state and commercial services, have integrated 24-hour monitoring and quality assurance, which fulfills both the certification and periodic check requirement above.

3.5 Ellipsoid Referenced Survey Control

In general, the ERS is possible through GNSS based sub-decimeter vertical control using some method of integer ambiguity resolution-enabled carrier-phase kinematic positioning. Differential and related carrier-phase methods based upon PPP kinematic GNSS methods are permitted, from a real-time kinematic (RTK) service or via a post-

processing. Post-processed vertical control has the advantage of enhanced quality control: quasi-independent forward- and reverse-time processing reduces the uncertainty in the vessel height solution otherwise present in RTK-based (forward-only) positioning.

GPS is preferred over other GNSS (e.g. GLONASS); however, if the availability of 5 or more GPS satellites is unacceptably low in a particular survey environment, a hybrid GPS-GNSS solution may be leveraged without explicit approval in the Project Instructions/SOW. Inertially-aided systems help to ensure success in the ERS regardless of the GNSS technique utilized; tightly-coupled inertial-aided GNSS is important to overcome positioning problems associated with intermittent loss of individual satellite signals.

3.5.1 ERS Planning and Operational Requirement

Survey planning and review by NOAA's Office of Coast Survey (OCS) Hydrographic Surveys Division Operations Branch shall include a component dedicated to the evaluation of specific regions for ERS.

The three principal factors that determine survey project ERS-eligibility pertain to the capabilities and infrastructure for:

1. Centimeter-level Global Navigational Satellite System (GNSS) kinematic positioning
2. Field unit capability
3. Ellipsoid-to-chart vertical datum (mean lower low water, MLLW) transformation

3.5.2 ERS GNSS Infrastructure

Satellite Orbits/Clocks

Satellite ephemeris products used in ERS shall be of adequate quality to obtain the desired level of accuracy from with respect to the GPS/GNSS vertical control component. For carrier-phase differential GNSS/GPS (baseline) processing, all International GNSS Service (IGS) products may be sufficient: Broadcast, Ultra-Rapid, Rapid and Final - use the best available orbits and clocks at the time of baseline processing. In the specialized PPP methods appropriate for ERS (Section 3.1), Ultra-Rapid (or better) orbit and clock products suffice. Multiple IGS Analysis Centers compute products. Orbit and clock files used in a positioning solution shall be consistent; do not mix products from different Analysis Centers.

Differential Baseline Limits

Centimeter level accuracy in carrier-phase differential GNSS positioning restricts the length between reference station and survey vessel. For planning purposes, a maximum-baseline length of 40 km is used for the pair-wise, vessel-to-single reference station configuration. A combination of National Continuously Operating Reference Station (CORS) sites, field-installed temporary shore stations, and other approved stations are used to satisfy the nominal maximum-baseline constraint.

A Virtual Reference Station (VRS) system may be used by employing a network of four or more user-installed or continuously operating reference stations surrounding the ERS project area. For planning purposes, a maximum inter-station baseline length of 70 km is used. A majority of the ERS area should be located within the convex hull formed about the network of stations; otherwise, a single-base differential configuration may prove to be more effective than a VRS system.

Data Rate

The nominal maximum required data rate for reference station data is equal to that of the vessel (rover) data: 1 Hz.

Reference station data rates as low as 30 seconds are permitted when carrier-phase interpolation methods are used in inertially-aided GNSS positioning.

3.6 ERS Datum Transformation Requirements

The standard method for the ellipsoid-to-chart datum transformation is to utilize the National VDatum transformation framework and software developed and published by NOAA. However, certain ERS projects may proceed in areas lacking VDatum coverage using one of the alternative ellipsoid-to-chart datum separation (SEP) models described below. The method of datum transformation to be used will be prescribed in the Hydrographic Survey Project Instructions.

A description of the ERS processing procedures and the comparisons conducted between ERS and traditional water levels shall be included in the appropriate Descriptive Report (DR), Horizontal and Vertical Control Report, and/or Data Acquisition and Processing Report. As appropriate in the DR, document specific vessel days or lines that have not been processed using ERS techniques as the vertical reducer to MLLW, where discrete zoning provides better results, and/or where the vertical uncertainties of the post processed vertical positional data are out of the range determined in Section 5.1.3.

3.6.1 VDatum

NOAA VDatum software is developed jointly by offices with the National Ocean Service (NOS). 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. At present time, uncertainties for VDatum are known only at the shore stations used for separation model creation and are still not fully assessed away from these shore stations for all VDatum models. Therefore, the sole use of VDatum without additional validation requirements and QC checks will be limited to instances in which there is confidence in the uncertainty of the separation model throughout the entire survey area.

VDatum QC Requirements

At the discretion of HSD/NSD, after reviewing the *a priori* uncertainty associated with the particular VDatum region, certain additional QC requirements for VDatum evaluation may be required. These steps will be determined by HSD/NSD and will be specified in the Hydrographic Survey Project Instructions. Final determination of the method to be used to reduce data to chart datum resides with HSD/NSD after evaluation of these QC checks and may be based on a recommendation from the Chief of Party.

1. Point-wise Ellipsoid-MLLW SEP QC

    a. True validation of the accuracy of a VDatum ellipsoidal SEP value (e.g., ellipsoid- MLLW) is achieved by obtaining a GPS height observation at a point wherein the tidal datum is known. Presumably data from all tidal bench marks with historical datums are already incorporated into VDatum and QC requirements represent points/areas "far" from those nodal locations

    b. Traditional water level observations tied to the ellipsoid, acquired for 30 days or more, provide an accurate point-check on the SEP. Such ellipsoid tidal datum observations may be conducted using an ellipsoidally-referenced water level gauge. Less accurate checks using water level observations of less than 30 days may be employed using the ERS vessel as a "tide buoy" or water level "altimeter", followed by traditional comparison to water levels from a primary NWLON station

2. ERS / Zoned Hydrography Comparisons

    a. A basic test methodology that includes the acquisition and processing of sounding data in the "traditional" manner (i.e. reduction to MLLW using water levels, discrete zoning, and/or TCARI), and then compared to ellipsoidally-referenced data. Such VDatum verification survey lines should be conducted according to the following basic guidelines:

        i. Line spacing is such that the high-frequency character of the overall SEP surface is sampled. These specific line spacing requirements are detailed in the PI and SOW and are dictated by the local geoid and topography of the sea surface (TSS)

        ii. Such spatial sampling is adequate to compute a ERZT separation surface (Section 3.6.2)

In order for HSD/NSD to approve the use of VDatum as the method to transform final survey data to vertical chart datum, QC checks should reveal that the uncertainty in this transformation is equal to, or better than, utilizing traditional observed water level methods. The typical contribution of the error for tides and water levels to the total survey error budget falls between 0.10 m and 0.45 m (Section 5.2.3.5), therefore these QC methods should show that using VDatum achieves results equal to or better than these values, while ensuring that data do not exceed total allowable vertical uncertainty limits (Section 5.1.3).

3.6.2 Ellipsoid Referenced Zoned Tides (ERZT)

An alternative ERS datum transformation option in areas lacking a published or verified VDatum model is to relate approved zoned water levels to the ellipsoid. ERZT SEP observations are formed by adding the ERS in-situ water line heights to the given zoned water level model heights. The final ERZT SEP model shall be formed by combining these observations from all project survey lines traversing the piece-wise continuous regions associated with the tidal zones. Gridded ERZT SEP nodes within each tide zone shall be equal to the mean of the contained observations; alternatively, a fixed 1 km x 1 km spatial binning of the ERZT SEP observations may be used in the model. The character of the final ERZT SEP model may be adjusted according to preliminary or previously-unverified VDatum model coverage, as long as hydrographic accuracy is maintained.

3.6.3 Constant Value Separation Model

At the discretion of HSD/NSD, a constant SEP value for "small" survey areas in close proximity to known ellipsoid-to-chart datum SEP points may be used. Certain additional QC requirements for constant value SEP model may be required. These steps will be determined by HSD/NSD and will be specified in the Hydrographic Survey Project Instructions.

4 Tides and Water Levels Requirements

Contents

4.1 General Project Requirements and Scope

4.1.1 Scope

The requirements and specifications contained in this section cover the water level based vertical datum requirements for operational support of hydrographic surveys and shoreline mapping surveys conducted as part of the NOAA Nautical Charting Program. The scope of this support is comprised of the following functional areas:

1. Tide and water level requirements planning
2. Preliminary tidal zoning development
3. Control water level station operation, monitoring, and maintenance
4. Subordinate water level station installation, operation, monitoring, maintenance, and removal
5. Data quality control, processing, and tabulation
6. Tidal datum computation and tidal datum recovery
7. Generation of water level reducers and final tidal zoning
8. Quality control check of contractor submitted data to CO-OPS

For NOAA in-house hydrographic surveys, personnel from the NOAA's National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) are responsible for functional areas 1, 2, 3, 5, 6 and 7. NOS hydrographers shall be responsible for functional area 4 above.

For NOAA contract hydrographic surveys, NOS CO-OPS personnel are responsible for functional areas 1, 2, 3 and 8. NOAA contract hydrographers shall be responsible for functional areas 4 through 7 above. NOS CO-OPS will be responsible for operating, maintaining, and processing data from the National Water Level Observation Network (NWLON) control stations.

4.1.2 Objectives

The work performed according to the requirements and specifications of this document is required for NOS major program areas of navigational products and services. The first objective is to provide time series water level data and associated water level reducers that can be applied to hydrographic soundings for correction to chart datum. The second objective is to establish and/or recover tidal datums relative to local bench marks at each station that can be used for continuing and future hydrographic surveys in the area. The third objective is to provide new information or updated information that can be used to update NOAA tide prediction products and tidal zoning to promote safe navigation applications.

4.1.3 Planning and Preliminary Tidal Zoning

CO-OPS is responsible for all assessments and planning of tide requirements for NOS hydrographic surveys. CO-OPS will analyze historical data and tidal characteristics for each project area, specify operational NOS control stations, specify subordinate tide station locations to be installed, and provide the preliminary tidal zoning to be used during survey operations. CO-OPS will provide 6-minute interval tide predictions relative to chart datum for appropriate NOS control stations prior to each survey and will also provide historical published bench

mark information available for all historical tide stations specified for reoccupation. If CO-OPS provides a new preliminary tidal zoning scheme, the contractor must use that zoning scheme first for each project, and then, may generate a new scheme if the one provided is not adequate. At the conclusion of the survey, the contractor shall suspend the use of the preliminary zoning scheme and develop a final zoning scheme using correctors derived from the subordinate stations installed during the survey. Refer to Section 4.5.2 for further details.

4.1.4 NOS Control Stations and Data Quality Monitoring

National Water Level Observation Network

CO-OPS manages the NWLON of approximately 210 continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with satellite transmitter, near real-time (within about 18 minutes of collection) preliminary data are made available to all users through the CO-OPS Web homepage at https://tidesandcurrents.noaa.gov/. Verified products, such as edited 6-minute data, hourly heights, high and low waters, and monthly means are made available over the Web within one to four weeks after data collection. NWLON data and accepted tidal datums are used in hydrographic surveys either to provide tide reducers directly or for control for datum determination at subordinate (short-term) stations. Preliminary and verified data are made available over the Web relative to Mean Lower Low Water (MLLW) datum, station datum, or special water level datum as a user option in the interface.

Data Quality Monitoring

CO-OPS has an in-place Continuous Operational Real-Time Monitoring System (CORMS) that provides quality control and system monitoring functions on a 24 hour/day, 7 days/week, all year around basis for CO-OPS monitored gauges. CORMS will monitor the status and performance of all in-house hydro gauges equipped with satellite transmitter using the NOS satellite message format and that are installed by either CO-OPS, NOAA Ships, Navigational Response Teams (NRT), or CO-OPS Indefinite Delivery/Indefinite Quantity (IDIQ) contractors for NOAA in-house hydro projects only. Once these gauges are transmitting data, they will be listed on the hydro hot list by CO-OPs. The CORMS system description can be found in System Development Plan, CORMS. CORMS is a NOS provided support function to the operational field parties and does not relieve the hydrographer of responsibility for performing QC and ensuring proper gauge operation. It is recommended that all NOAA hydrographers confirm operating status of required control stations each morning prior to commencing survey operations. In addition to the support by CORMS, NOAA hydrographers may utilize the DiagTool diagnostic monitoring function available from the Hydro Hot List (HHL), available here https://tidesandcurrents.noaa.gov/hydro.shtml. As stated in Section 4.1.1, for NOAA hydrographic contract surveys, the contractor is responsible for all data monitoring, repairs, and proper functioning of the subordinate gauges during survey operations that require data from that subordinate station.

4.1.5 General Data and Reference Datum Requirements

The present NOAA Nautical Chart Reference Datum for tidal waters is MLLW for hydrographic surveys and Mean High Water (MHW) for shoreline mapping surveys based on the NOAA National Tidal Datum Epoch (NTDE) of 1983-2001 as defined in the Tide and Current Glossary. All tidal datum computations and water level reductions shall be referenced to this datum. The final determination of an appropriate control station for the subordinate station datum computation must result from a direct comparison of the collected subordinate station observations with all nearby potential control stations such that the station best matching in tidal characteristics and ranges will be used as the final control for datum computation.

In non-tidal coastal areas soundings will be reduced to Low Water Datum (LWD) which is Mean Sea Level (MSL) 0.5 ft. In great lakes all soundings will be reduced to Great lakes Low Water Datum as referenced to the current

International Great Lakes Datum 1985 (IGLD85). In areas which are charted to 'Special Datums' such as Columbia River Datum (CRD), Hudson River Datum (HRD), Mississippi River Low Water Reference Plane (LWRP), etc., the soundings will be reduced to the specific special datum. If a subordinate station has a currently published datum, every effort must be made to set the station datum for the new installation to the historic station datum via re-occupation, so that all newly collected observations are on the same zero reference as the currently accepted datum. If the length of the new series of observations is shorter than that of the accepted datum time series, the newly submitted datum may be validated as acceptable for survey use but may not supersede the longer already published datums.

4.1.6 Error Budget Considerations

The water level reducers can be a significant corrector to soundings to reduce them relative to chart datum especially in shallow water areas with relatively high ranges of tide. The errors associated with water level reducers are generally not depth dependent, however. The portion of the error of the water level reducers must be balanced against all other sounding errors to ensure that the total sounding error budget is not exceeded. The allowable contribution of the error for tides and water levels to the total survey error budget falls between 0.10 m and 0.45 m (at the 95% confidence level) depending on the complexity of the tides.

Following the present CO-OPS hydrographic survey error budget analysis procedure for determination of the estimated error at the 95% Confidence Interval (CI):

1. 95% CI = b + 1.96 (s)

   Where b = systematic errors and biases; s = random errors at the one standard deviation level. Systematic errors are additive:

2. $b_{total} = b_1+b_2+b_3+\ldots..b_n$

   Random errors are treated as independent, with the total determined by squaring the individual errors (one standard deviation) and computing the square root of their sum:

3. s_{total} = square root $(((s_1)^2+(s_2)^2+(s_3)^2+\ldots.(s_n)^2))$

The total error of the tides and water levels can be considered to have component errors of:

1. Leveling Error: Water level observations must be collected relative to a known vertical reference, called Station Datum. Vertical movement of the water level sensor relative to Station Datum must be measured at an accuracy within 0.012 m.

   Vertical control must be assessed on a systematic basis and at installation, modification, and removal of the water level sensor.

2. Measurement Error: The instrumentation utilized for water level observations must be able to measure the true mean water level to an accuracy within 0.090 m for each 6 minute observation. Errors resulting from the dynamic effects of waves, currents and water density must also be considered.

   Gauges/sensors need to be calibrated, and sensor design and data sampling need to include strategies to reduce measurement errors due to waves, currents, temperature, and density effects. The measurements need to be properly referenced to the bench marks and tide staffs, as appropriate and monitored for vertical stability.

3. Data Processing Error: Regular automated and manual quality control is conducted to ensure error introduced through the collection and processing of raw water level data is within 1.0 cm.

   Data spikes, bad data points and missing data are several examples of how uncertainty can be increased for raw water level observations. A variety of regular automated (e.g. computer algorithms) and manual (e.g. monthly processor verification) quality control steps must be completed to ensure water level observations utilized for downstream products are as accurate as possible.

4. Fixed and Bottom Mounted Pressure Gauges: The error in correcting measurements for barometric pressure and placing the measurements on station datum through the use of a virtual tide staff.

5. The Datum Error: The error in computation of tidal datums for the adjustment to an equivalent 19-year NTDE periods for short-term stations.

   The shorter the time series, the less accurate the datum, i.e. the bigger the error. An inappropriate control station also decreases accuracy. The NTDE does not apply in the Great Lakes, however the accuracy of datum based on shorter time series is analogous. The estimated error of an adjusted tidal datum based on one month of data is 0.08 m for the east and west coasts and 0.11 m for the Gulf coast (at the 95% confidence level).

6. The Zoning Error: The error in application of tidal zoning.

Tidal zoning is the extrapolation and/or interpolation of tidal characteristics from a known shore point(s) to a desired survey area using time differences and range ratios. The greater the extrapolation/interpolation, the greater the uncertainty and error. Estimates for typical errors associated with tidal zoning are 0.10 m at the 95% confidence level. However, errors for this component can easily exceed 0.20 m if tidal characteristics are very complex, or not well defined, and if there are pronounced differential effects of meteorology on the water levels across the survey area.

Project planning by NOS attempts to minimize and balance these potential sources of errors through the use and specification of accurate and reliable water level gauges, and optimization of the use of zoning schemes, control stations, the number of subordinate stations required, and the length of observations required within practical limits of the survey area and survey duration. The practical limits depend upon the tidal characteristics of the area and suitability of the coastline for the installation and operation of appropriate water level stations. Typical errors estimates can be found in Section 4.1.6.

Estimated Errors Budget

1. Leveling, Measurement, Processing and Pressure Gauge Errors

Sources of Error	Estimated Maximum	Typical	Error Type
Leveling Error	<0.012m	0.005m	(random)
Measurement Errors			
Calibration	<0.009m	0.003m	(random)
Dynamic effects (waves >2.0 m)	<0.100m	0.050m	(random)
Dynamic effects (currents >4 knots)	<0.050m	0.030m	(random)
Dynamic effects (density)	<0.030m	0.010m	(random)

Processing Error	<0.010m	0.005m	(random)
Pressure Gauge Errors			
Barometric pressure correction	<0.010m	0.005m	(random)
Staff-to-gauge readings	<0.030m	0.020m	(random)

2. Tidal Datum Computation Error

Using a NWLON control station

Length of Series	East Coast	Gulf Coast	West Coast	Error Type
30 days	0.040m	0.055m	0.040m	(bias)
90 days	0.030m	0.046m	0.036m	(bias)

First Reduction (FRED): Western and Northern AK

Length of Series	Estimate	Error Type
30 days	0.149m	(bias)
90 days	0.107m	(bias)

3. Tidal Zoning Error

Zoning	Estimate	Error Type
Typical Areas	0.100m	(random)
Complex Areas	0.200m	(random)

4.2 Data Collection and Field Work

4.2.1 Water Level Station Requirements

Data from NOS NWLON stations will be provided to support hydrographic survey operations where appropriate. Data provided are relative to Chart Datum that MLLW for the 19-year NTDE.

The acquisition of water level data from subordinate locations may be required for hydrographic surveys and if so shall be specified by NOS in each individual set of Hydrographic Survey Project Instructions. These stations shall be used to provide 6-minute time series data, tidal datum references and tidal zoning which all factor into the production of final tide reducers for specific survey areas. Station locations and requirements may be modified after station reconnaissance or as survey operations progress. Any changes shall be made only after consultation between CO-OPS and the hydrographer (and Contracting Officer's Representative (COR) if contract survey) as moving required stations to new locations may require new seven-digit station identifier numbers and new/historical station and bench mark information.

The duration of continuous data acquisition shall be a 30-day minimum except for zoning stations. Preferably, the duration of continuous data acquisition would be a full calendar month that could significantly reduce the error in the datum calculated. Data acquisition shall be from at least 4 hours before the beginning of the hydrographic survey operations to 4 hours after the ending of hydrographic survey operations, and/or shoreline verification in the applicable areas. Stations identified as "30-day" stations are the "main" subordinate stations for datum establishment, providing tide reducers for a given project and for harmonic analysis from which harmonic constants for tide prediction can be derived. At these stations, data must be collected throughout the entire survey period in specified areas for which they are required. Levels shall be conducted as soon after installation as is realistically feasible so that at least 30 days of water level data are bracketed by levels. Additionally, supplemental

and/or back-up gauges may also be necessary based upon the complexity of the hydrodynamics and/or the severity of environmental conditions of the project area. In areas where lack of data limits CO-OPS' understanding of the tidal regime, it is possible that if insufficient water level data is collected concurrent with the survey, CO-OPS may not be able to provide tide control within the required vertical specification.

In non-tidal areas, the correctors for hydrographic soundings are simply water level measurements relative to a specified local low water level datum established for navigational purposes. Laguna Madre, parts of Pamlico Sound, and parts of Florida Bay are examples of such areas classified as non-tidal that have special low water datums. Some river areas also have special datums due to the effects of seasonal changes on the river, e.g. CRD, HRD, or Mississippi River LWRP. Great Lakes permanent stations will provide water level data referenced to an established Low Water Datum relative to IGLD85.

4.2.2 Water Level Measurement Systems and Data Transmissions

Water Level Sensor

Generally, the acoustic or Microwave Water Level (MWWL) system shall be preferred for hydrographic or shoreline mapping subordinate station installations. In cases where acoustic wells or MWWL sensor support arm cannot be installed due to terrain, or in cold climates, installation of a portable digital bubbler system is authorized. For projects in the Great Lakes, the MWWL sensor is acceptable during ice-free periods of data collection.

The NOS is currently using the Aquatrak® self-calibrating air acoustic sensors at the majority of the NWLON stations. For further information, refer to Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991. At stations where the acoustic sensor cannot be used due to freezing or the lack of a suitable structure, a Paroscientific intelligent pressure (vented) sensor incorporated into a gas purge system, a well/float with absolute shaft angle encoder (Great Lakes Stations), or a MWWL sensor are used for water level measurements. For further information, refer to the Paroscientific Inc. Digiquartz® Pressure Instrumentation. For further information, refer to the NOAA Ocean Systems Test and Evaluation Report, Limited Acceptance of the Design Analysis WaterLog ® H3611i Microwave Radar Water Level Sensor – NOAA Technical Report NOAA CO-OPS 061, https://tidesandcurrents.noaa.gov/publications/NOAA_Tech_075_Microwave_Water_Level_2014_Final.pdf. CO-OPS has also approved the use of Bottom Mounted Pressure gauges (BMPGs) in locations where standard water level gauges (e.g. acoustic, MWWL, vented pressure) are not possible or offshore data is required. Specifications for use of BMPGs can be found at the end of this section.

The water level sensor shall be a self-calibrating air acoustic, MWWL, pressure (vented), or other suitable type that is approved by CO-OPS. All sensors falling within the "other" category will need sensor specifications submitted to CO-OPS for approval during the planning phases of each survey it is requested to be used. It may not be assumed that because CO-OPS approved an "other" sensor for one survey in one year, that sensor is approved for all future surveys in future years. The sensor measurement range shall be greater than the expected range of water level. The required water level sensor resolution is a function of the tidal range of the area in which hydrographic surveys are planned. Gauge/sensor systems shall be calibrated and the results documented pre and post deployment. The calibration standard's accuracy must be traceable to National Institute of Standards and Technology (NIST).

Where the air acoustic sensor or MWWL cannot be installed, NOS uses a vented strain gauge pressure sensor in a bubbler configuration (Refer to the User's Manual for the WaterLog® Series H-355 Pump). NOS uses a combination protective well/parallel plate assembly on the acoustic sensor and a parallel plate assembly (with 2" orifice chamber) on the bubbler orifice sensor to minimize systematic measurement errors due to wave effects and current effects, as shown in Figure 4.1.

Known error sources for each sensor shall be 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.

Data Collection Platform (DCP) and Transmissions

The Data Collection Platform (DCP) shall acquire and store water level measurements at every 6- minutes. The The DCP shall acquire and store water level measurements at every 6- minutes. The water level measurements shall consist of an average of at least 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 which comprise the 6-minute measurements shall be computed and stored, as well as the number of outliers. The 6-minute centered average water level data is required for compatibility with the NWLON stations, and the standard deviation provides valuable data quality information regarding each measurement. The clock accuracy of a satellite transmitter system shall be within 1 second so that channel "stepping" does not occur. Non-satellite radio transmitter systems shall have a clock accuracy of within one minute per month.

The data transmissions requirements are applicable where CO-OPS is monitoring the gauges as described in Section 4.1.4 above. The ability to monitor water level measurement system performance for near real-time quality assurance is essential to properly support hydrographic survey operations. Therefore, it is required that, where access to the satellite is available, the measurement system shall be equipped with a Geostationary Operational Environmental Satellite (GOES) transmitter to telemeter the data to NOS hourly. The data transmissions must use a message format identical to the format as currently implemented in NOS NGWLMS. This is required to assure direct compatibility with the NOS Data Management System (DMS). This data format is detailed in the reference document "NGWLMS GOES MESSAGE FORMATTING" (refer to Section 4.7). Once the station and gauge information is configured in DMS and station listed on the HHL, the NOS CORMS will monitor all water level measurement system GOES transmissions to assure they are operating properly. Data that is not transmitted by GOES or data transmitted but not in NOS compatible GOES format or is submitted to CO-OPS on electronic formats and must conform to the format specified in the above document so that data can be loaded properly into DMS software. Refer to Section 4.6.2 for further details on the water level data format specifications.

Close coordination is required between hydrographer and Engineering Division (ED) of CO-OPS for all hydrographic water level installations with satellite transmission capability. NOS will assist in acquiring assigned platform ID's, time slots, etc. At least three business days prior to the initiation of GOES data transmission in the field, information about the station number, station name, latitude, longitude, platform ID, transmit time, channel, and serial numbers of sensors, and DCP shall be provided to ED Configuration and Operational Engineering Team (COET) (nos.coops.oetteam@noaa.gov). The station and DCP information must be configured in DMS before data transmissions begin so that the data will be ingested. The metadata required prior to transmission in field can be documented in the eSite Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 4.6 Data Submission Requirements).

Bubbler Orifice and Parallel Plate Assembly

This bubbler orifice bottom assembly is made of red brass; its chemical properties prevent the growth of marine life by the slowly releasing copper oxide on its metal surface. A Swagelok® hose fitting is screwed into the top end cap and is used to discharge compressed air. The air flows through the bottom of the orifice at a rate sufficient to overcome the rate of tidal change and wave height. This opening establishes the reference point for tidal measurements. The parallel plates produce a laminar flow across the orifice to prevent Venturi effect. A two inch by eight-inch pipe provides the correct volume of air for widest range of surf conditions encountered by most coastal surveys.

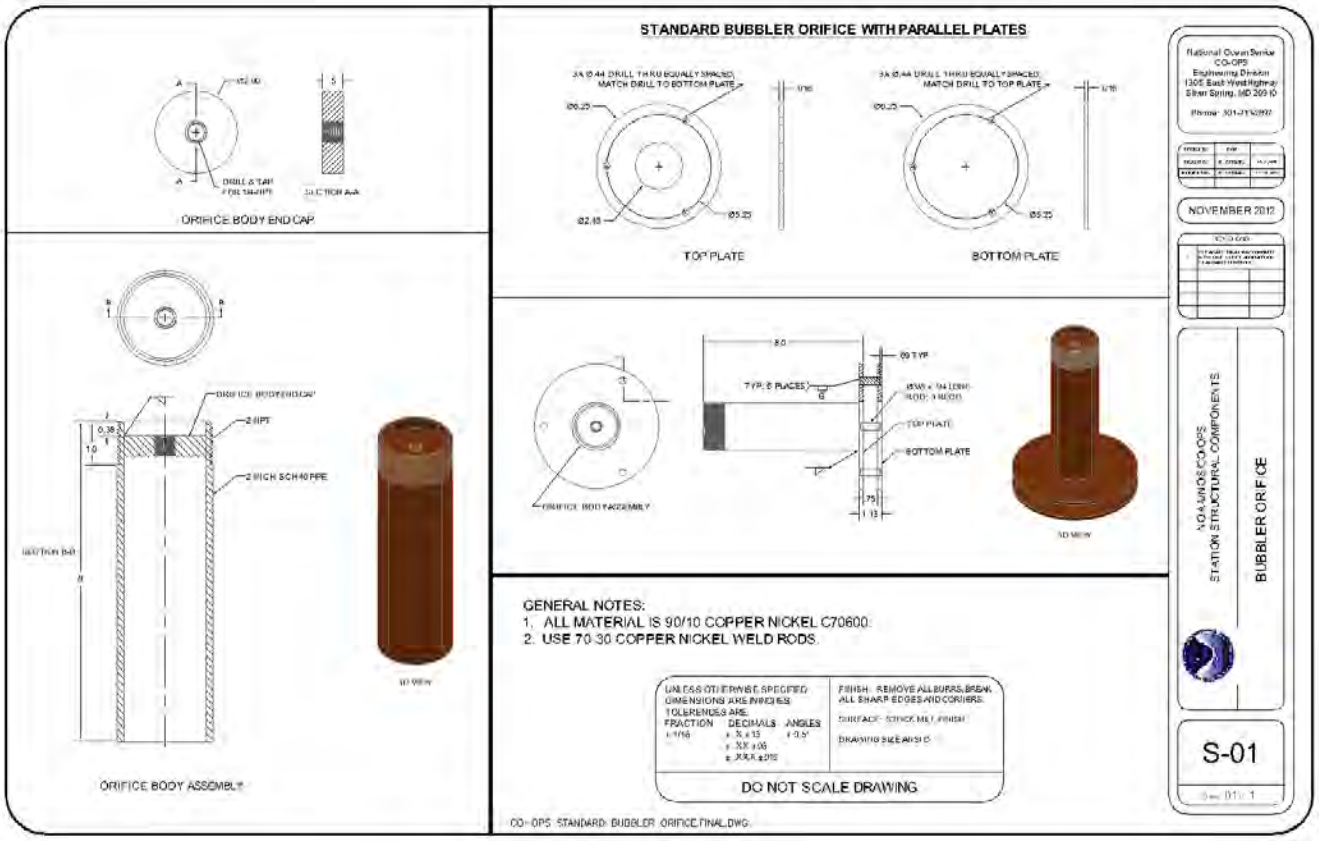


Figure 4.1: Bubbler Orifice with Parallel Plates Bottom Assembly

4.2.2.1 Bottom Mounted Pressure Gauge (BMPG)

A Bottom Mounted Pressure Gauge (BMPG) station consists of bottom-mount moorings and recovery lines, water level sensors (as specified below), water density sensors (conductivity sensor or hydrometer), barometric pressure sensor, tide staff (fixed scale, or leveling-to-water's edge rod equipped with wave stilling tube(staff shots), five tidal bench marks, and connection to WGS84 ellipsoid datum via Global Positioning System (GPS) observations. The BMPG requires the configuration of two water level collection platform systems for redundancy, and to validate any movement.

BMPGs may be used by NOS hydrographic survey contractors to collect water level data only after the following conditions have been met:

1. For zoning gauges or other supplementary data that is in addition to the required subordinate stations as stipulated in the Project Instructions (communications with the Hydrographic Planning Team (HPT) about the placement of this station are suggested).

2. To replace a required subordinate installation where traditional shore-based water level stations with gauges mounted on near shore infrastructure are not possible during the summer months (non-ice deployments). This includes areas where the low tide line is far off shore and the full range of tide cannot be measured with typical MWWL, acoustic, or bubbler gauges. Communications detailing the reason why standard methodologies for data collection are not viable are required.

The hydrographic survey contractors shall design and install their own mooring systems such that the sensor platform shall not move in a manner that would impact the accuracy of the water level data. The objective is to have a mooring that will not move horizontally or vertically during deployment, to ensure the viability of the data

series. A description of the mooring design and anticipated drag load on the sensor platform shall be included in the station documentation submittal as a separate system design document. The sensor platforms shall be deployed offshore far enough (200 -1500 m) to ensure measurement of the lowest expected water level.

Water density shall be obtained every six-minutes by using a bottom mounted conductivity and temperature (CT) sensor. CT sensors shall undergo documented manufacturer recommended calibrations and field team acceptance tests prior to each deployment. The calibrations and acceptance tests results should be submitted as part of the deliverables.

Barometric pressure shall be obtained every six minutes using a nearby reliable existing source (NWLON station, National Weather Service (NWS), airport, etc.). If these sources are not available, then a separate barometric pressure sensor shall be installed at the tide station location or on land as close to the BMPG location or as close as practicable for the duration of the survey. Barometric pressure sensors shall also have documented manufacturer recommended calibrations and acceptance tests performed by the field teams prior to each deployments. This correction is an added correction to those needed for a normal in-house shore-based pressure gauge(s) vented to the atmosphere. The correction should be of suitable accuracy, when a standard industry barometric pressure sensor is installed. The calibrations and acceptance tests results should be submitted as part of the deliverables.

Specifications for BMPG tide staff readings can be found in Section 4.2.4.

Water level pressure sensor shall be Paroscientific Digiquartz or equivalent. The sensor shall have a documented calibration. The contractor shall perform and document acceptance checks related to the sensors operation prior to deployment. The system shall have internal recording capability with a sampling scheme that produces a pressure reading every 6-minutes, similar to the DQAP 36 five-second averages. The system shall keep accurate internal time with no noticeable drift over a 3-month deployment period, e.g. less than 5 seconds drift over a 3-month period. The system shall be deployable for a minimum of 30-days without having to be retrieved for maintenance or data downloading. The water level is obtained from BMPGs by applying corrections for barometric pressure and for water density using standard manufacturer software and the hydrostatic equation relationships. Barometric pressure shall be measured at a location representative of the BMPG deployment site and at a minimum sampling rate of hourly observations. Documentation detailing how the BMPG data were put onto station datum shall be supplied.

4.2.2.2 GPS Tide Buoys

The National Ocean Service has accepted the use of GPS buoys to support hydrographic surveys in low current, low-energy environments. Performance of buoys as water level collection systems is degraded in some operating environments, including areas with strong currents and high waves. Buoys should not be deployed in an environment where the currents regularly exceed 1 knot. The referenced GPS base station should not be more than 40km from the buoy deployment area and GPS solutions should be realized using the Inertially Aided Post Processed Kinematic approach, employing both in situ inertial or tilt sensors and post-processed GPS positions, following the guidance in Section 3. Other methods of GPS processing may be approved on a case-by-case basis.

If the hydrographer determines that the deployment of a GPS buoy is necessary and warranted for the support of a project, the hydrographer should consult with Office of Coast Survey (OCS) Hydrographic Surveys Division (HSD) and CO-OPS (HPT) prior to deployment.

4.2.3 Station Installation, Operation and Removal

Hydrographers shall obtain all required permits and permissions for installation of the water level sensor(s), DCPs, bench marks, and utilities, as required.

Water level station and its various components (tide house, Data Collection Platform, all sensors, 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, or as specified by the COR, if applicable. Water level station and all installed components shall be structurally sound, secure, and safe to use for NOS, local partners, and the general public, as appropriate. The hydrographer or contractor shall provide CO-OPS the position of all water level gauges installed before hydrography begins, including those that were not specified in the Hydrographic Survey Project Instructions, as appropriate. The positions, generated from a hand-held GPS receiver, of bench marks and stations installed or recovered shall be documented as latitudes and longitudes (degrees, minutes, and tenth of seconds).

The following paragraphs provide general information regarding requirements for station installation, operation and maintenance, and station removal.

Station Installation

- A complete water level gauge installation shall consist of the following:
- The installation of the water level measurement system (water level sensor(s), DCP, and satellite transmitter), its supporting structure and a tide staff if required.
- The recovery and/or installation of a minimum of five bench marks and a level connection between the bench marks, the water level sensor(s), and tide staff (if applicable).
- Required series of gauge/staff comparisons, at a minimum of three hours, through a significant portion of a tidal cycle observed and documented.
- The preparation of all documentation and forms that shall be submitted to CO-OPS within 30 days of installation.

Operation and Maintenance

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in writing using appropriate maintenance forms (Section 4.6.1 Station Documentation) 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 of start and completion of the maintenance activity; date and time of adjustments in sensor/DCP, datum offset, sensor offset, or time; field party; parts/components replaced; component serial numbers; tests performed; etc. Documentation of any site visits associated with the operations and maintenance of a station shall be submitted to CO-OPS within 15 days of the site visit.

When GOES telemetry and NOS satellite message format is used, the hydrographer shall monitor the near-real time water level gauge data daily for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. This monitoring can be performed by accessing the CO-OPS Diagnostic web page https://www.TidesandCurrents.noaa.gov. The data over this system are typically available for review within three to four hours after collection.

Removal

- Closing levels - a level connection between the minimum number bench marks and the water level sensor(s) and tide staff (if applicable).

- Removal of the water level system and restoration of the premises, reasonable wear and tear accepted.

- Required series of gauge/staff comparisons, at a minimum of three hours, through a significant portion of a tidal cycle (when applicable) observed and documented.

- The preparation of all documentation, forms, data, and reports which shall be submitted to CO-OPS within 30 days of removal.

4.2.4 Tide Staff

Staff

The hydrographer shall install a tide staff at a station if the reference measurement point of a sensor (zero of a gauge) cannot be directly leveled to the bench marks, e.g. orifice is laid on the sea floor in the case of pressure based bubbler gauges. Whether a pressure gauge can be leveled directly or not, staff readings are still required for assessment of variations in gauge performance due to density variations in the water column overtime. Frequent gauge/staff comparisons during deployment shall be required to assist in assuring measurement stability and minimizing processing type errors. The tide staff shall be mounted independent of the water level sensor so that stability of the staff or sensor is maintained independently. Staff shall not be mounted to the same pile on which the water level sensor is located. The staff shall be plumb. When two or more staff scales are joined to form a long staff, the hydrographer shall take extra care to ensure the accuracy of the staff throughout its length. The distance between staff zero and the staff stop shall be measured before the staff is installed and after it is removed and the staff stop above staff zero height shall be reported on the eSite report or Tide Station Report.

In areas of large tidal range and long sloping beaches (i.e. Cook Inlet and the Gulf of Maine), the installation and maintenance of tide staffs can be extremely difficult and costly. In these cases, the physical installation of a tide staff(s) may be substituted by systematic leveling to the water's edge from the closest bench mark. The bench mark becomes the "staff stop" and the elevation difference to the water's edge becomes the "staff reading".

Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle shall be required (1) at the start of water level data collection, (2) at frequent intervals during deployment, and (3) at the end of a deployment before gauge has been removed. The staff observations at the installation and removal of the water level gauge shall consist of a minimum of three hours of observations at a 6-minute interval. The staff observations shall be performed two times per week, during each week of the project, with at least an hour-long observation at a 6-minute interval for each time. Where staff observations cannot be performed two times a week as required, an explanation is required for the deficiency of number of observations and staff-to-gauge observations shall be performed at least:

- minimum eight times spread out over each month (e.g. two times per week) and at each time at least 1 hour of observations at 6 minute interval, or

- minimum of four times spread out over each month (e.g. one time per week) and at each time at least 2 hours of observations at 6 minute interval.

The performed staff observations along with the time stamped gauge data, shall be forwarded to CO-OPS ED and the HSD/NSD Project Manager or COR within 15 business days or sooner, if practicable.

The staff-to-gauge differences should remain constant throughout the set of observations and show no increasing or decreasing trends. After the water level data has been collected, the averaged staff-to-gauge shall be applied to water level measurements to relate the data to staff zero. A higher number of independent staff readings decrease the uncertainty in transferring the measurements to station datum and the bench marks. Refer to Section 4.7.

If the staff is found destroyed during the deployment, then a new staff shall be installed for the remainder of the deployment and a new staff-to-gauge constant shall to be derived by staff-to-gauge observations. When a staff or an orifice is replaced or re-established, check levels shall be run to minimum of three bench marks including the Primary Bench Mark (PBM). Refer to Section 4.2.6 for leveling frequency and other leveling requirements.

For water level historic stations that are reoccupied, NOS CO-OPS will provide the station datum (SD) information for the station. This information is generally given about the PBM above the historic SD. In that case, for pressure sensors that require staff-to-gauge observations, all the water level data shall be placed on the station datum as detailed in Figure 4.2 and by using the following equation:

Water level data on the SD = (Preliminary pressure water level data on an arbitrary datum as collected by the gauge) + (PBM above SD) - (Staff zero below PBM) - (weighted staff-to-gauge constant)

Staff zero below PBM = (Staff stop below PBM) + (Staff zero below Staff stop)

The staff-to-gauge constant shall be derived as a weighted average of all the staff-to-gauge readings done for the project. The staff zero below PBM is obtained generally by (a) leveling from PBM to staff stop and (b) then measuring the staff stop to staff zero elevation with a steel tape and (c) then combining the two (a and b) elevation values. The staff zero below PBM is obtained by averaging the elevations differences during the opening (installation) and closing (removal) leveling runs for short-term occupations.

At most locations requiring BMPG deployments, a "virtual tide staff" procedure may be required. This procedure requires repeat geodetic leveling from a bench mark or temporary bench mark (backsight) to a level rod held at the water's edge (foresight staff shots). The water level shall be read off the level rod scale, taking into account wave action (a small stilling tube attached to the rod helps with this reading). Foresight water level readings shall be made every 6-minute for a three-hour period after initial deployment of the pressure sensors and just prior to retrieval of the sensors. Back sight closures to the bench mark shall be made at the beginning and end of the three-hour periods with the leveling instrument set-up remaining undisturbed.

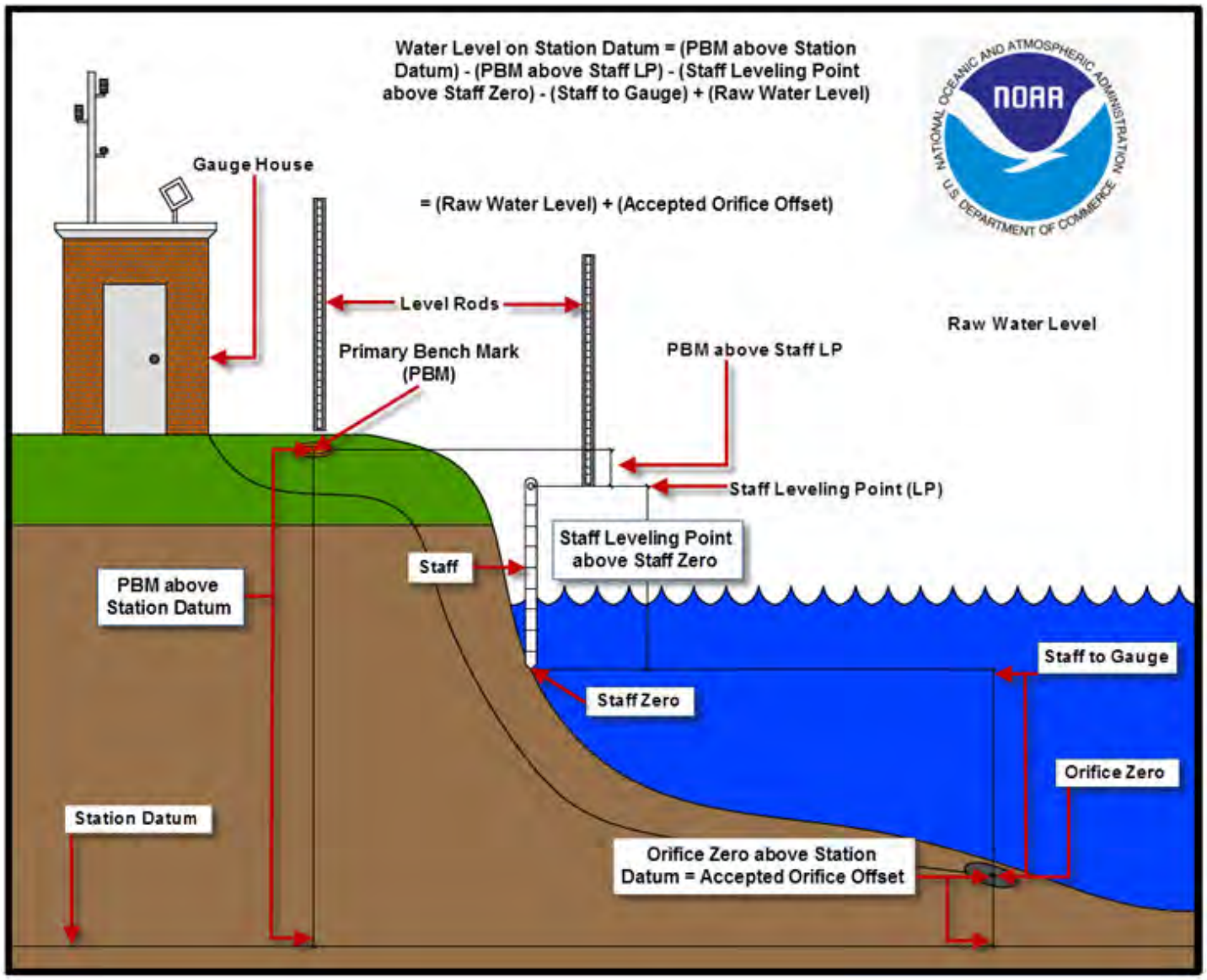


Figure 4.2: Relationship of Station Datum, Orifice, and Staff

4.2.5 Bench Marks

According to the National Geodetic Survey (NGS) geodetic glossary, a bench mark is a relatively permanent, natural or artificial, material object bearing a marked point whose elevation above or below an adopted surface (datum) is known. A bench mark is set to monitor 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 relationship between the bench marks, the water level sensor, and tide staff shall be established by differential leveling.

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 five marks for subordinate stations installed for hydrographic and shoreline mapping surveys.

Before installing a new mark, perform a 1.6 kilometer (1 mile) radial search from the tide station (DCP) location at NGS web site, https://www.ngs.noaa.gov/datasheets/ or the NGS Online Positioning User Service (OPUS)

database https://www.ngs.noaa.gov/OPUS/ 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, 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 CO- OPS ED) and present year so that the new stamping is different from the original stamping of the mark and the stamping of other marks in the local leveling network.

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 CO-OPS ED and the supporting FOD field office. If the disturbed or mutilated bench mark is the PBM and it is not holding its elevation, contact CO-OPS ED for assistance in selecting another PBM and determining its elevation above Station Datum.

NOAA will furnish the individual NOS standard bench mark disks to be installed. Bench mark descriptions shall be written according to User's Guide for Writing Bench Mark Descriptions. Descriptions shall be checked by verifying distances with tape measurements in metric units, verifying cited landmarks, verifying the location using a hand-held GPS 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.

All benchmarks must be identified on the benchmark diagram using the CO-OPS standard bench mark diagram title block. If a digital diagram is used, submit the digital file in JPEG format with the leveling files and photos. Submission of updated bench mark diagrams are required only when necessary to document newly established marks or physical changes in the area. Refer to reference number 32 for the bench mark diagram template (Section 4.7).

4.2.5.1 Number and Type of Bench Marks

The User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, dated October 1987, specifies the installation and documentation requirements for the bench marks. The required minimum separation between the bench marks is 200 ft. (61.0 m). Each water level station will have one bench mark designated as the PBM, which shall be leveled on every run. The PBM is typically the most stable mark in close proximity to the water level station. The surveyor shall select a PBM at sites where the PBM has not already been designated. For historic water level station reoccupations, CO-OPS COET will furnish the designation/ stamping of the PBM and PBM elevation above station datum, if available.

The most desirable bench mark for GPS observations will have 360 degrees of horizontal clearance around the mark at 10 degrees and greater above the horizon and stability code of A or B. Refer to User's Guide for GPS Observations At Tide and Water Level Station Bench Marks. An obstruction diagram must be submitted with the initial GPS Observation documentation included in the installation deliverables.

If the PBM is determined to be unstable, another mark must be designated as PBM. Contact CO-OPS ED for assistance in selecting another PBM and determining its elevation above Station Datum the date of change and the elevation difference between the old and new PBM shall be documented.

4.2.5.2 Digital Photographs of the Bench Marks

Digital photographs of water level station components (station, DCP, sensors, well, supporting structure, equipment, and bench marks) shall be taken and submitted. The station and 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. GPS photos shall be taken according to the User's Guide for GPS Observations at Tide and Water Level Station Bench Marks.

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 location of 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 (if applicable), 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.

All digital station bench mark photo files should be named such that the name of the file will indicate the station number, dash, Permanent Identifier (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. Close-up photo vertically taken of the bench mark is photo type 1, chest or waist level photo vertically taken of the bench mark is photo type 2, and the horizontal view taken of the bench mark is photo type 3. For photo type 3, include the cardinal direction (N, NE, S, SE, etc.) that the camera is pointing. If there are more than one type of photo taken then rename them as 1A, 1B, 2A, 2B, 3A, 3B, etc. If a PID is available, then use designation instead of stamping for the naming of the file. Use a maximum of 30 alphanumeric characters to the left of the dot. So, if you are exceeding 30 alphanumeric characters in the name, then truncate the stamping or designation so that maximum characters in the name are 30. For example, the bench mark E close-up photo for Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg.

New bench mark without a PID and disk face photo	9414290-4290A2008-1-20090101.jpg
Existing bench mark with a PID and eye level view photo	9410660-DY2512-BM N-2-20090101.jpg
Existing bench mark without a PID and north direction photo	9447130-7130E1990-3N-20090101.jpg

4.2.5.3 Obtaining and Recording of Positions of Stations, Data Collection Platform, Sensors, and Bench Marks Using a Handheld 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 (if applicable) 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 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 Aquatrak sensors, MWWL 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.

For bench marks, obtain positions using the hand-held GPS receiver and 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.

4.2.6 Leveling

At least, geodetic third-order levels (refer to reference 2 in Section 4.6, but 2nd order class I levels are preferred) must be run at short-term subordinate stations operated for less than one-year. Additional field requirements and procedures used by NOS for leveling at water level stations can be found in the User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations. Electronic digital/barcode level systems are preferable. Specifications and standards for digital levels can be found in Standards and Specifications for Geodetic Control Networks (Standards and Specifications for Geodetic Control Networks and Geodetic Leveling (NOAA Manual NOS NGS 3)) and additional field requirements and procedures used by NOS for electronic leveling at water level stations can be found in the User's Guide for Electronic Levels with Translev and WinDesc.

The leveling connection to an acoustic sensor shall be done at the Aquatrak Leveling Point (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 acoustic 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.

The leveling connection to a MWWL sensor shall be done at the MWWL Leveling Point (LP). The MWWL LP is located on the top of the flange.

When pressure sensors are used to collect the water level data, the orifice must be mounted on a vertical surface such as a piling of a wharf so that the precise elevation of orifice below the staff stop could be measured with a steel tape, and the elevation of the staff stop can be measured via differential leveling to the nearest bench mark and with the primary bench mark. If the orifice cannot be mounted to a vertical surface (i.e. if the elevation of the orifice cannot be determined precisely with the primary bench mark), then staff-to-gauge readings are required to relate the water level datums to the bench marks. Refer to additional information about staff and staff observations in Section 4.2.4.

4.2.6.1 Leveling Frequency

Levels shall be run between the water level sensor(s) or tide staff and the required number of bench marks when the water level station is installed, modified (e.g., water level sensor serviced, staff, or orifice replaced), for time series bracketing purposes, or prior to removal. In any case, levels are required at an interval of six (6) months during the station's operation, and are recommended after severe storms, hurricanes, and earthquakes to document stability (see stability discussed below). Bracketing levels to appropriate number of bench marks (five for 30-day minimum stations) are required (a) if a gauge is in operations for more than 30 days but less than 12 months (b) or if final tides are required, or (c) after 6 months for stations collecting data for long term hydrographic projects.

4.2.6.2 Stability

If there is an unresolved movement of the water level sensor or tide staff zero relative to the PBM, from one leveling to the next, of greater than 0.006 m, the hydrographer shall verify the apparent movement by re-running the levels between the sensor zero or tide staff to the PBM. If the vertical stability cannot be verified, contact CO-OPS ED. This threshold of 0.006 m should not be confused with the closure tolerances used for the order and class of leveling.

4.2.7 Water Level Station Documentation

The field team shall maintain a documentation package for each water level station installed for hydrographic projects. The documentation package shall be forwarded to CO-OPS and HSD Project Manager/COR after a) installation of a station, b) performance of bracketing levels, c) gauge maintenance and repair, and d) removal of the station. Refer to time frames for submission of documentation Section 4.6.5 for documentation deliverable requirements.

Generally, all documentation shall be submitted when a station is installed. For removal and intermediate site visit(s), only information that has changed shall be submitted (e.g., levels and abstract for bracketing or removal levels, Site Report for maintenance and repair or station removal, etc.). Refer to Section 4.6.1 for Documentation Submission Requirements and Section 4.6.5 for specific documentation submission time frames.

NOAA Raster Navigational Charts

The link below provides an interactive map to search for NOAA Raster Navigational Charts. This link will provide Chart numbers which CO-OPS uses on documents such as the bench mark diagram and published bench mark sheet. http://www.charts.noaa.gov/InteractiveCatalog/nrnc.shtml

United States Geological Survey (USGS) Quad Names

The USGS quad name is required on both the bench mark diagram and for use on the header of the published bench mark sheet. A digital image of the quad map showing the station location is not required. There is a Google Earth layer which will display USGS Quad names within the US. The only input needed is the latitude and longitude information. It is also listed by states if GPS information is not available. USGS quad maps (7.5 minute x 7.5 minute) can be obtained using this Google Earth layer. See the following link to download the Google Earth layer: http://www.usgsquads.com/index.php/map-indexes/mapfinder

4.2.8 Additional Field Requirements

Generally, upon completion of the data acquisition for each gauge installed, the data must be sent as a batch for a 30-day minimum station unless the data are transmitted via satellite. For long-term surveys, with additional data acquisition where subordinate acoustic or MWWL sensors have been installed for more than 1 year, contractors or NOAA field platforms may submit interim water level data deliverables at 3-month intervals unless the data is transmitted via satellite.

All water level data from a gauge shall be downloaded and backed up at least weekly, regardless of whether the gauge data have been sent via satellite.

For new stations without assigned station numbers, submit latitude and longitude of the gauge site to CO- OPS and HSD Project Manager/COR at least three business days prior to installation. A new station number will be provided prior to installation.

The progress sketch shall show the field sheet, layout, area of hydrography, gauge locations, and other information as appropriate. Verify the location of the gauge as shown on the bench mark diagram, field tide note, eSite Report, Xpert Site report, Site Report or Tide station report.

4.2.9 Geodetic Connections and Datums Relationship

Tidal datums are local vertical datums that may change considerably within a geographic area. A geodetic datum is a fixed plane of reference for vertical control of land elevations. The North American Vertical Datum of 1988 (NAVD 88) is the accepted geodetic reference datum of the National Spatial Reference System (NSRS) and is officially supported by the NGS through a network of GPS Continuously Operating Reference Stations (CORS). Elevations can also be referenced to the ellipsoid and the current accepted ellipsoid is GRS80.

The relationship of tidal datums to geodetic datums and ellipsoidal datums is needed to support many coastal mapping, hydrographic surveying, VDatum, engineering and oceanographic applications including monitoring sea level changes, surveying on ellipsoid, and the deployment of GPS electronic chart display and information system, etc.

GPS requirements are specified in the latest published edition of CO-OPS "User's Guide for GPS Observations at Tide and Water Level Stations". All GPS work shall be done according to this document and the required deliverables shall be submitted as specified.

For surveying on ellipsoid and Ellipsoidally Referenced Surveys (ERS), select the most stable bench mark that is obstruction free for GPS observations, collect minimum of a 4-hours of GPS observations, submit the data through OPUS, and submit the published OPUS datasheet. Where OPUS is not able to provide solutions (e.g. in remote Pacific Islands), provide the data to HSD Project Manager/COR. These data will be submitted to NGS for a solution through the Program for the Adjustment of GPS Ephemerides (PAGES) software. The tidal, geodetic, and ellipsoidal datums connection is required for VDatum modeling and supports coastal applications decision making.

Publish your OPUS solution using https://www.ngs.noaa.gov/OPUS/ with options: publish and the following criteria:

Careful Field Procedures

- 4+ hour GPS data file
- Verify antenna type, height, and plumb
- Fixed height tripod recommended, brace the legs with sandbags or chain

Permanent Mark of Public Interest

- Durable, stable setting, with good satellite visibility
- Description & photos to aid future recovery

High-quality OPUS Solution Involves

- ≥ 70% observations used
- ≥ 70% ambiguities fixed
- ≤ 3 cm root mean square (RMS)
- ≤ 4 cm peak-to-peak, lat. & long.
- ≤ 8 cm peak-to-peak, ellipsoid height

4.3 Data Processing and Reduction

4.3.1 Data Quality Control

The required output product used in generation of tide reducers and for tidal datum determination is a continuous time series of 6-minute interval water level data for the desired time period of hydrography and for a specified minimum time period from which to derive tidal datums. CO-OPS will monitor the installed system operation information for all gauges equipped with GOES satellite transmitter. The 6-minute interval water level data from the water level gauges shall be quality controlled to NOS standards by the contractor for invalid and suspect data as a final review prior to product generation and application. This includes checking for data gaps, data discontinuities, datum shifts, anomalous data points, data points outside of expected tolerances such as expected maximum and minimum values and for anomalous trends in the elevations due to sensor drift or vertical movement of the tide station components and bench marks.

Quality control shall include comparisons with simultaneous data from backup gauges, predicted tides or data from nearby stations, as appropriate. Data editing and gap filling shall use documented mathematically sound algorithms and procedures and an audit trail shall be used to track all changes and edits to observed data. All inferred data shall be appropriately flagged. Water level measurements from each station shall be related to a single, common datum, referred to as Station Datum. Station Datum is an arbitrary datum and should not be confused with a tidal datum such as MLLW. All discontinuities, jumps, or other changes in the gauge record (refer to the specific gauge user's guide) that may be due to vertical movement of the gauge, staff, or bench marks shall be fully documented. All data shall be recorded on UTC and the units of measurement shall be properly denoted on all hard-copy output and digital files. Refer to Section 4.6 Data Submission Requirements for details.

4.3.2 Data Processing and Tabulation of the Tides

The continuous 6-minute interval water level data are used to generate the standard tabulation output products. These products include the times and heights of the high and low waters, hourly heights, maximum and minimum monthly water levels, and monthly mean values for the desired parameters. The times and heights of the high and low waters shall be derived from appropriate curve fitting of the 6-minute interval data. For purposes of tabulation of the high and low tides and not non-tidal high frequency noise, successive high and low tides shall not be tabulated unless they are greater than 2.0 hours apart in time and 0.030 meters different in elevation. Hourly heights shall be derived from every 6-minute value observed on the hour. Monthly mean sea level and monthly mean water level shall be computed from the average of the hourly heights over each calendar month of data. Data shall be tabulated relative to a documented consistent station datum such as tide staff zero, arbitrary station datum, MLLW, etc. over the duration of the data observations. Descriptions of general procedures used in tabulation are also found in the Tide and Current Glossary, Manual of Tide Observations, and Tidal Datum Planes. CO-OPS uses a web based Water Level Interface (WALI) for the purpose of efficient loading and processing of water level data and computing tidal datums. The use of WALI is a mandatory requirement for contractors to facilitate loading, processing and verification of products. However, contractors are NOT required to utilize WALI derived products for final deliverables to the OCS. Contractors may choose to also process data using company specific software and use these products for final OCS deliverables. For access to a WALI account, please use the following link: https://access.co-ops.nos.noaa.gov/wali/login.do.

4.3.3 Data Editing and Gap Filling Specifications

When backup sensor data are not available, data gaps in 6-minute data shall not be filled if the gaps are greater than three consecutive days in length. Data gap filling shall use documented mathematically and scientifically sound algorithms and procedures and an audit trail shall be used to track all gap-fills in observed data. Data gaps of less than 3-hours can be inferred using interpolation and curve-fitting techniques. Data gaps of longer than three

hours but less than three days shall use external data sources such as data from a nearby station or astronomical predictions. All data derived through gap-filling procedures shall be marked as inferred. Individual hourly heights, high and low waters, and daily means derived from inferred data shall also be designated as inferred.

4.3.4 Computation of Monthly Means

Monthly means are derived on a calendar month basis, in accordance with the definitions for the monthly mean parameters as found in the Tide and Current Glossary. Greenwich High and Low Water Intervals (HWI and LWI) are not required for mixed diurnal or diurnal tide stations. For purposes of monthly mean computation, monthly means shall not be computed if gaps in data are greater than three consecutive days. For partial months of data, tide-by-tide comparison with the control station data shall be performed.

4.4 Computation of Tidal Datums and Water Level Datums

4.4.1 Datum Computational Procedures

Datums are computed by the "standard" method of range ratio comparison generally on the West coast and Pacific Islands where there exists a large diurnal inequality in the low and high waters. The "modified" method of range ratio comparison is generally used on the East Coast, Gulf of Mexico, and Caribbean where small differences exist in the low and high water diurnal inequalities. For stations requiring a datum determination, at least 30 continuous days of tide observations are required (with the exception of a full calendar month of February). A tide-by-tide datum computation (TBYT) should only be used when a full calendar month of data is not available. Data series of less than a full calendar month may not meet NOS quality control standards, therefore, if data collection is anticipated to be less than a calendar month for logistical reasons survey personnel should notify HSD Project Manager/COR at their earliest convenience to determine data utility for survey support. For stations that collect complete months of data, a monthly mean simultaneous comparison (MMSC) must be used for datum computations. Datum computations for data series of a year or more should be computed on complete years of data using MMSC methodology. Datum computations of complete months and complete years reduces error due to any seasonal bias in the data. Descriptions of the tidal datum computational procedures are found in the Tide and Current Glossary, Tidal Datum Planes, Manual of Tide Observations, NOAA Special Publication NOS CO-OPS Tidal Datums and Their Applications and Computational Techniques for Tidal Datums.

4.4.2 Tidal Datum Recovery

Whenever tide stations are installed at historical sites, measures shall be taken to "recover" the established tidal datums through leveling which shall be accomplished by referencing the gauge or tide staff zero "0" to at least two existing bench marks (three bench marks are preferred) with a published tidal elevation. All possible effort must be applied to attempt to recover as many historic tidal benchmarks as possible. Through this process, the published MLLW elevation is transferred by level differences to the "new" gauge or tide staff and compared to the MLLW elevation computed from the new data on the same zero "0". Factors affecting the datum recovery (i.e. differences between old and newly computed datums) include the length of each data series used to compute the datums, the geographical location, the tidal characteristics in the region, the length of time between reoccupations, the sea level trends in the region, and the control station used. Based on all of these factors, the datum recovery can be expected to vary from +/- 0.03 m to +/- 0.08 m. Hence, this process also serves as a very useful quality control procedure. After a successful datum recovery is performed and bench mark stability is established, the historical value of MLLW shall be used as the operational datum reference for data from the gauge during hydrographic survey operations.

4.4.3 Quality Control

It is essential for tidal datum quality control to have data processing and leveling procedures carried out to the fullest extent. Every effort should be made to bracket at least 30 days of data with levels to ensure stability of the time series and reduce the error involved with tidal datum computation. Caution must also be used in computing tidal datums in riverine systems or in regions of unknown tidal regimes. Tide-by-tide comparisons between subordinate and control station data will often detect anomalous differences that should be investigated for possible gauge malfunction or sensor movement. Datums shall be established from more than one bench mark. Differences in elevations between bench marks based on new leveling must agree with previously established differences from the published bench mark sheets. Any changes in the elevation differences must be reconciled before using in any datum recovery procedure. Datum accuracy at a subordinate station depends on various factors, but availability and choice of an adequate control station of similar tidal characteristics, similar daily mean sea level and seasonal mean sea level variations, and similar sea level trends are the most important. The length of series will also determine accuracy. The longer the series, the more accurate the datum and the greater quality control and confidence gained from analyzing numerous monthly mean differences between the subordinate and control station. At reoccupied historical stations for which datum recoveries are made, updated datums shall be computed from the new time series and compared with the historical datums as the survey progresses.

4.5 Final Zoning and Tide Reducers

Data relative to MLLW from subordinate stations or from NWLON stations, as appropriate, shall be applied to reduce sounding data to chart datum, either directly or indirectly through a correction technique referred to as tidal zoning. Whether corrected or direct, time series data relative to MLLW or other applicable LWD applied to reference hydrographic soundings to chart datum are referred to as "tide reducers" or "water level reducers".

4.5.1 Water Level Station Summaries

Data are reduced to mean values and subsequently adjusted to NTDE values for tidal datums and characteristic tidal attributes as prescribed in Section 4.3 and Section 4.4. "Summary files" shall be created for each subordinate tide station occupied for the survey. These summary data facilitate the development of co-range and co-phase lines and final zoning schemes. They also provide input into the NOS tidal datum bench mark publication process that supports navigation, boundary and shoreline determination, and coastal engineering and management. NTDE values for Greenwich high and low water intervals, mean and diurnal ranges and high and low water inequalities shall be tabulated in these summary files which also contain the datums, the time and length of the series and NOS control station which was used to compute 19-year equivalent NTDE values. NTDE datums shall be tabulated in the summary file relative to a documented consistent station datum such as tide staff zero or arbitrary station datum.

Summary file data from new station occupations and NOS provided summaries from historical occupation and control stations within the survey area shall be used as input data to the tidal zoning process.

4.5.2 Construction of Final Tidal Zoning Schemes

As tidal characteristics vary spatially, data from deployed water level gauges may not be representative of water levels across a survey area. Tidal zoning shall be implemented to facilitate the provision of time series water level data relative to chart datum for any point within the survey area such that prescribed accuracy requirements are maintained for the water level measurement component of the hydrographic survey. NOS currently utilizes the "discrete tidal zoning" method for operations; survey areas are broken up into a scheme of zones that bound areas of common tidal characteristics (NOS also uses Tidal Constituent and Residual Interpolation (TCARI) as outlined in Section 4.5.4). The minimum requirement is for a new zone for every 0.06 m change in mean range of tide and

every 0.3 hour progression in time of tide (Greenwich/Tropic high and low water intervals). Phase and amplitude corrections for appropriate tide station data shall be assigned to each zone.

As part of the process, tidal characteristics shall be accessed using geographic spatial placement of summary data in a commercial GIS compatible format to assess spatial variations in tidal characteristics. Co-range and co-phase maps shall be generated to provide the base for development of zoning schemes. Preliminary zoning, which is based on available historical tide station data and estuarine and global tide models, is referenced to an applicable predictions reference station for utilization during fieldwork. For final processing, preliminary zoning shall be superseded by "final zoning" which is a refinement based on new data collected at subordinate stations during the survey. It is expected that new water level data collected during the survey may change the understanding of the tidal regime in the area and that the orientation of the co-tidal lines and thus the geometry of the tidal zoning will change. With the final zoning scheme, correctors for each zone shall be derived from a subordinate station specifically installed for the survey rather than the reference station used with preliminary zoning. For contract surveys, the contractor shall develop and utilize a zoning scheme to the specifications mentioned above such that water level reducers are within required accuracy across the entire survey area. Zoning errors shall be minimized such that when combined with errors from actual water level measurement at the gauge and errors in reduction to chart datum, the total error of the tide reducers is within specified tolerances, usually 0.45 m as defined by the IHO. The final zoning scheme and all data utilized in its development shall be documented and submitted.

4.5.3 Tide Reducer Files and Final Tide Note

Verified time series data collected at appropriate subordinate stations are referenced to the NTDE MLLW (Chart Datum) through datum computation procedures outlined in Section 4.4. For the contractors, time series data collected in six-minute intervals and reduced to chart datum as specified, both from subordinate gauges and from NWLON stations where appropriate, shall be used either directly or corrected through use of a zoning scheme as determined appropriate by the contractor such that tide reducers are within specified tolerances. A Final Tide Note shall be submitted for each hydrographic sheet with information as to what final tidal zoning should be applied to which stations to obtain the final tide reducers.

4.5.4 Tidal Constituents and Residual Interpolation (TCARI)

The OCS designed Tidal Constituent and Residual Interpolation (TCARI) to provide tidal corrections relative to MLLW at selected hydrographic survey areas along the coast utilizing 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. Just as in discrete zoning, the use of TCARI requires the oceanographer to evaluate and understand the tidal characteristics of the survey areas. Success in both methods requires that tide stations be in operation during survey operations as well as information from historical tide stations and other sources. Gaps in information limit both methodologies. A revised TCARI grid will not be provided for surveys conducted while the required tide gauges are not in operation.

TCARI first requires the development of a model grid to cover the survey area. TCARI then requires a spatial field of accepted harmonic constituents from historical stations for the interpolation instead of just the average time and range of tide which tidal zoning requires. 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 delivered to the survey platform. Survey platforms must obtain the observed data from the specified tide stations during the survey so that TCARI can apply the interpolated water level residuals to the tide reducing process. The

final TCARI grid will also need to incorporate the residuals, harmonics and datums from any and all new subordinate installations. TCARI may be made available for contracted projects at the OCS's discretion.

4.6 Data Submission Requirements

Data submission requirements for water level measurement stations are comprised of both supporting documents for each of the installation of stations, site visits for maintenance of stations, and the removal of stations, along with the formatted digital water level data collected by the water level measurement system required for NOS quality control and ingestion into the NOS data base management system. In addition, documentation for processing and tabulation of the data, tidal datum computation, and final tidal zoning are required.

In the unique cases where one subordinate installation may support the tide reduction of multiple survey sheets, NOAA platforms may request final tide notes to be completed prior to the actual removal of the subordinate gauge. The same documentation requirements of a station removal apply to the interim tide note submissions including: at least 30 days of water level data collected; bracketing levels; completed datum offset computation worksheet; staff-to-gauge observation worksheet; benchmark descriptions; and an updated site report. These documents will need to be submitted at the time of the final tide request, as if the station was removed, and in accordance with the timelines outlined in Section 4.6.5.

4.6.1 Station Documentation

The documentation package shall be forwarded to CO-OPS and HSD Project Manager/COR after a.) installation of a station, b.) performance of bracketing levels, c.) gauge maintenance and repair, d.) removal of the station, and e.) interim tide note requests. Refer to Section 4.6.5 for time frames for documentation submission requirements. The station documentation generally includes, but is not limited to the following:

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. eSite Report, Water Level Station Xpert Site Report, or Tide Station Report (NOAA Form 77-12), or equivalent. (eSite report application is in web based electronic format, Water Level Station Xpert Site Report or Tide Station report in Microsoft Excel format)

5. Sensor test worksheet (JPEG and PDF format)

6. Sensor elevation drawing (JPEG and PDF format) showing sea floor, pier elevation and sensor(s) elevation if sensor is mounted vertically. For stations with Aquatrak sensors, provide the Aquatrak Sounding Well Diagram. For BPMGs, provide the design currents, depth and other information pertaining to the mooring design

7. Water level transfer form (applicable for Great Lakes stations only, in JPEG and PDF format)

8. 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 handheld GPS) of the gauge, NOAA chart number and USGS Quad map name (JPEG and PDF format)

9. 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)

10. Bench mark descriptions with handheld GPS coordinates (in WinDesc for digital and optical leveling). (Refer to User's Guide for Writing Bench Mark Descriptions, NOAA/NOS, Updated January 2003)

11. Digital photographs of bench mark disk face (close-up), setting, bench mark locations from two different (perpendicular) cardinal directions, station, DCP, equipment, underwater components, and vicinity (JPEG and PDF format). 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. 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, component, and view name (e.g. 8661070 tide station view south)

12. Level records (raw levels) including level equipment information (electronic files) and field notes of precise leveling, if applicable

13. Level abstract (electronic file for optical and barcode levels (Translev))

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. Calibration certificates for Invar leveling rods, if applicable (in PDF format)

16. Staff-to-gauge observations, if applicable (in Microsoft Excel and PDF format)

17. Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (in PDF format)

18. Other information as appropriate, or as specified in the contract (in PDF format)

19. Water level data download (preliminary, as applicable)

20. All required GPS deliverables (OPUS published data sheet, NGS OPUS solution report, and bench mark photos) as specified in CO-OPS "User's Guide for GPS Observations at Tide and Water Level Station Bench Marks"

4.6.2 Water Level Data

The final observed water level measurements shall be reported as heights in meters to three decimal places (i.e. 0.001 m). All heights shall be referenced to station datum and shall be referenced to UTC. The final tide reducer time series data shall be referenced to MLLW and shall be referenced to UTC. The contractor shall provide the water level data in the format specified below from the water level gauges installed.

The preliminary water level data and the correctors used to convert the data to chart datum shall be retained by the contractor for a period of not less than three years after the survey is completed or as stipulated in the contract, whichever is longer. All algorithms and conversions used to provide correctors shall be fully supported by the calibrations, maintenance documentation, leveling records, and sound engineering/oceanographic practices. Sensors for measurements used to convert data (e.g. pressure to heights) shall be calibrated and maintained for the entire water level collection period. The preliminary water level data and documentation supporting algorithms and cor-

rectors applied to the data shall be submitted to CO-OPS.

All digital water level and ancillary data shall be transmitted in a format dependent on the DCP configuration. If GOES satellite is used, the data shall be transmitted and received using the NOS compressed pseudo binary format (see NGWLMS GOES Message Formatting). These satellite messages are then decoded by NOS DMS upon receipt from National Environmental Satellite, Data, and Information Service (NESDIS) before further processing and review by CORMS can be completed. If satellite transmission configurations cannot be installed, the data shall be manually downloaded from the DCP and submitted to NOS, as shown in the format below, in a digital format as an ASCII data attachment. It may be prudent to submit data at more frequent intervals under specific circumstances.

Data download files shall be named in the following format: xxxxxxxy.w1.DAT, where xxxxxxx is the seven digit station number, y is the DCP number (usually 1), w1 is the product code for 6-minute data, and DAT is the extension (Use T = 2, 3...if more than one file is from the same station and DCP). This is the format needed when the data is loaded into DMS. Each water level data file (XXX.BWL or XXX.ACO) shall have only 3 months of data. If the water level station was operational for more than three months, please submit multiple xxxxxxxy.DAT files, each file with only three months of data. Additionally, to expedite the provision of interim deliverables for long-term surveys, interim station packages (including leveling and water level data) may be submitted at 3-month intervals.

Multiple DCPs may have been used to collect 6-minute water level data for a particular site, and backup or redundant DCP data may be used to fill the gap in the primary DCP data, but, water level data shall be submitted for single DCP (numbered as 1). All the water level data shall be on station datum. Each input record (including the final record) ends with a carriage return and excludes any extraneous characters such as trailing blank spaces for all types of water level data (6-minute water level data, hourly height, high/low, monthly means, and station datum).

The 6-minute interval data shall have the following format for CO-OPS database to accept. The font used within the submitted water level data files must be Courier or Courier New with a font size of 12.

Acoustic Sensor Data (XXX.ACO format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 1 (DCP number, use 2, 3 , etc., for additional DCPs)
Column 9-19 Date (MMM DD YYYY format, e.g. JAN 01 2009)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01,...., 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00, 06, 12,..., 54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 Temperature 1 (tenth of degrees C in integer format)
Column 51-56 Temperature 2 (tenth of degrees C in integer format)
Column 57-58 Sensor type (Ax for acoustic type, "x" is a number 1-9)
Column 59-60 Blank
Column 61-61 Data Source (S for Satellite, D for Diskette)

Sample data:

85169901AUG17	2008	05:00	1138	23	0	308	297A1	D
85169901AUG17	2008	05:06	1126	26	0	308	298A1	D
85169901AUG17	2008	05:12	1107	26	1	309	298A1	D

Pressure Sensor or Generic Data (XXX.BWL format)

Column 1- 7 Station ID (7 digits, assigned in the project instructions)
Column 8- 8 1 (DCP number, use 2, 3, etc., for additional DCPs)
Column 9-19 Date (MMM DD YYYY format, e.g. JAN 01 2009)
Column 20-20 Blank
Column 21-22 Hours in 24 hour format (i.e. 00, 01,..., 23)
Column 23-23 : (colon)
Column 24-25 Minutes (00-54)
Column 26-32 Data value in millimeters, right justified, (e.g. 1138)
Column 33-38 Sigma (standard deviation in millimeters in integer format)
Column 39-44 Outlier (integer format)
Column 45-50 DCP temperature (tenth of degrees C in integer format)
Column 51-52 Sensor type (Z1 for generic or pressure)
Column 53-53 Blank
Column 54-54 Data Source (S for Satellite, D for Diskette)

Sample data:
85169901AUG 17 2007 05:00 1138 23 0 308Z1 D
85169901AUG 17 2007 05:06 1126 26 0 308Z1 D
85169901AUG 17 2007 05:12 1126 26 1 309Z1 D

Note: pressure data must be accompanied by documented staff observations as listed in Section 4.2.4, if applicable.

Microwave Water Level Sensor Data (XXX.QC format)

Column 1-7 Station ID (7 character)
Column 8-8 1 (DCP number, use 2, 3, etc., for additional DCPs)
Column 9-10 Blank
Column 11-27 Date and Time (MMM DD YYYY HH:MM format, e.g. Jun 01 2013 14:48)
Column 28-28 Blank
Column 29-30 Sensor Id (2 characters, e.g. Y1 for MWWL)
Column 31-31 Blank
Column 32-32 Source (1 character, e.g. Satellite [S], PORTS [Z], Tsunami [T], Storm surge [X], Diskette [D])
Column 33-33 Blank
Column 34-34 Type (1 character, e.g. Primary [P], Redundant [R])
Column 35-35 Blank
Column 36-41 Pressure value (integer divide by 1000 – field length 6)
Column 42-42 Blank
Column 43-48 Primary water level value (integer divide by 1000) - (Acoustic [A1], Pressure [N1], Storm surge [S1], Tsunami [U1], Air gap [Q1, MWWL[Y1])
Column 49-49 Blank
Column 50-55 Primary water level sigma (integer divide by 1000 – field length 6)
Column 56-56 Blank
Column 57-62 Primary water level outliers (integer)
Column 63-63 Blank
Column 64-69 Backup water level value (integer divide by 1000 - field length 6) Backup [B1], Second Pressure [T1])
Column 70-70 Blank

Column 71-76 Backup water level sigma (integer divide by 1000 – field length 6)
Column 77-77 Blank
Column 78-83 Backup water level outliers (integer)
Column 84-84 Blank
Column 85-90 Backup water level water temp (integer divide by 10)
Column 91-91 Blank
Column 92-97 First air temperature (integer divide by 10)
Column 98-98 Blank
Column 99-104 Second air temperature (integer divide by 10)
Column 105-105 Blank
Column 106-111 Datum offset (integer divide by 1000)
Column 112-112 Blank
Column 113-118 Sensor offset (integer divide by 1000)
Column 119-119 Blank
Column 120-125 Backup water level gain (integer divide by 1000)
Column 126-126 Blank
Column 127-132 Backup water level offset (integer divide by 1000)

Sample data:
86310442 MAY 01 2013 15:24 Y1 D P 999999 3269 3 1 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999
86310442 MAY 01 2013 15:30 Y1 D P 999999 3246 3 0 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999
86310442 MAY 01 2013 15:36 Y1 D P 999999 3228 3 0 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999

4.6.3 Tabulations and Tidal Datums

Contractors shall provide digital-copies of tabulations of staff/gauge differences. Through WALI, contractors shall provide 6-minute quality controlled and quality assured data, hourly heights, high and low waters, monthly means, and water level datums for the entire time series of observations from each water level station. Within the WALI Processing Package, contractors shall include the final contractor computed tidal datums, and the tide-by- tide and/or monthly mean simultaneous comparison sheets from which the final tidal datums were determined. Audit trails of data edits and gap filling shall be summarized and provided. A typical WALI submitted processing package will include but is not limited to: Initial time series query; Offline QC checks (pre- and post-edit); 6-min plot before editing or filling any breaks; Filling of breaks: Before plots, Sheets showing fill information from another sensor or station (if any), and After plots; Tabulation sheet; 6-min plot with higher highs and lower lows that have been paired (when applicable); Tide checks; High and Low tides report; Monthly means; Final time series query; tidal datum computations; Bodnar Analysis (if applicable); and final datums.

4.6.4 Tide Reducers and Final Zoning and Final Tide Note

The final zoning scheme shall be fully supported by documentation of data and methodology that comprised the final zoning model. The contractor shall provide the final tidal zoning scheme digitally in ArcGIS compatible format and in CARIS compatible format.

Final tide reducers shall be submitted in the specified format.

All documentation listed below shall be forwarded to CO-OPS and HSD Project Manager/COR:

- Contractor created summary files
- Documentation of NOS summary files utilized for final zoning
- *GIS compatible zoning development steps in ArcGIS and CARIS formats including geographical presentation of summary data and co-phase/co-range maps, if appropriate
- GIS compatible digital final zoning files
- Final TCARI grid (if applicable)
- Final tide reducer data files
- Final Tide Note
- GIS compatible survey outline

The final zoning schemes shall be fully supported by documentation of data and methodology that derived the final zoning model. Methodology shall include an oceanographic analysis.

*If no subordinate water level station was installed, then preliminary tidal zoning may be used as final tidal zoning pending availability of verified water levels and confirmed stability during periods of survey operations at the designated control stations.

4.6.5 Submission and Deliverables - Documentation and Timelines

All documentation, raw water level data, processed data including hourly height, high/low data, monthly means data, and computed datums, OPUS published data sheet and bench mark photos (as listed in Section 4.6), and other reports (as listed above in Section 4.6.4) as required , shall be forwarded within 30 business days of the removal of the water level stations. Appropriate documentation shall also be submitted within 30 days of station installation as well as within 30 days of any intermediate site visits, including the request for interim final tide deliverables. Final zoning schemes with methodological documentation shall be submitted within 45 days of the removal of the stations/gauges. For long-term surveys with additional water level data acquisition is required for more than one year, contractors and field units may submit interim station packages (including leveling and water level data) to CO-OPS at 3-month intervals. Explanations of any delays in submissions of final zoning schemes beyond the 45 days shall accompany any submissions that are submitted beyond the 45-day requirement. All contractors and NOAA field units shall copy the OCS COR or project manager, as appropriate, on all final water level station and zoning packages submitted to CO-OPS.

Submit a transmittal letter to the appropriate COR listing what is being forwarded to CO-OPS. Submit a duplicate transmittal letter, all data and documentation to CO-OPS ED, as listed below.

All data and documentation shall be submitted in digital format. Please refer to Sections 4.6.1, 4.6.2, 4.6.3, and 4.6.4 for details about various data and documentation.

Standard station documentation package includes the following:

1. Transmittal letter

2. Field Tide Note, if applicable

3. Calibration records for sensors

4. eSite Report, Xpert Site Report, or water level station report

5. Sensor test worksheet

6. Sensor elevation drawing

7. Water level transfer form (Great Lakes stations only)

8. Bench mark diagram

9. "Station to reach statement

10. Bench mark diagram

11. Photographs of bench marks, station, DCP, equipment, and vicinity in digital and paper format

12. Levels (raw) (electronic files) and field notes of precise leveling

13. Abstract of precise leveling

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. Calibration certificates for Invar leveling rods, if applicable

16. Staff-to-gauge observations, if applicable

17. Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable

18. Other information as appropriate, or as specified in the contract

19. Water level data, preliminary 6-minute data, all tabulated data, such as hourly heights, high and low, monthly means, and station datum data in the specified format

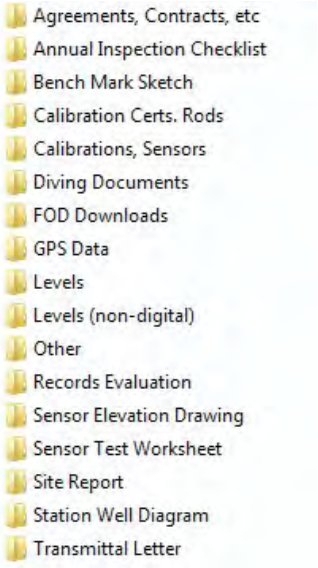
20. GPS data and documentation, NGS OPUS Solution Report, OPUS published data sheet and 4 photos of GPS bench mark, as applicable per CO-OPS document (reference 8 in Section 4.7)

21. Contractor created summary files, final zoning, final tide reducer data, final tide note, and co-phase, co-range maps, if appropriate. Zoning files must be in GIS format with all associated metadata included. (Metadata includes but is not limited to water level stations, intervals of tide, ranges of tide, tidal datums, and any other information on which the revised zoning is based. All metadata on which the zoning scheme is based must be included.) If this information is not included, CO-OPS will not be able to validate the zoning. JPEGs, PDFs, or other simple image files are not acceptable.

Generally, for established water level stations, the bench mark diagram, and "To Reach" statement need only be submitted if those items have been revised during the station maintenance.

When using the electronic/barcode system, the data disk and hard copies of the abstract and bench mark description or recovery notes shall be submitted. For optical levels, submit the raw levels and the leveling abstract.

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/CDROM etc. Here is a template of a complete Hydro Station Package:



Additionally, a folder containing final zoning and all supporting documentation should be submitted per Section 4.6.4, if applicable.

Submit one copy of all the documentation, preliminary and quality controlled water level data, including NGS OPUS Solution Report, OPUS published data sheet and 4 photos of GPS bench mark, final tidal zoning, final tidal reducers, final tide note, etc., in required digital formats.
Submit the completed station package to:

Chief, Engineering and Development Branch
NOAA/NOS/CO-OPS/ED/EDB
SSMC 4, Station # 6515
1305 East-West Highway Silver Spring, MD 20910-3281
Tel # 240-533-0491

4.6.6 CO-OPS Final Deliverables and Timelines

The following timelines are provided for reference:

CO-OPS' review and acceptance, hereinafter "CO-OPS' Acceptance", of all final documentation, as outlined in section 4.6.1, will be conducted within 20 business days of submission.

NOAA Hydrographic Surveys

For hydrographic surveys that required no subordinate installations or updates to the preliminary zoning due to expansion of the project area, for example, Final Tide Notes will be issued to the NOAA Platform and/or HSD Project Manager/COR within 14 calendar days of receipt of the request to Final.Tides@noaa.gov.

For in-house hydrographic surveys that required installation of a subordinate installation(s) and/or updates to the preliminary zoning, the final tide reduction product (either discrete tidal zoning or TCARI grid) will be revised and the final tide note will be delivered to the NOAA Platform and HSD Project Manager within 45 calendar days of either the receipt of the request to Final.Tides@noaa.gov or of the final documentation acceptance (CO-OPS' Acceptance), whichever of the two is the later date. The publishing of water level data and water level products from reconnaissance installations and non-required installations, not meeting specification in time or vertical uncertainty, is up to the discretion of CO-OPS Management.

Contract Hydrographic Surveys

TCARI Zoned Projects

For projects not requiring the installation of subordinate water level stations, contractors shall request a final TCARI grid upon completion of acquisition. A final TCARI grid will be made available to the contractor within 14 calendar days of receipt of the request to Final.Tides@noaa.gov.

For contracted hydrographic surveys that required installation of a subordinate installation(s) and the tide reduction product was a TCARI grid, water level data and water level data products will be accepted and published within 45 calendar days of the final documentation acceptance (CO-OPS' Acceptance) and notification from the contractor that water level data and water level products are ready to be reviewed within the WALI application. The publishing of water level data and water level products from reconnaissance installations and non-required installations, not meeting specification in time or vertical uncertainty, is up to the discretion of CO-OPS Management. The revised final TCARI grid and the final tide note will be delivered to the HSD Project Manager/COR within 45 calendar days of either the receipt of the request to Final.Tides@noaa.gov or the final documentation acceptance (CO-OPS' Acceptance), whichever of the two is the later date. The below list highlights the contractor and government timeline and responsibilities for requesting and processing a TCARI final reduction product.

1. Closing documentation delivered to CO-OPS (submitted by KR within 15 business days (~21 calendar days) of completion of station removal)

2. CO-OPS Operation & Engineering Team performs metadata review & approval, CO-OPS Data processing team sets WALI stations parameters and permissions are granted (within 20 business (~28 calendar days) days from receipt of closing documentation)

3. Contractor utilizes WALI to process data and datums (computation of harmonic constituents not required) and submits a final tides request (must be completed within 10 business days (~14 calendar days) of notification of metadata acceptance and WALI configuration)

4. Data verification, datum verification, harmonic processing and final tide generation and delivery occurs within 45 calendar days from notification by contractor that products are complete and ready for review

Discrete Zoned Projects

For contracted hydrographic surveys not requiring the installation subordinate water level stations, submission of water level products for validation is only required if the contractor modifies the CO-OPS provided preliminary discrete zoning. If submitting modified water level products for validation, the contractor's final zoning scheme will be delivered to the HSD Project Manager/COR within 45 calendar days after submission.

For contracted hydrographic surveys that required installation of a subordinate installation(s) and the tide reduction product was discrete tidal zoning, water level data and water level data products will be validated and published within 45 calendar days of the final documentation acceptance (CO-OPS' Acceptance) and notification from the contractor that water level data and water level products are ready to be reviewed within the WALI application. The publishing of water level data and water level products from reconnaissance installations and non-required installations, not meeting specification in time or vertical uncertainty, is up to the discretion of CO-OPS Management. Validation of the contractor's final zoning scheme will be delivered to the HSD Project Manager/COR within 45 days after the water level data and water level data products have been published. The below list highlights the contractor and government timeline and responsibilities when submitting a discrete final reduction product for validation.

1. Closing documentation delivered to CO-OPS (submitted by KR within 15 business days (~21 calendar days) of completion of station removal)

2. CO-OPS Operation & Engineering Team performs metadata review & approval, CO-OPS Data processing team sets WALI stations parameters and permissions are granted (within 20 business (~28 calendar days) days from receipt of closing documentation)

3. Contractor utilizes WALI to process data and datums (computation of harmonic constituents not required) and submits a final tides request (must be completed within 10 business days (~14 calendar days) of notification of metadata acceptance and WALI configuration)

4.7 Guidelines and References

References for the water level measurement and leveling requirements issued by the NOS CO-OPS and the NGS are listed below.

Most of these documents are available on CO-OPS web site at https://tidesandcurrents.noaa.gov/.

The latest version of the documents can be found on the CO-OPS publication page https://tidesandcurrents.noaa.gov/pub.html or the CO-OPS Field Library https://tidesandcurrents.noaa.gov/fieldlibrary/Welcome.

1. Next Generation Water Level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991

2. User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations, NOAA/ NOS, dated October 1987

3. User's Guide for Writing Bench mark Descriptions, NOAA/NOS, Updated January 2011

4. Users Guide for Electronic Levels with Translev and WinDesc updated March_2013

5. Standing Project Instructions for Coastal and Great Lakes Water Level Stations, Updated October 2013

6. User's Guide for 8200 Bubbler Gauges, NOAA/NOS, updated February 1998

7. User's Guide for 8200 Acoustic Gauges, NOAA/NOS, updated August 1998

8. User's Guide for 8210 Bubbler Gauges, NOAA/NOS, updated February 2001

9. User's Guide for GPS Observations At Tide and Water Level Station Bench Marks, NOAA/NOS, updated March 2013

10. Tidal Datums and Their Applications, Special Publication No. CO-OPS 1, NOAA/NOS, June 2000

11. Manual of Tide Observations, U.S. Department of Commerce, Publication 30-1, Reprinted 1965

12. Tidal Datum Planes, U.S. Department of Commerce, Special Publication No.135, Marmer 1951

13. Tide and Current Glossary, U.S. Department of Commerce, NOAA, NOS, January 2000

14. NOAA Technical Report NOS 64 "Variability of Tidal Datums and Accuracy in Determining Datums from Short Series of Observations", Swanson, 1974

15. Data Quality Assurance Guidelines for Marine Environmental Programs, Robert J. Farland, Office of Ocean Engineering, NOAA, March, 1980

16. System Development Plan, CORMS: Continuous Operational Real-Time Monitoring System, NOAA Technical Report NOS OES 014, U.S. Department of Commerce, NOAA, NOS February, 1997

17. NGWLMS GOES MESSAGE FORMATTING FOR HOURLY TRANSMISSIONS, Phil Libraro, September 2003.

18. Computational Techniques for Tidal Datums, NOAA Technical Report NOS CO-OPS 2, U.S. Department of Commerce, NOAA, NOS, DRAFT December 1998

19. Standards and Specifications for Geodetic Control Networks, Federal Geodetic Control Committee, September 1984

20. NOAA Technical Memorandum "NOS NGS-58, Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards 2 cm and 5 cm), Version 4.3", November 1997

21. Geodetic Leveling, NOAA Manual NOS NGS 3, U.S. Department of Commerce, NOAA, National Ocean Survey, August, 1981

22. Sutron Xpert Operations and Maintenance Manual, October 2006

23. Upgrading an Existing Water Level Station or Installing a New Water Level Station, SOP-3.2.3.5, May 2011.

24. GOES-Enabled Portable Tide Gauge Setup, Configuration, and Data Export Procedures

25. 9210BXlite Data Logger Operations and Maintenance Manual

26. Paros User's Manual

27. Satlink2 Operations and Maintenance Manual

28. H-3551 Pump User's Manual

29. User's Guide for the e-Site Report Application

30. e-Site Report User Access Guide to Build, Submit, Reject, Advance and Approve Steps

31. NOAA Ocean Systems Test and Evaluation Report, Limited Acceptance of the Design Analysis WaterLog® H3611i Microwave Radar Water Level Sensor – NOAA Technical Report NOAA CO-OPS 061

32. CO-OPS Specifications and Deliverables for installation operation and removal of water level stations

5 Depth Sounding

Contents

5.1 General Standards for Depth

The requirements of this section shall apply to all depths included in bathymetric data products or feature attribution, regardless of source. Note that some depth sounding systems and processing techniques may produce individual measurements which do not conform to these standards. The hydrographer shall ensure that final depths delivered to NOS are compliant with these specifications.

5.1.1 Definition of Terms

For the purposes of this Section, technical terms will be used as defined in the Glossary of IHO Special Publication 44, 5th Edition.

Additional terms:

- Sounding: A measurement from the sea surface to the seafloor, regardless of method (echo sounder, lidar, lead line, diver's least depth gauge, etc.). A "sounding" may be corrected for factors such as sound speed, vessel draft, and water levels, but remains the product of a single measurement sample.

- Depth: A fully processed seabed elevation value relative to an established vertical datum, portrayed in a gridded data set or product surface of a hydrographic survey. A surveyed "depth" may be computed based on statistical analysis and uncertainty estimates from a sample set of "soundings".

- Depth Value: A generic vertical seabed elevation value, inclusive of "soundings" and "depths".

5.1.2 Units and Rounding

Depth values shall be recorded in meters, with a precision of at least centimeters. This precision shall be maintained throughout the processing pipeline and all digital data products.

Uncertainty estimates for depth soundings and ancillary measurements shall be recorded with sufficient precision to support Total Propagated Uncertainty (TPU) estimates for depth values at centimeter precision.

Depths reported in the Descriptive Report (DR), other reports, or correspondence shall be accompanied with the associated estimate of TPU. Both depth and TPU shall be rounded to the nearest centimeter by standard arithmetic rounding ("round half up").

5.1.3 Uncertainty Standards

As mentioned in Section 1, these NOS Specifications are partly based on the IHO Standards for Hydrographic Surveys as outlined in Special Publication 44 (S-44), 5th Edition. IHO S-44 specifications are suggested minimum standards that member states may choose to follow. The IHO minimum standards for uncertainty are used in the NOS Specifications as a convenient point of reference. When the NOS Specifications refer to an IHO Order, it is usually in terms of the final uncertainty of a depth value. These specifications should not be interpreted to imply that NOAA Hydrographic Surveys "meet" a particular IHO survey order overall.

NOS standards for Total Vertical Uncertainty (TVU) in hydrographic surveys apply to general water depths and least depths over wrecks and obstructions. By extension, they also apply to the elevations of rocks or other features which uncover at low water and to the measurement of overhead clearances. These standards apply regardless of the method of determination; whether by single beam echo sounder, multibeam echo sounder, lidar, lead line,

diver investigation, or other method.

The formula below shall be used to compute the maximum allowable TVU for all depth estimates included in bathymetric data products or feature attribution after application of correctors for all systematic and system specific errors. At least 95% of geographically distributed grid nodes shall meet this specification and the percentage of nodes that do not meet the maximum allowable TVU shall be discussed in the Descriptive Report.

$$\pm\sqrt{a^2+(b*d)^2}$$

Where:

- a represents that portion of the uncertainty that does not vary with depth
- b is a coefficient which represents that portion of the uncertainty that varies with depth
- (b x d) represents that portion of the uncertain that does vary with depth
- d is the depth

The variables a and b shall be defined as follows:

- In depths less than 100 meters, a = 0.5 meters and b = 0.013 (IHO Order 1)
- In depths greater than 100 meters, a = 1.0 meter and b = 0.023 (IHO Order 2)

The maximum allowable uncertainty in depth includes all inaccuracies due to residual systematic and system specific instrument errors; the speed of sound in water; static vessel draft; dynamic vessel draft; heave, roll, and pitch; and any other sources of error in the actual measurement process, including the errors associated with water level (tide) variations (both tidal measurement and zoning errors).

5.1.4 Resolution and Feature Detection Standards

Bathymetric data resolution and feature detection are functions of the parameters of the sounding equipment, the manner in which it is operated, and processing methods. NOS defines resolution and feature detection standards for bathymetric data in terms of the requirements of the final gridded data set (Sections 5.2 and 5.3). Regardless of depth measurement technique, the hydrographer shall select and operate depth sounding equipment and process the resulting measurements in a manner adequate to meet these requirements.

5.2 Multibeam and Other Echosounders

Many Hydrographic Survey Project Instructions require the use of multibeam echosounders for NOS Hydrographic Surveys. However, there may be surveys which require single beam or other sonar-based techniques. Therefore, the standards included in this section will be valid for all echosounding data.

Note on Phase Measuring Bathymetric Sonars (PMBS): NOAA's investigation of PMBS systems (also known as interferometric sonars, or Phase Differencing Bathymetric Sonars) has shown that the discrete soundings generated by these systems may have unacceptably high uncertainty for use in nautical charting and that some systems may be incapable of reliably resolving features to the standards required in this manual. If bathymetry generated from PMBS systems is intended to be used to meet these Specifications, the system as used in the survey must demonstrably meet the object detection and depth uncertainty standards and be specifically authorized by the Chief, NOS Office of Coast Survey Hydrographic Surveys Division.

This guidance does not apply to phase-based detection algorithms of multibeam echosounders.

5.2.1 Gridded Data Specifications

5.2.1.1 Background

In the Navigation Surface approach, survey data are archived as a certified digital terrain model rather than as a set of verified soundings. HSD has determined that the highest resolution the data can support is rarely needed for navigation products. A compromise grid resolution between the highest resolution possible and a resolution required for navigation products has the advantage of preserving high-resolution data for other users without needlessly burdening NOAA field units and contractors. The nautical chart is then created from scale-appropriate generalizations of the Navigation Surface elevation model.

The Navigation Surface requires that each sounding have a horizontal and vertical uncertainty estimate. This requires robust, verified error models for all systems which contribute measurements to the final depth solution. These include not only echosounders, but positioning system, heave, pitch, and roll sensors, sound speed instruments, tide gauges, static and dynamic draft measurements, and anything else that contributes to the calculation of a depth value. Once this comprehensive error model is assembled, the uncertainties in each measurement may be propagated from the measurement platform to each individual sounding. Only when each sounding has an associated Total Propagated Uncertainty can we combine the soundings into a Navigation Surface with depth and uncertainty attributes for each node.

The open source Bathymetric Attributed Grid (BAG) format was developed as an open source exchange format for gridded data. The Open Navigation Surface Working Group (ONSWG) was formed to develop the format. ONSWG is comprised of government and private sector groups. The primary goals of the ONSWG are to define an open, platform independent, grid database file format suitable for access, archival, and interchange of Navigation Surface results, and to develop an open source software access library to operate on this format. For more information see http://www.opennavsurf.org.

5.2.1.2 General Grid Requirements

5.2.1.2.1 Management of Multiple Grids

This section defines grid resolution, feature detection, and coverage specifications as a function of depth and survey requirement. Many surveys will cover a sufficiently wide range of depths and echosounder properties to require bathymetric data at several different resolutions. Currently, the BAG standard supports only single-resolution grids. The CARIS Bathymetry with Associated Statistical Error (BASE) surface has variable resolution functionality; however, it is not presently approved for NOAA surveys. Therefore, the hydrographer is required to create and manage individual grids for each required depth/resolution band.

The hydrographer will adjust the extents and number of grids based on the bathymetry of the survey area, feature detection requirements, the type of echosounder used and other appropriate factors. However, adjacent grids shall always overlap in depth to ensure no gaps in coverage exist at the transition from one depth grid to another.

5.2.1.2.2 Multiple Echosounding Sources in a Single or Multiple Grids

In cases where multiple echosounding sources (e.g., single beam and multibeam) are used to cover a survey area, create different grids for different system types (i.e. single beam echosounders or multibeam echosounders). The exception to this is for crossline data; where main scheme and cross line system types differ, the resulting data will

be submitted in a single grid provided doing so will not reduce the resolution of the strictest resolution requirement. In those cases where there is vast disparity between the coverage type and/or resolution of the different sounding sources (e.g., single beam main scheme soundings with scattered high resolution multibeam feature developments, or a mix of multibeam echosounders with varying specifications), multiple device-specific grids may be required. See Section 5.2.2 for additional guidance, and consult with the HSD/NSD Project Manager or COR if necessary.

5.2.1.2.3 Designated Soundings

The hydrographer has the responsibility to review the surface and ensure that it reflects the conditions in the survey area. Even in cases where the appropriate resolution was selected, it is possible that the grid may fail to portray some navigationally significant depths and features. At the hydrographer's discretion, a sounding may be "designated", meaning it will override the gridded surface and force the model to recognize an estimated reliable least depth. These are also known as golden soundings.

Note that the criteria below is for a sounding to be eligible for designation; it is not to imply circumstances where a sounding shall be designated. In general, designation should be very exclusive and soundings selected for designation should be done so with the utmost discretion. It is generally expected that the only soundings designated in a survey are the least depths on features when the hydrographer is guided by additional external information regarding the nature of the submerged feature (e.g. a priori knowledge or other evidence that may include a diver investigation or information from side scan sonar) and those soundings of critical importance, whether atop dangers to navigation or in an area of critical underkeel clearance where the designation directly increases safety of navigation.

Designated soundings are created primarily to 1) facilitate FFF feature management (see Section 7.4) but selectively 2) they may be created in areas of critical underkeel clearance to override the gridded surface model to recognize an estimated least depth (see below).

1. Facilitate Feature Management - Section 7.4

2. Override Gridded Surface Model - A designated sounding shall not be created to ensure the gridded surface represents a significant shoaler sounding unless both of the following are true:

a. The top of the natural topography is greater than 1 m proud of the surrounding seafloor, and
b. The difference between the gridded surface and potential designated sounding is greater than the allowable TVU at that depth:

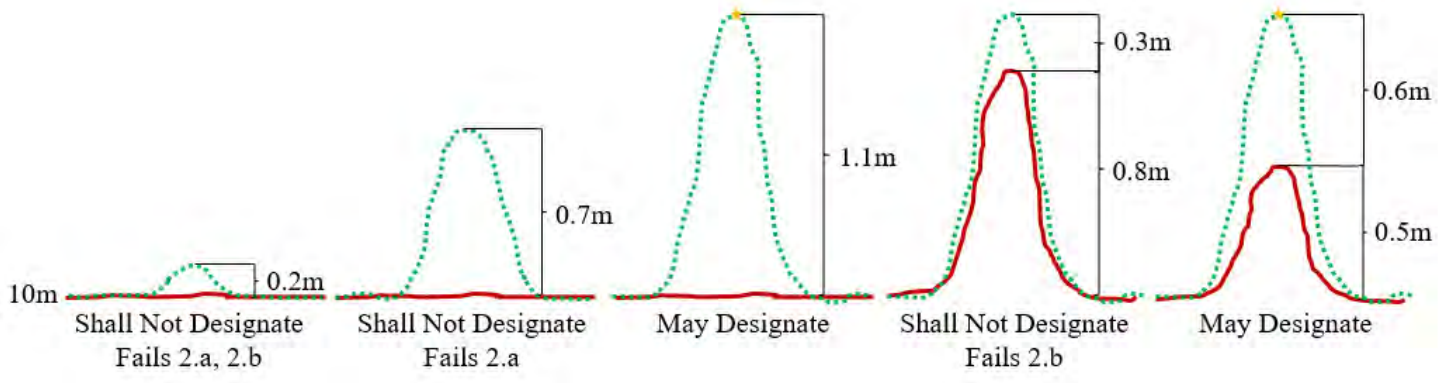


Figure 5.1: The designated sounding guidance above is applied to these example scenarios at depth of 10 m. At this depth, the allowed TVU is 0.52 m (see Section 5.1.3). Following the designated sounding guidance above, in this example, the hydrographer may designate a sounding when the difference between the gridded surface and reliable shoalest sounding is greater than the allowable TVU, 0.52 m. The red lines represent a gridded surface and the green dots represent survey soundings.

Additionally, no sounding shall be designated that is within 2 mm at the scale of the survey (i.e. 20 m for 1:10,000 scale) of another shoaler sounding.

Departures from this designated sounding guidance to override the gridded surface model may occur at the hydrographer's discretion but shall be individually addressed in the Descriptive Report.

If the hydrographer finds that a high occurrence of navigationally significant soundings are eligible for designation using the guidance above, a higher grid resolution may be required. The hydrographer may increase the resolution beyond that specified in Section 5.2.2 for small areas of the survey to increase grid accuracy and data processing efficiency. If large areas of higher resolution are required, the hydrographer shall consult with HSD/NSD Project Manager or COR for guidance. All surfaces will be assessed against the submitted resolutions, not the assigned resolutions (e.g., a field unit grids an area at 0.5 m resolution for the purposes of minimizing designated soundings must then meet the density requirements for a 0.5 m resolution surface).

If noisy data or 'fliers' are incorporated into the gridded solution, the surface may be shoaler or deeper than the seafloor. If these spurious soundings cause the gridded surface to be shoaler or deeper than the reliably measured seabed by greater than the maximum allowable TVU at that depth, the noisy data shall be rejected and the surface recomputed.

5.2.1.2.4 Attribution

Each node of the grid includes not only a depth value, but other attributes. The following minimum attributes shall be associated with each grid node:

- Depth Value
- Total Vertical Uncertainty: The uncertainty value for the grid node shall be the greater of 1) standard deviation of the soundings contributing to the depth solution, or 2) the *a priori* computed uncertainty estimate. The hydrographer shall include a discussion in the DAPR on how the uncertainty was computed on each individual sounding and how the uncertainty was computed on the grid, with a justification for that methodology. The hydrographer shall examine the finalized grids and explain in the DR any areas of unusually high uncertainty.

The following additional attributes shall be included if supported by the hydrographer's data processing software:

- Shoal Depth: Depth value of the shoalest measurement which contributed to the depth solution
- Sounding Density: Number of soundings contributing to the depth solution
- Standard Deviation: Standard deviation of the depths within the capture radius of the node

5.2.2 Coverage and Resolution

The following coverage and resolution requirements shall be followed by contractors and NOAA field units unless stated otherwise in the Hydrographic Survey Project Instructions. If the requirements of the grid for an area do not seem appropriate, the hydrographer should notify HSD/NSD Project Manager or COR to discuss an alternative coverage requirement. If not discussed after the pre-survey assessment (Section 1.4), this discussion should occur early in the data acquisition phase of the project. An exemption (or contract modification) must be approved by the HSD/NSD Project Manager or COR. Any deviations from the requirements shall be discussed in the Descriptive Report and the written approval for deviation shall be included in the Descriptive Report Appendices.

There are four classifications of coverage: Object Detection Coverage, Complete Coverage, Set Line Spacing, and Trackline (transit and reconnaissance). The required survey coverage classification will be specified in the Project Instructions. Within the definition of the coverage classifications, a SSS contact (Section 6.1.3.2) and/or MBES feature (Section 7.1) is defined by the minimum size of a feature required to be located and portrayed in the assigned coverage requirement at depth. Field operations shall be conducted such that the accuracy requirements in Sections 5.1.3 and 5.1.4 are met for the entire coverage. Bathymetric splits, if required, are defined immediately following the four classifications of coverage in Section 5.2.2. Specific requirements of each coverage classification are given below in Sections 5.2.2.2, 5.2.2.3, 5.2.2.4, and 5.2.2.5.

1. **Object Detection Coverage** is assigned for critical under keel clearance areas and may be accomplished with either:

   Option A) 100% bathymetric bottom coverage with multibeam sonars with object detection multibeam developments (i.e. 50 cm grid resolution in 0-20 m depth range) of contacts and features or

   Option B) 200% side scan sonar coverage with concurrent multibeam bathymetry collection with object detection multibeam developments (i.e. 50 cm grid resolution in 0-20 m depth range) of contacts and features. Bathymetric splits, where appropriate, are required (Section 5.2.2.1).

2. **Complete Coverage** may be accomplished with either:

   Option A) 100% bathymetric bottom coverage with multibeam sonars with complete coverage multibeam developments (i.e. 1 m grid resolution in 0-20 m depth range) of contacts and features, or

   Option B) 100% side scan sonar coverage with concurrent multibeam bathymetry collection with complete coverage multibeam developments (i.e. 1 m grid resolution in 0-20 m depth range) of contacts and features. Bathymetric splits, where appropriate, are required (see Section 5.2.2.1). Note that 100% side scan sonar is insufficient to disprove a feature (see Section 7.3.4). Refer to Section 6.1.2 to confirm proper SSS acquisition parameters. Gaps in 100% SSS coverage should be treated as gaps in coverage and addressed accordingly.

3. **Set Line Spacing** is assigned when acquiring bathymetric data in areas too shallow for efficient full bottom coverage bathymetry or too hazardous for use of equipment. Set line spacing may be accomplished with single beam or multibeam, as specified in the Project Instructions. If both single beam and multibeam are specified in the Project Instructions, a separate single beam surface is required (See 5.2.1.2 Multiple Echosounding Sources in a Single or Multiple Grids). Bathymetric splits, where appropriate, are required (see Section 5.2.2.1).

4. **Trackline** survey operations can be classified as either Transit, which is intended to be used simply as an opportunity to collect data while a vessel transits from location A to location B; or Reconnaissance, which is intended to be used when the intended survey products will require a higher level of accuracy than Transit specifications will produce, but a traditional survey consisting of systematic line spacing or full bottom coverage is not required.

5.2.2.1 Bathymetric Splits

Additional lines may be required between the planned lines of set line spacing; these additional sounding lines run between main scheme lines are referred to as "splits." Meeting object detection and complete coverage requirements with side scan sonar does not alleviate the requirement for bathymetric splits.

If a charted depth falls between 2 sounding lines and is shallower than the adjacent survey soundings, the field unit shall split the lines to verify or disprove the charted depth. Splits shall be acquired for both multibeam and single beam hydrography to adequately define shoals, contours and/or significant deeps indicated between main scheme lines, and to verify currently-charted depths that are shallower than any adjacent echosounder coverage.

Prudence and reason-based judgment on the part of the field hydrographer are of paramount importance in determining when splits should be run and when a shoal/contour/deep has been adequately developed. However, care should be taken to ensure that an excess of caution does not hinder field efficiency. The nature of the bottom must be considered. If it is rocky, there is more likelihood of dangerous pinnacles being present. If the bottom is composed of sand or mud, there is less chance that a natural danger exists. The importance of the region should be considered from the point of view of navigation. All shoal indications in areas of low under-keel clearance must be examined. In areas of lesser importance, the number of examinations may be reduced; however, the least depth over detached features surrounded by navigable waters shall be determined regardless of the importance of the area.

5.2.2.2 Object Detection Coverage

Option A: Object Detection Multibeam Coverage

- Detect and include in the grid bathymetry all significant features measuring at least 1 m x 1 m x 1 m in waters up to 20 meters. In depths greater than 20 meters, detect and include in the grid bathymetry features measuring approximately 5% of depth vertically.

- Object Detection Coverage surfaces shall have the following grid-resolution thresholds as a function of depth range, unless an exception is approved as described in Section 5.2.2.

Depth Range (m)	Resolution (m)
0-20	0.5
18-40	1
36-80	4
72-160	8
144-320	16

The application of depth range thresholds to bathymetric surfaces shall only occur during the finalization stage and all final submitted grids shall include only the grid coverage within the specified depth ranges listed above. In cases of steep slopes, the overlap between grids of different resolutions may need to be increased to prevent gaps in their junction. In these cases, the courser resolution grid should have its shoaler extent modified to prevent this coverage gap.

- At least 95% of all nodes on the surface shall be populated, with at least 5 soundings.

- The maximum propagation distance shall be no more than the grid resolution divided by $\sqrt{2}$.

- For Object Detection Coverage, a holiday is defined as: three or more collinear contiguous nodes sharing adjacent sides in the surface created at the required resolution. Figure 5.2a and 5.2b demonstrate object detection holidays. Figure 5.2c is not an object detection holiday because the three nodes are not collinear and does not require additional coverage. There shall be no holidays in the grid or over the tops of potentially significant features.

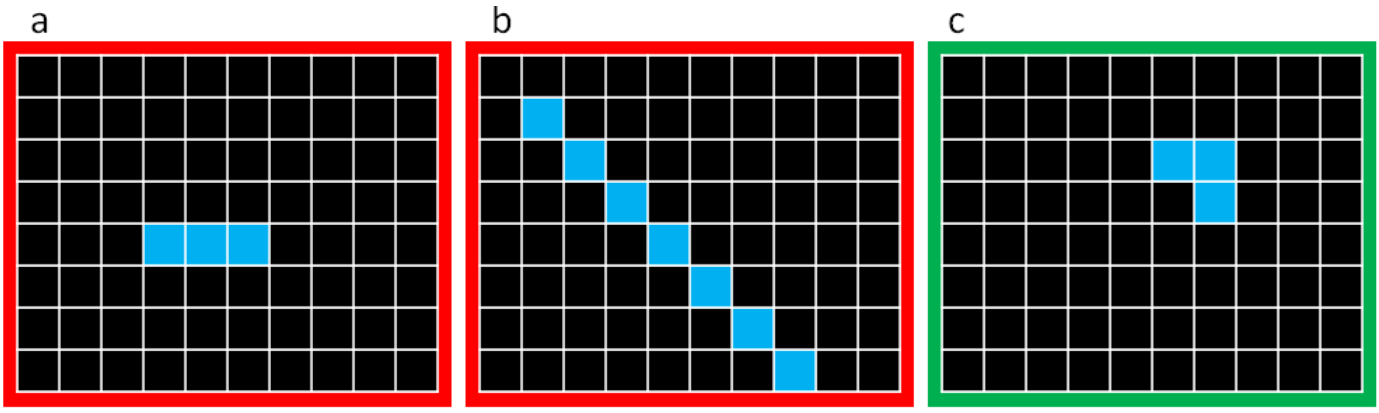


Figure 5.2a and 5.2b: Examples of Object Detection holidays. Figure 5.2c: Not an Object Detection holiday

Option B: 200% side scan sonar coverage with concurrent multibeam

- Line spacing shall be such that at least 200% of seafloor is ensonified with side scan sonar coverage. Gaps in 200% side scan sonar coverage should be treated as gaps in coverage and addressed accordingly.

- Multibeam sonar data shall follow object detection coverage multibeam coverage specifications. Extended gaps in multibeam coverage resulting from underlap between adjacent survey lines is not considered a holiday when using SSS to determine line spacing. Multibeam sonar data shall at least extend across the SSS nadir gap and shall follow object detection multibeam coverage density requirements for which at least 95% of all nodes on the surface shall be populated with at least 5 soundings.

- 200% side scan sonar data is sufficient to disprove a feature. Refer to Section 6.1.2 to confirm proper SSS acquisition parameters.

- Bathymetric splits, where appropriate, are required (see Section 5.2.2.1).

5.2.2.3 Complete Coverage

Option A: Complete Coverage Multibeam

- Detect and include in the bathymetry surface all significant features measuring at least 2 m x 2 m horizontally, and 1 m vertically in waters up to 20 meters. In depths greater than 20 meters, detect and include in the grid bathymetry features measuring approximately 5% of depth vertically.

- Complete Coverage multibeam surfaces shall have the following grid-resolution thresholds as a function of depth range, unless an exception is approved as described in Section 5.2.2:

Depth Range (m)	Resolution (m)
0-20	1
18-40	2
36-80	4
72-160	8
144-320	16

For depths greater than 320 meters, the grid resolution shall be 5% of the water depth, not to exceed 32 m resolution. The application of depth range thresholds to bathymetric surfaces shall only occur during the finalization stage

and all final submitted grids shall include only the grid coverage within the specified depth ranges listed above. In cases of steep slopes, the overlap between grids of different resolutions may need to be increased to prevent gaps in their junction. In these cases, the coarser resolution grid should have its shoaler extent modified to prevent this coverage gap (e.g. change 2 meter resolution depth range to 16-40 meters).

- At least 95% of all nodes on the surface shall be populated, with at least 5 soundings.
- The maximum propagation distance shall be no more than the grid resolution divided by $\sqrt{2}$.
- All significant shoals or features found in waters less than 20 m shall be developed to complete coverage standards (i.e. 1 m resolution surface in depths 0-20 m).
- For Complete Coverage, a holiday is defined as: at least three by three unpopulated nodes in the surface at the required resolution. Figure 5.3a is an example of two holidays in the complete coverage surface that require additional multibeam coverage. Figure 5.3b demonstrates adequate complete coverage in the multibeam surface with no holidays and no additional coverage required. There shall be no holidays in the grid or over tops of potentially significant features.

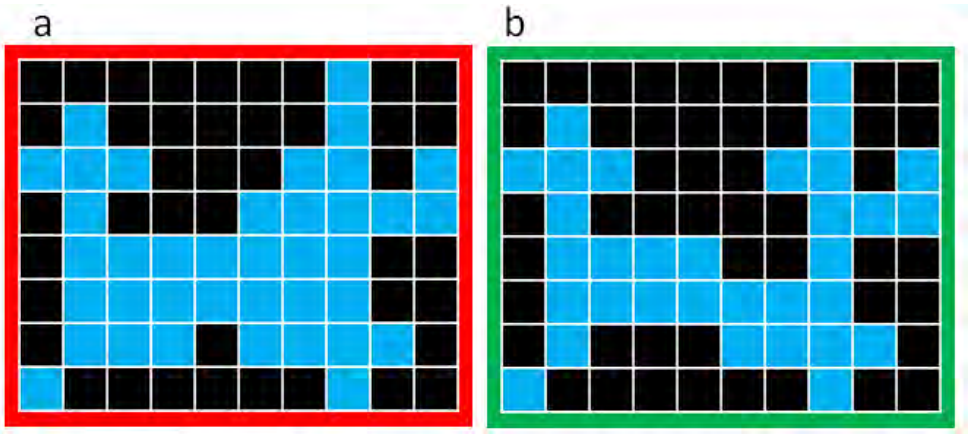


Figure 5.3a: Example of a Complete Coverage holiday Figure 5.3b: Not a Complete Coverage holiday.

Option B: 100% side scan sonar coverage with concurrent multibeam

- Line spacing shall be such that at least 100% of seafloor is ensonified with side scan sonar coverage. Gaps in 100% side scan sonar coverage should be treated as gaps in coverage and addressed accordingly.
- Multibeam sonar data shall follow complete coverage multibeam coverage specifications. Extended gaps in multibeam coverage resulting from underlap between adjacent survey lines is not considered a holiday when using SSS to determine line spacing. Multibeam sonar data shall at least extend across the SSS nadir gap and shall follow complete coverage multibeam coverage density requirements for which at least 95% of all nodes on the surface shall be populated with at least 5 soundings.
- 100% side scan sonar data is insufficient to disprove a feature. Refer to Section 6.1.2 to confirm proper SSS acquisition parameters.
- Bathymetric splits, where appropriate, are required (Section 5.2.2.1).

5.2.2.4 Set Line Spacing

The hydrographer shall conduct multibeam and/or single beam acquisition at the line spacing specified in the

Hydrographic Survey Project Instructions. Bathymetric splits, as appropriate, are required (see Section 5.2.2.1). Note: neither 200% SSS with concurrent multibeam, nor 100% SSS with concurrent multibeam are considered "Set Line Spacing" surveys, as they respectively define Object Detection and Complete Coverage standards.

The following four set line spacing coverage options exist. Contact the HSD/NSD Project Manager or COR with any question as to which set line spacing coverage is required.

Option A: Multibeam sonar set line spacing without concurrent side scan sonar coverage

- At least 95% of all nodes on the surface shall be populated, with at least 5 soundings.
- The maximum propagation distance shall be no more than the grid resolution divided by $\sqrt{2}$.
- Continuous along-track coverage is required. For depths up to 20 m, no holiday spanning more than 3 nodes along-track shall exist; for depths deeper than 20 m, hydrographers discretion shall be used so long as no other requirements are violated, notwithstanding any violation of other coverage requirements.
- All charted depths falling between sounding lines and shallower than adjacent surveyed soundings shall be verified or disproved.
- In depths greater than 20 m, any shoal indications rising more than 10% of the surrounding depths should be investigated.
- All significant shoals or features found in waters less than 20 m deep shall be developed to either object detection or complete coverage standard, as assigned in the Project Instructions.
- The following grid-resolution thresholds as a function of depth range shall be used unless an exception is approved as described in Section 5.2.2. In cases of steep slopes, the overlap between Set Line Spacing multibeam coverage grids shall include only the grid coverage within the specified depth ranges as listed below.

Depth Range (m)	Resolution (m)
0-80	4
72-160	8
144-320	16

Option B: Single beam sonar set line spacing that is not the primary sounding technique

- This data is acquired incidental to complete coverage or object detection coverage
- Example of this type is nearshore single beam data for NALL definition
- These soundings shall be processed and delivered as separate grids from other sounding sources (i.e. multibeam echosounder).
- Due to the potentially sparser sounding sets produced by single beam echosounders, statistical methods for estimating depth (such as CUBE or CARIS Uncertainty Weighted Grids) yield less certain results with single beam than multibeam. Thus, all single beam sounding sets shall be fully "cleaned" (i.e., all "fliers" and other erroneous soundings removed) prior to creation of gridded bathymetric products and that grids

be computed with a "shoal" layer.

Option C: Single Beam Sonar set line spacing that is the primary sounding technique

- Gridded at 4 m resolution, regardless of depth

- Due to the potentially sparser sounding sets produced by single beam echosounders, statistical methods for estimating depth (such as CUBE or CARIS Uncertainty Weighted Grids) yield less certain results with single beam than multibeam. Thus, all single beam sounding sets be fully "cleaned" (e.g., all "fliers" and other erroneous soundings removed) prior to creation of gridded bathymetric products and that grids be computed with a "shoal" layer.

Option D: In rare instances, single beam sounding resolution be scaled with depth.

- This will be specified in the Project Instructions or other communication from the HSD/NSD Project Manager or COR. In these cases, grid resolution shall be between 20% and 40% of depth.

- Due to the potentially sparser sounding sets produced by single beam echosounders, statistical methods for estimating depth (such as CUBE or CARIS Uncertainty Weighted Grids) yield less certain results with single beam than multibeam. Thus, all single beam sounding sets be fully "cleaned" (e.g., all "fliers" and other erroneous soundings removed) prior to creation of gridded bathymetric products and that grids be computed with a "shoal" layer.

5.2.2.5 Trackline Specifications

The following specifications are intended solely for field units conducting Trackline survey operations as specified in Project Instructions. Unless specifically noted below, the requirements in the Hydrographic Surveys Specifications and Deliverables (HSSD) shall be met.

Generally, due to the sparse nature of the data and relaxed standards only trackline data that is shoaler than existing charted data will be represented on the nautical chart product. Trackline data may not be used by the hydrographic branches to disprove or modify charted features. If the hydrographer would like a feature disproved or modified, they must consult with the HSD/NSD Project Manager or COR and subsequently develop the area with Complete Coverage or Object Detection requirements.

5.2.2.5.1 Transit Surveys

- Horizontal Control at a minimum shall be stand-alone GPS. The recommendation is DGPS or WAAS.

- Water level correctors need to be applied and described in the DR Summary per Appendix K. A zerotide file application is appropriate for transit surveys.

- Sound speed profiles are not required as the use of sound speed profiles derived from World Ocean Atlas data is acceptable. The sound speed uncertainty values shall be determined by the VelociPy Variance Wedge SOP.

- Shoal and feature developments are not required. Further development of DTONs and significant shoals may occur if determined to be critical by the hydrographer and/or after consult with the HSD/NSD Project Manager or COR. A FFF is only required if a DTON or new features have been developed.

- There is no defined along track sounding rate.

- The coarsest gridding resolution shall follow the table below. The field unit may submit finer resolution grids, if warranted.

Depth Range (m)	Resolution (m)
0-40	4
40 and greater	16

- The recommended gridding algorithm is uncertainty. Swath and CUBE are acceptable.

- There is no grid node density requirement.

- Holidays are acceptable. If holidays, defined as at least three by three nodes in the surface at the required resolution, occur, document their existence in the Descriptive Report as "Holidays exist in the delivered data due to the acquisition technique of this survey".

- No crosslines are required.

- Acquisition of MBES acoustic backscatter is required as per Section 6.2.

- Bottom samples are not required.

- A Microsoft Word DR Memo per Appendix K is required. A Data Acquisition and Processing Report is not required as long as the DR contains the pertinent processing information. A Horizontal and Vertical Control Report is not required.

- The field unit shall document in the chart comparison section of the Descriptive Report all areas where there are significant discrepancies between soundings collected and charted soundings.

- Field unit shall report off-station ATONs or ATONs not serving their intended purpose in the Descriptive Report.

5.2.2.5.2 Reconnaissance Surveys

- Horizontal Control at a minimum shall be stand-alone GPS. The recommendation is DGPS or WAAS.

- Water level correctors need to be applied and described in the DR Summary per Appendix K. Vertical Control will be determined by HSD/NSD during the project planning stage.

- A minimum of 1 sound speed profile per day is required. A new sound speed profile can be acquired when there is greater than or equal to a 2 m/s difference between the surface sound speed value and the surface sound speed from the latest full sound speed profile. Sound speed profiles must be obtained through in-situ measurement (e.g. CTD, MVP, etc) by either XBT, XCTD, CTD or MVP equipment. The sound speed uncertainty values shall be determined using the VelociPy Variance Wedge SOP.

- Shoal and feature developments are not required. Further development of DTONs and significant shoals may occur if determined to be critical by the hydrographer and/or after consult with the HSD/NSD Project Manager or COR. A Final Feature File (see Section 7.3) is only required if a DTON or new features have

been developed.

- The required along track resolution is 3.2 pings/3 m in depths less than or equal to 40 m. In depths greater than 40 m, there is no required along track resolution requirement.

- The coarsest gridding resolution shall follow the table below. The field unit may submit finer resolution grids, if warranted.

Depth Range (m)	Resolution (m)
0-40	4
40 and greater	16

- The recommended gridding algorithm is uncertainty. Swath and CUBE are acceptable.

- There is no grid node density requirement.

- Holidays are acceptable. If holidays, defined as at least three by three nodes in the surface at the required resolution, occur, document their existence in the Descriptive Report as "Holidays exist in the delivered data due to the acquisition technique of this survey".

- Crosslines shall be collected on an opportunistic basis during round trip voyages.

- Acquisition of MBES acoustic backscatter is required as per Section 6.2.

- Bottom samples are not required.

- The Project Instructions will specify which format of a Descriptive Report (DR) is required: DR Summary or XML DR (Appendix K). A Data Acquisition and Processing Report is not required as long as the DR contains the pertinent processing information. A Horizontal and Vertical Control Report is not required.

- The field unit shall document in the chart comparison section of the Descriptive Report all areas where there are significant discrepancies between soundings collected and charted soundings.

- Field unit shall report off-station ATONs or ATONs not serving their intended purpose in the Descriptive Report.

5.2.3 Corrections to Echo Soundings and Uncertainty Assessment

To meet the accuracy and resolution standards specified in Section 5.1 and Section 5.2, and to create a BAG that includes an accurate uncertainty layer, the hydrographer must conduct an error analysis of their survey systems.

Precise and accurate measurements are fundamental to the field of hydrography. Synchronization of multiple sensors with the sonar system is essential for meaningful spatial analysis of the data. All measurements, however careful and scientific, are subject to some uncertainties. Error analysis is the study and evaluation of these uncertainties with the purpose of estimating the extent of the uncertainties and when necessary, reducing them.

An important distinction exists between such corrections to echo soundings measured relative to the in-situ water level (discussed above), to that of 3-D positioning of echo soundings relative to an ellipsoid as is done in ERS hydrography (Section 3.1). In ERS, the height uncertainty of the survey platform encompasses the otherwise

individual correctors associated with draft and heave. Additionally, the uncertainty associated with zoned water levels is replaced by uncertainties present in the vertical datum transformation.

In recognition of the possibility that some discrepancies in soundings may not be detected until the final processing phase of the survey, the determination and application of corrections to echo soundings must be accomplished and documented in a systematic manner. In addition, all corrections should be applied in such a way that the on-line values may be removed and replaced with a revised set of correctors during office processing. Corrections to echo soundings are divided into five categories, and listed below in the sequence in which they are applied:

- Instrument error corrections account for sources of error related to the sounding equipment itself.
- Draft corrections shall be added to the observed soundings to account for the depth of the echosounder transducer below the water surface.
- Dynamic draft corrections shall be applied to soundings to correct the vertical displacement of the transducer, relative to its position at rest, when a vessel is underway.
- Speed of sound corrections shall be applied to soundings to compensate for the fact that echosounders may only display depths based on an assumed sound speed profile while the true speed may vary in time and space.
- Attitude corrections shall be applied to multibeam soundings to correct the effect of vessel motion caused by waves and swells (heave, roll, pitch) and the error in the vessel's heading.

5.2.3.1 Instrument Error Corrections

In modern digital sounding instruments, instrument errors are generally small and of a fixed magnitude independent of the observed depth. Proper set up and adjustment of digital sounding equipment using internal checks and echo simulators will often eliminate instrument error entirely. However, to ensure the proper operation of echosounders, "confidence checks" shall be conducted periodically.

For single beam echosounders, a comparison should be made at least once per project with depths from bar checks, lead lines, or other single beam echosounders.

For multibeam echosounders, comparisons should be made at least once per project between the nadir (vertical) beam of the multibeam and a single beam system or lead line. On surveys where multiple vessels collect data that overlaps with each other to allow comparison of depths, the frequency of formal confidence checks can be reduced to once per survey. In addition, frequent checks should be made between the overlap of mainscheme and crosslines collected on different days. These comparisons should be made frequently during data collection to find errors promptly, and not saved until final data processing after the field party has left the working grounds.

Comparisons should be conducted during calm sea conditions, preferably in areas with a relatively flat bottom. Any differences should be investigated, and if, after analysis, a corrector is necessary, it should be applied with an explanation of the cause of the difference explained in the Descriptive Report (DR) Section 8.1.4 B.2, Quality Control.

5.2.3.2 Draft Corrections

The corrections for draft account for the depth of the transducer reference point below the surface of the water. Draft corrections comprise a value for the draft of the vessel at rest, sometimes known as static draft, and settlement

corrections which compensate for the variation in draft that occurs when the vessel is making way. The sum of the static draft and the settlement and squat correctors is known as the dynamic draft. Draft is transducer-specific. When more than one transducer is fixed to a vessel, the hydrographer must exercise care to apply the proper draft correction for each transducer. In addition to the draft values, to complete the vessels' error model, the hydrographer must determine the uncertainty associated with all draft values.

Static Draft

The static draft, as an echo-sounding correction, refers to the depth of the transducer reference point below the surface of the water when the vessel is not making way through the water. The required frequency of static draft measurements depends upon the range of variation in the vessel draft and the depths of water to be surveyed. For depths of 30 m or less, the static draft shall be observed and recorded to at least the nearest 0.1 m. Measurements are required with sufficient frequency to meet this criterion. When sounding in waters deeper than 30 m, the static draft shall be observed and recorded to at least the nearest 0.2 m.

Draft values for small vessels such as survey launches should be determined for the range of loading conditions anticipated during survey operations (maximum and minimum). Draft values for larger vessels must be observed and entered into the record before departing from and upon returning to port. In both cases, the draft should be determined by averaging the max/min or beginning/ending values if the differences do not exceed ±0.2 m. Otherwise, the applicable draft should be determined in at least 0.1 m increments. If significant changes to a vessel's draft (greater than ±0.1 m) occur, draft values shall be modified and applied accordingly.

Loading and static draft uncertainties typically represent a small percentage of the total error budget. However, the accuracy of the error model and the results of BAG surface processing are dependent on knowledge of all the uncertainty values that compose the model.

Dynamic Draft

Transducers are generally displaced vertically, relative to their positions at rest, when a vessel is making way. Depth measurements are correspondingly affected by these vertical displacements. The displacements may be of sufficient magnitude to warrant compensation, especially when sounding at moderate to high speeds in shoal water. The factors accountable for this vertical displacement are called settlement. Major factors that influence dynamic draft are hull shape, speed, and depth of water beneath the vessel.

Settlement is the general difference between the elevations of a vessel when at rest and when making way. For lower speed, non-planing vessels, settlement is caused by a local depression of the water surface. Settlement is not an increase in the vessel displacement and, therefore, cannot be determined by reference to the water surface in the immediate vicinity. Vessels surveying at higher speeds may experience a negative settlement, or lift, when planing.

If a Heave-Roll-Pitch (HRP) sensor is used to determine changes in squat, care must be taken to ensure that squat is not corrected for twice. Conversely, if attitude corrections are not used in single beam data processing, the dynamic draft correction must include any appreciable effects due to vessel trim.

Combined effects of dynamic draft at the full range of sounding speeds must be confirmed (i.e. performed and then compared to or averaged with similar past dynamic draft analyses) by the hydrographer at least once a year to at least 0.05 meter precision for each vessel, including launches and skiffs used for hydrographic surveying in shoal or moderate depths. Follow up measurements should be made if there are any major changes to the loading or change to the vessel power plant. When the measurements are made, each vessel should carry an average load and have an average trim. Sounding vessel speeds (or RPM) must be entered in the hydrographic records during survey operations to permit accurate corrections for dynamic draft.

The uncertainty value for Dynamic Draft will be dependent on the method that Dynamic Draft was calculated. Typically, several runs at various speeds will be used to calculate the Dynamic Draft. The uncertainty value could then be the standard deviation calculated for each speed measurement.

5.2.3.3 Speed of Sound Corrections

To ensure that the overall depth measurement accuracy criteria specified in Section 5.1.3 are met, speed of sound observations should be taken with sufficient frequency, density, depth, and accuracy. The certainty at which the speed of sound can be determined is a complex function of the measurement of salinity, temperature and depth, or alternately, sound speed and depth.

Sound Speed values derived from Conductivity, Temperature, and Depth measurements shall be calculated using the Chen-Millero equation. Use of Wilson's equation is no longer authorized.

The speed of sound through water shall be determined using instrumentation capable of producing sound speed profiles with errors no greater than 2 meters per second. The hydrographer shall calibrate sound speed profiler(s) annually. Calibration correctors shall be applied to all profiler data. These instrument(s) shall be re-calibrated at intervals not greater than twelve months during the service life of the instrument while in operational support of OCS hydrographic survey operations. In addition, the instrument(s) must be recalibrated when they are removed from operations or at the end of their service life. Copies of calibration data shall be included in Separate II, Sound Speed Profile Data (see Section 8.1.4).

A geographic distribution of profiles is necessary to correct for spatial and diurnal variability. The sound speed profile must reach the deepest depths of the survey, but the physical measurement of sound only needs to extend to the maximum depth required to perform ray tracing that results in data that meets depth accuracy requirements. Sound speed correctors must be determined accurately and often enough to ensure that the depth accuracy requirements in Section 5.1.3 are met. If changes in the temperature or salinity in the water column dictate that updated correctors are needed, additional sound speed profiles shall be acquired. Additionally, the hydrographer should establish a means of monitoring changes in the water column between subsequent speed casts.

Speed corrections shall be based on the data obtained from the profile, and not based on an averaged sound speed reading for the water column. Survey specific sound speed information shall be included in Separate II, Sound Speed Profile Data (see Section 8.1.4).

Sound Speed Corrections for Single Beam Surveys

For each individual area identified, a minimum of at least one cast each week, taken in the waters surveyed that week, is required. The variation of physical conditions throughout a survey area or any portion thereof may dictate that this minimum may not be sufficient. Where casts taken early in a project indicate that physical characteristics are extremely variable, observations of speed may be required more frequently.

Sound Speed Corrections for Multibeam Surveys

The sound speed profile must be known accurately in multibeam swath sounding for two reasons. First, as in all echosounding, the depth is computed from the product of the speed and the elapsed time between transmission of a sound pulse and reception of its echo. Second, since sound pulses travel at oblique angles through the water column, variations in the speed profile will affect the path of sound through water. The sound path from the transducer to the bottom and back will affect not only the observed depth of water, but the apparent position of the observed sounding.

Even though sampling equipment and computer systems are capable of dividing the water column into intervals so small as to allow close approximation of the integral expression for harmonic mean speed, practical limitations may require the hydrographer to use a small number of discrete points on the speed profile for the purpose of correcting echo soundings. If the hydrographer chooses the inflection points of the smooth speed profile as the discrete points for layer boundaries, the speed curve between the points can reasonably be approximated by a straight line.

Integration of all the segments using the trapezoidal rule to approximate the area under each layer will yield very accurate results.

For multibeam operations, the following specifications apply to sound speed profile frequency and application:

- One sound speed profile shall be acquired immediately before the beginning of the data acquisition period. During the course of survey operations, changes in the water column should be monitored at a sufficient frequency such that the general requirements specified earlier in this section are met. If the surface sound speed sensor value differs by 2 m/s or more from the commensurate cast data, another sound speed cast shall be acquired. Any deviations from this requirement will be documented in the descriptive report. If the field unit has an alternate method to determine the frequency requirement during survey operations, a full description of the method used shall either be included in the Descriptive Report or Data Acquisition and Control Report.

- Sound speed profiles shall be acquired within the survey limits where subsequent data acquisition will occur or within a 250 m range limitation of the survey's hydro limits.

- The sound speed profile must reach the deepest depths of the survey, but the physical measurement of sound only needs to extend to the maximum depth required to perform ray tracing that results in data that meets depth accuracy requirements. Sound speed correctors must be determined accurately and often enough to ensure that the depth accuracy requirements in Section 5.1.3 are met.

The uncertainty value of the sound speed measurements must be part of the vessel's error model. One method used by NOAA is to use the manufacturers uncertainty values for the measured components of conductivity, temperature and pressure. These values must then be used to compute a total uncertainty for the profile by computing how each component's uncertainty is propagated through the sound speed computations.

A probe that measures speed of sound directly could use the manufacturers advertised uncertainty value.

Ideally, sound speed uncertainty should be computed based on both the unit's accuracy and the spatial and temporal error associated with sound speed variation over the entire survey area. However, such advanced error analysis is not currently available in NOAA's processing pipeline. Therefore, NOAA field units and contractors may use the uncertainty associated with measuring the speed of sound at a specific location.

5.2.3.4 Attitude Corrections

Heave, roll, pitch, heading, and navigation timing error corrections shall be recorded in the data files and applied to all multibeam soundings. Heave and heading shall be applied for all single beam data.

Heave, roll, and pitch: Heave shall be observed in no coarser than 0.05 m increments. Roll and pitch shall be observed in no coarser than 0.1 degree increments.

Heading shall be observed in no coarser than 0.5 degree increments.

The uncertainty value for heave, roll and pitch will typically be the manufacturer's values, assuming that the equipment is properly installed and maintained. The hydrographer must explain any variance from the manufacturer's values.

5.2.3.5 Error Budget Analysis for Depths

The hydrographer shall discuss (in Section 8.1.4 B.2 of the Descriptive Report) the methods used to minimize the errors associated with the determination of depth (corrections to echo soundings). Error estimate ranges for a selection of these errors (not necessarily a complete accounting) are presented below. These errors are inherent to hydrographic surveying and all have practical minimums that are usually achievable only under ideal circumstances or with highly specialized equipment. In addition, some errors may be dependent on depth (e.g. sound speed).

The error ranges provided below are first order estimates to allow hydrographers to get a basic 'feel' for the possible range in errors that may occur in practice. Hydrographers should note that the root sum square of the individual errors is used in the computation of TPU. The required depth accuracy requirements cannot be achieved if the worst error for each sensor shown below is used.

Maximum allowable errors are specified to ensure that all errors sources are properly managed. It should be noted that if the maximum value for each error source is used in an error budget (i.e. root-sum-squared), the result will exceed the prescribed accuracy standard. The minimum and maximum values discussed below are at the 95% confidence level (i.e. 2 sigma).

Measurement error: This includes the instrument error for the sounding system, the effects of imperfectly measured roll/pitch and errors in detection of the sea floor due to varying density of the bottom material. Multibeam systems are particularly susceptible to this error due to the off-nadir nature of outer beams. The minimum achievable value is expected to be 0.20 m at 10 m depth. The maximum allowable error is 0.30 m plus 0.5% of the depth.

Transducer draft error: This error is controlled by variability in vessel loading, and the techniques used to measure/monitor transducer draft. This error is depth independent with an expected minimum of 0.05 m and an allowable maximum 0.15 m.

Dynamic Draft error: Conventional methods of determining dynamic draft are limited by sea surface roughness and proximity of a suitable location to the survey area. Careful application of modern methods (Real Time Kinematic GPS) will minimize this error. This error is also depth independent although the effect of dynamic draft is greater in shallow water. The practical expected minimum is 0.05 m and the allowable maximum is 0.20 m.

Sound speed error: The factors associated with this error include (1) the ability to accurately measure sound speed or calculate sound speed from temperature, conductivity and pressure, (2) the spatial and temporal changes of sound speed throughout the survey area and (3) how the sound speed profile is used to convert measured time to depth. In addition, this error encompasses depth errors associated with refraction for multibeam systems. The expected minimum is 0.20 m and the allowable maximum is 0.30 m plus 0.5% of the depth.

Heave error: This error is directly dependent on the sea state and the sensitivity of the heave sensor but is not dependent on depth. The expected minimum is 0.05 m and the allowable maximum is 0.20 m.

Vertical Datum error: Tide/water level datum correction is discussed in detail in Section 4.1.6. The practical range for the uncertainty of zoned tide/water-level reducers is 0.20 meter to 0.45 meter. In the ERS, VDatum-modeled cumulative uncertainty (per the geometric, orthometric, and tidal components) shall be provided in the Project Instructions/SOW. ERZT SEP model uncertainty (see Section 3.6.2) shall be formulated according to the

standard error of the mean. That is, scale the variance of the ERZT SEP observations (sum of the GNSS water level height variance plus the zoned tide/water level reducer variance) by dividing by the number of quasi-independent observations forming each ERZT SEP model node.

5.2.3.6 Uncertainty Budget Analysis for Depths

The hydrographer shall discuss (in Section 8.1.4 B.2 of the Descriptive Report) the methods used to eliminate biases and characterize the uncertainty associated with the determination of depth. Uncertainty estimates for all components of the sounding measurement shall be provided. A sample of some possible uncertainty component types and common values are presented below. These and other uncertainties are inherent to hydrographic surveying; some itemized factors may include a combination of effects, accounting for otherwise several individually-listed components. Meticulous efforts are required to achieve the lowest uncertainties, usually calling for highly-specialized equipment and often only applicable under ideal conditions. The individual uncertainty components applicable to the survey system shall be combined in a Total Propagated Uncertainty (TPU) model to estimate the aggregate uncertainty for individual hydrographic measurements, soundings and heights.

The uncertainty component values provided below are estimates to allow hydrographers to get a basic "feel" for the possible uncertainty values that may occur in practice. The values discussed below are at the 68% confidence level (i.e. 1 sigma).

Motion Sensor Uncertainties: These values include heave, pitch and roll measurement uncertainties and can include gyro measurement uncertainty. A common value for gyro, pitch and roll measurement uncertainty is 0.02°. A common value for heave uncertainty is 5% of the heave amplitude or 0.05 m, whichever is greater.

Navigation Sensor Uncertainty: This value includes the uncertainty in the determination of the vessels position. This value will depend on the method of positioning used; e.g., 1 m in DGPS, sub-decimeter in ERS; see Chapter 3.

Timing Uncertainty: These values include the uncertainty in the measurement of time stamps used in the survey system and include Navigation Sensor timing, Gyro Sensor timing, Heave Sensor timing, Pitch Sensor timing and Roll Sensor timing. A commonly reported value for this is between 0.005 and 0.01 seconds.

Vessel Offsets: These values include the uncertainty in the measurements made to determine the survey system offsets. Ranges will depend on how accurately the offsets were measured but are commonly reported between 0.001 m and 0.1 m.

Vessel Speed: This value includes the uncertainty in the measurement of vessel speed. It is commonly reported as 0.03 m/s plus the average current in the area.

Loading: This value includes the uncertainty in draft changes throughout the survey due to factors such as fuel consumption, etc. Commonly reported values range between 0.01 and 0.3 m, depending on the vessel, fueling frequency and frequency of draft measurements.

Draft: This value includes the uncertainty in measurement of draft. Commonly reported values range between 0.01 and 0.2 m depending on how accurately the draft of the vessel can be measured.

Delta Draft: This value includes the uncertainty of the vessels dynamic draft measurements. Commonly reported values are between 0.01 and 0.03 m depending on dynamic draft measurement methodology and magnitude.

MRU Alignment: This value includes the uncertainties in the patch test determined bias measurements of yaw, roll and pitch. Commonly reported values are less than 1°.

Tides: This value includes the uncertainties in the measurement of tides and the uncertainty of the tide zone model. Tidal uncertainties have been discussed in detail in Section 4.1.6.

Sound speed: This value includes the uncertainties in the measurement of sound speed for full depth profiles and surface measurements. The factors associated with this uncertainty estimate include (1) the ability to accurately measure sound speed or calculate sound speed from temperature, conductivity and pressure, (2) the spatial and temporal changes of sound speed throughout the survey area and (3) how the sound speed profile is used to convert measured time to depth. Commonly reported values range between 0.3 and 4 m/s.

5.2.4 Quality Control

5.2.4.1 Multibeam Sonar Calibration

Prior to commencing survey operations, the hydrographer shall conduct a system accuracy test (i.e. patch test) to quantify the accuracy, precision, and alignment of the multibeam system. Testing shall include determination of residual biases in roll, pitch, heading, and navigation timing error and the uncertainty of these values. These values will be used to correct the initial alignment, calibrate the multibeam system and used in the computation of the Total Propagated Uncertainty (TPU) for each sounding. System accuracy testing should be conducted in an area similar in bottom profile and composition to the survey area, and during relatively calm seas to limit excessive motions and ensure suitable bottom detection. In addition, system accuracy tests should be conducted in depths equivalent to the deepest depths in the survey area. Static transducer draft, dynamic draft corrections, sound speed corrections, and tide corrections shall be determined and applied to the data prior to bias determination.

The order in which these biases are determined may affect the accurate calibration of the multibeam system. The hydrographer should determine the biases in the following order: navigation timing error, pitch, roll, heading (yaw). Deviations from this order or other variations on the accepted calibration methods shall be explained in the project documentation

Pitch and navigation timing error biases should be determined from two or more pairs of reciprocal lines 500–1,000 m long, over a 10–20 degree smooth slope, perpendicular to the depth curves. The lines should be run at different speeds, varied by up to 5 knots, for the purpose of delineating the along track profiles when assessing time delay. Navigation timing error bias could also be determined from running lines over a distinct feature (i.e., shoal) on the bottom, as long as the feature is ensonified by the vertical (nadir) beam.

Roll bias should be determined from one or more pair of reciprocal lines 500–1000 m in length over a flat bottom. Lines should be run at a speed which will ensure significant forward overlap.

Heading (yaw) bias should be determined from two or more adjacent pairs of reciprocal survey lines, made on each side of a submerged object or feature (i.e., shoal), in relatively shallow water. Features with sharp edges should be avoided. Adjacent swaths should overlap by 10–20 percent while covering the shoal. Lines should be run at a speed which will ensure significant forward overlap.

Once calibration data have been processed and final system biases determined, the new corrections shall be used in a performance check to ensure that the new system biases are adequate. The hydrographer shall discuss procedures and results in Section A. Equipment and optional Section B. Quality Control of the project Data Acquisition and Processing Report (Section 8.1.5.1). Copies of all system alignment, accuracy, calibration reports, and performance checks shall be included in the Data Acquisition and Processing Report.

System accuracy testing shall be repeated whenever changes (e.g., sensor failure, replacement, re-installations, re-

configurations, or upgrade; software changes which could potentially affect data quality) are made to the system's baseline configuration, or whenever assessment of the data indicates that system accuracies do not meet the requirements in Section 5.1.

5.2.4.2 Positioning System Confidence Checks

See Section 3.2 and Section 3.3 for details.

5.2.4.3 Crosslines

The regular system of sounding lines shall be supplemented by a series of crosslines for verifying and evaluating the internal consistency of surveyed soundings and positions. Crosslines shall be acquired and processed to the same accuracy and data quality standards as required for mainscheme lines, and shall be included in the grids that are submitted as the final bathymetric product of the survey. As a quality control tool, the benefits of crosslines are most readily derived when they are acquired at or near the beginning of survey operations.

Crosslines shall have good temporal and geographic distribution (across depth ranges, distinct water masses, and vessels) such that maximal nadir-to-nadir comparisons are achieved. Each temporal and geographic distribution (e.g. boat day) shall be crossed at least once. Crosslines shall not exceed 1 km spacing. An example of appropriate geographic distribution of crossline spacing is shown in the below Figure 5.4.

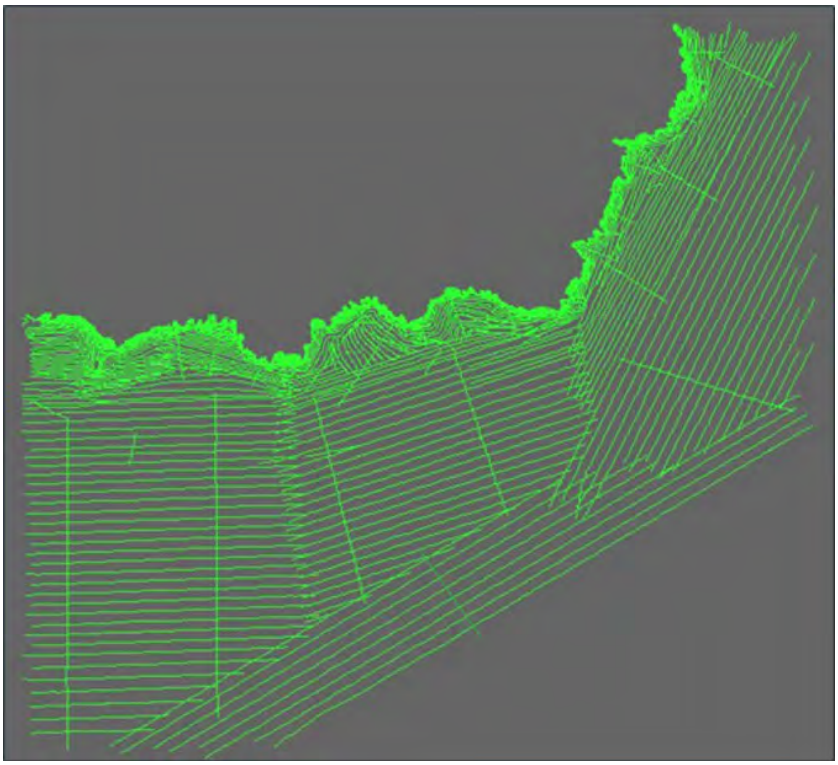


Figure 5.4: An example of appropriate geographic distribution of crossline spacing

Crossline requirements are dependent on bathymetric coverage type assigned and achieved by the field unit, Section 5.2.2:

- Object Detection or Complete Coverage: Lineal mileage of crosslines shall be approximately 4% of main scheme mileage in areas surveyed to meet object detection or complete bathymetric coverage requirements.

- Set Line Spacing: Lineal mileage of crosslines shall be approximately 8% of main scheme mileage in areas surveyed with set line spacing coverage using single beam or multibeam echosounders. This applies for mixed main scheme and crossline techniques, i.e. single beam main scheme with multibeam crosslines or vice versa

Set Line Spacing vs. Object Detection or Complete Coverage

Crosslines are not the primary means of identifying systematic errors and blunders in multibeam echosounder data used to achieve Object Detection or Complete Coverage coverage. If errors are rapidly varying over the period of the lines, issues are reliably identified in the bathymetric grid through examination of depth values and ancillary attributes such as uncertainty and standard deviation. Crosslines in an object detection or complete bathymetric coverage survey do, however, provide an additional semi-independent check for spatial and temporal correlation of the data set across the range of area, time, seabed relief and bottom types, survey vessels, and sonar systems represented. For this analysis to be valid, crosslines must be acquired with the same attention to accuracy and data quality as mainscheme data. Whenever possible, crosslines should be acquired under different conditions (vessel, sonar system, tide state, etc.) than main scheme data.

The primary purpose of crosslines in a set line spacing coverage area is to identify systematic errors and blunders in the surveying system. Discrepancies between main scheme and crossline coverage indicate potential systematic errors in offsets, biases, or correctors or the application thereof, faulty positioning or echosounder operation, or other issues. The hydrographer shall compare mainscheme and crossline coverage to identify, evaluate, and rectify any such errors (see Analysis and Documentation, below).

Analysis and Documentation

Two possible methods of conducting the independent analysis are beam by beam statistical analysis or surface difference. Other methods may be used. The chosen method must be described in the DAPR or DR. Regardless of method, the comparison shall be performed at the same resolution as the final survey product as required in Section 5.3.2.

The hydrographer shall evaluate each area of overlapping crossline and mainscheme coverage to ensure that the depth values from the two datasets do not differ more than the maximum allowable TVU for the depth of the comparison area (Section 5.1.3). Any deviations from this standard shall be investigated, and the source of error identified and corrected. If unexplained or excessive discrepancies persist, additional crosslines shall be re-acquired to assist in resolution of the issue.

The hydrographer shall evaluate crossline to mainscheme agreement, and discuss the method and results in Section 8.1.4 B of the Descriptive Report. If the magnitude of any discrepancies varies widely over the survey, the hydrographer shall make a quantitative evaluation of the disagreements area by area. If differences were found to be within the allowable maximum TVU, the hydrographer shall note this. Conversely, any errors identified through crossline analysis and the means by which they were corrected shall be discussed.

5.3 Lidar

5.3.1 Accuracy and Resolution Standards

All requirements outlined in Section 5.1 apply to bathymetric lidar data products and feature attribution. For project specific guidance the hydrographer shall refer to the Project Instructions

5.3.1.1 Lidar Resolution Standards

Spatial resolution: The hydrographer shall maintain and operate the lidar system, from data acquisition to processing, to detect hazardous features. As the spatial resolution (i.e., the spacing of the lidar footprint on the seafloor) is dependent on a wide range of variables: 1) propagation of light through the water, 2) the received signal strength, 3) the object detection algorithms used, 4) changes in water depth, and 5) aircraft height above the surface the actual bottom resolution may not remain constant. The hydrographer shall make a statement in the Descriptive Report describing the areas within the survey where they are confident the specified spatial resolution was obtained.

5.3.1.2 Gridded Data Specifications

In the Navigation Surface approach, survey data are archived as a certified digital terrain model rather than as a set of verified or certified soundings. For lidar bathymetry, the archived elevation model should be saved at the highest resolution supported by the sounding data. For example, if the laser spot spacing on the seafloor of a full coverage lidar survey is 3 meters, the elevation model could be saved at a grid spacing of 3 meters. However, if environmental conditions (i.e. kelp, turbidity, or sea state) create differences in data density an alternative approach may be discussed with the HSD/NSD Project Manager or COR and clearly described in the Descriptive Report (DR). This practice has the advantage of preserving this high-resolution data for a variety of known and unknown future purposes, even if such resolution will never appear on a navigational or charting product. Charting products such as paper charts are created from scale-appropriate generalizations of the elevation model. In reality, the final resolution of the surface may be slightly coarser than "the highest resolution supported by the sounding data" due to depth ranges, bottom topography and other variables. Refer to Section 5.2.1 for more guidance. See also Section 7.5 for guidance on delineating and characterizing rocky seabed areas.

The data density and resulting grid resolutions created shall be discussed with the COR during the project planning phase. Any deviations from the plan, project instructions or Specifications and Deliverables shall be discussed with the COR and clearly described in the Descriptive Report (DR) and Data Acquisition and Processing Report (DAPR) If in rocky nearshore areas, the least depths of many features in a relatively small area fail to be preserved, see Section 5.2.1.2.3 for more guidance. See also Section 7.5.1 for guidance on delineating and characterizing this rocky seabed area.

The Navigation Surface for lidar requires that each sounding have a horizontal and vertical uncertainty. The uncertainty value for the grid shall be the greater of the standard deviation and the a priori computed uncertainty estimate. To do this effectively, an error model is needed for all systems supplying measurements to compute the sounding; including the GPS sensors and anything else that contributes to the calculation of a sounding. If a complete error model is not yet available to compute the TPU for each individual sounding then the hydrographer may apply a single uncertainty value to all grid nodes that reflect the vertical error budget for a given survey. The hydrographer shall include a discussion in the DAPR on how the uncertainty was computed on each individual sounding and how the uncertainty was computed on the grid, with a justification for that methodology.

5.3.2 Coverage and Resolution

In general, there are two classifications of bathymetric lidar coverage: Complete and Reconnaissance coverage. The required spot spacing and survey coverage will be specified in the Project Instructions.

Complete Coverage requires a minimum of 200% coverage, a minimum laser spot spacing of 4 meters, and conforms to the depth accuracy standards outlined in Section 5.1. In situations where poor water clarity and related environmental factors make complete coverage impossible the COR shall be notified. In addition the hydrographer shall identify (textually and graphically) those areas where full coverage was not obtained and/or

further investigation using sonar may be required.

Reconnaissance coverage refers to range of coverage overlap and laser spot spacing requirements below the minimum specified for Complete coverage. Data products and feature information produced under Reconnaissance requirements are used to obtain general bathymetry for applications other than nautical charting (e.g. navigational safety, operational planning, and research). The Hydrographic Survey Project Instructions will identify if a given surveys is for reconnaissance purposes and the hydrographer shall indicate the requirement in the Descriptive Report.

Complete lidar coverage

- Grid resolution shall nominally be 3 meters - If survey data can support higher resolutions, then use hydrographer discretion and submit a higher resolution, if appropriate.

- Maximum surface uncertainty is IHO Order 1 for depths less than 100 meters. The hydrographer must ensure that accurate least depths are obtained on all significant features. Individual soundings that do not meet the Horizontal Position Accuracy as defined in Section 3.2 or do not meet the Vertical Uncertainty standards as defined in Section 5.1.3, shall not be applied to the grid.

As always, the hydrographer must ensure that the data accurately reflects the condition of the seafloor at the time of the survey and adjust operations if required. Any deviations from the specifications must be clearly explained in the Descriptive Report and discussed with the COR as they occur.

Attribution

By definition each node of the grid includes not only a depth value, but other attributes. The following minimum attributes shall be associated with each grid node

- Depth Value

- Total Vertical Uncertainty: The uncertainty value for the grid node shall be the greater of the standard deviation of the soundings contributing to the depth solution, and the a priori computed uncertainty estimate. The hydrographer shall include a discussion in the DAPR on how the uncertainty was computed on each individual sounding and how the uncertainty was computed on the grid, with a justification for that methodology. The hydrographer shall examine the finalized grids and explain and explain in the DR any areas of unusually high uncertainty.

- Shoal Depth: Depth value of the shoalest measurement which contributed to the depth solution.

- Sounding Density: Number of soundings contributing to the depth solution.

- Standard Deviation: Standard deviation of the depths within the capture radius of the node.

5.3.3 Corrections to Lidar Soundings

To meet the accuracy and resolution standards for measured depths specified in Section 5.2.3, and to create a Bathymetric Attributed Grid (BAG) that includes an accurate uncertainty layer, the hydrographer should conduct an error analysis of their survey systems. Precise measurements are fundamental to the field of hydrography. Synchronization of multiple sensors with the lidar system is essential for meaningful spatial analysis of the data. All measurements, however careful and scientific, are subject to some uncertainties. Error analysis is the study and

evaluation of these uncertainties with the purpose of estimating the extent of the uncertainties and when necessary, reducing them. In recognition of the possibility that some discrepancies in sounding may not be detected until the final processing phase of the survey, the determination and application of corrections to soundings must be accomplished and documented in a systematic manner. In addition, it is preferable that all corrections be applied in such a way that the on-line values may be removed and replaced with a revised set of correctors during office processing. Corrections to soundings are divided into five categories, and listed below in the sequence in which they are applied: Instrument error corrections account for sources of error related to the sounding equipment itself. Roll, pitch, heading, and navigation timing error (latency) corrections shall be applied to lidar soundings to correct the effect of the aircraft's motion caused by turbulence, the error in the aircraft's heading, and the time delay from the moment the position is measured until the data is received by the data collection system (navigation timing error). The hydrographer shall also discuss (in Section 8.1.4 B2. of the Descriptive Report) the methods used to quantify the survey systems error model. Uncertainty estimates for all components of the sounding measurement should be provided.

Instrument Error Corrections

In modern digital sounding instruments, instrument errors are generally small and of a fixed magnitude independent of the observed depth. Proper set up and adjustment of Lidar equipment using internal checks will often eliminate instrument error entirely. However, to ensure the proper operation of the lidar system "confidence checks" shall be conducted periodically. Frequent checks should be made between the overlap of main scheme and crosslines collected on different days. These comparisons should be made frequently during data collection to find errors promptly, and not saved until final data processing after the field party has left the working grounds. Any differences should be investigated, and if, after analysis, a corrector is necessary, it should be applied with an explanation of the cause of the difference explained in the Descriptive Report (DR) Section 8.1.4 B2., Quality Control.

5.3.4 Quality Control

5.3.4.1 Lidar Calibration

Field calibration is performed by the system operator through flights over a calibration site that has been accurately surveyed using GPS or conventional survey techniques such as triangulation or spirit leveling. Typically, the calibration site may include a large, flat-roofed building whose corners have been accurately surveyed with GPS and a large, flat parking lot and runway. The calibration may include flights over the site in opposing directions, as well as cross flights. The field calibration is used to determine corrections to the roll, pitch, and scale calibration parameters. Field calibrations must be performed for each project or every month, whichever is shorter. Prior to commencing survey operations, the hydrographer shall conduct a system accuracy test to quantify the accuracy, precision, and alignment of the lidar system. Testing shall include determination of residual biases in roll, pitch, heading, and navigation timing error and the uncertainty of these values. These values will be used to correct the initial alignment, calibrate the lidar system and used in the computation of the Total Propagated Uncertainty (TPU). Once calibration data have been processed and final system biases determined, the new corrections shall be used in a performance check to ensure that the new system biases are adequate. The hydrographer shall discuss procedures and results in Section A. Equipment and optional Section B. Quality Control of the project Data Acquisition and Processing Report (Section 8.1.5.1). Copies of all system alignment, accuracy, calibration reports, and performance checks shall be included in the Data Acquisition and Processing Report. System accuracy testing shall be repeated whenever changes (e.g., sensor failure, replacement, reinstallations, reconfigurations, or upgrade; software changes which could potentially affect data quality) are made to the system's baseline configuration, or whenever assessment of the data indicates that system accuracies do not meet the requirements in Section 5.2.3.

5.3.4.2 Positioning System Confidence Checks

See Section 3.2 Section 3.3 for details.

5.3.4.3 Lidar Crosslines

General: The regular system of sounding lines shall be supplemented by a series of crosslines for verifying and evaluating the accuracy and reliability of surveyed soundings and positions. Crosslines shall have good temporal and geographic distribution.

Crosslines shall be acquired and processed to the same accuracy and data quality standards as required for mainscheme lines and shall be included in the grids that are submitted as the final bathymetric product of the survey. Lineal of crosslines shall be at least 4 % of main scheme mileage in areas requiring complete coverage (refer to 5.3.2).

Under certain conditions (e.g., steep terrain, airspace restrictions, or relatively narrow band of coverage) crosslines may not be possible. In such cases, a deviation from this requirement shall be requested from the COR and explained in the Descriptive Report.

The hydrographer shall make a general evaluation of the lidar crossline to main scheme agreement, and discuss the results in Section 8.1.4 B of the Descriptive Report. If the magnitude of the discrepancy varies widely over the survey, the hydrographer shall make a quantitative evaluation of the disagreements area by area.

An independent analysis of the crossline and main scheme data shall be conducted. Although any crossline/main scheme disagreements should be obvious in the attributes of the combined surface, an independent analysis is still required to ensure that the surface implementation is correct and to help find any hidden problems. Include a statement regarding the results of the comparison in Section 8.1.4 B of the Descriptive Report. If created, the difference surface shall also be included in the final deliverables.

6 Acoustic Backscatter

Contents

During hydrographic surveys, the use of side scan sonar may be required for supplementing echosounding by searching the region between regular sounding lines for additional indications of dangers and bathymetric irregularities to meet object detection requirements. The use of side scan sonar to meet object detection requirements does not alleviate the responsibility of the hydrographer to investigate features or acquire splits as discussed in Section 5.2.2.1. Any requirement for side scan sonar coverage in conjunction with a hydrographic survey will be specified in the Hydrographic Survey Project Instructions.

6.1 Towed Side Scan Sonar

6.1.1 Coverage

Scanning coverage is the concept used to describe the extent to which the bottom has been covered by side scan sonar swaths, that is, the band of sea bottom which is ensonified and recorded along a single vessel track line. For hydrographic purposes, scanning coverage of an area is expressed in multiples of 100 percent, and is cumulative. One hundred percent coverage results in an area ensonified once, and two hundred percent coverage results in an area ensonified twice. Advisory note: Side scan coverage may not be achieved as planned due to varying water conditions, such as thermoclines, limiting such coverage.

The scanning coverage requirements will be stated in the Project Instructions. Approved 200-percent coverage techniques are as follows:

Technique 1. Conduct a single survey wherein the vessel track lines are separated by one-half the distance required for 100-percent coverage.

Technique 2. Conduct two separate 100-percent coverages wherein the vessel track lines during the second coverage split the difference between the track lines of the first coverage. Final track spacing is essentially the same as technique 1.

Technique 3. Conduct two separate 100-percent coverages in orthogonal directions. This technique may be advantageous when searching for small man-made objects on the bottom as the bottom is ensonified in different aspects. However, basic line spacing requirements for single-beam echosounders may not be met when using this technique.

6.1.2 Side Scan Acquisition Parameters and Requirements

6.1.2.1 Accuracy

The side scan sonar system shall be operated in such a manner that it is capable of detecting an object on the sea floor that measures 1 m x 1 m x 1 m from shadow length measurements.

6.1.2.2 Speed

The hydrographer shall tow the side scan sonar at a speed such that an object 1 m x 1 m x 1 m would be independently ensonified a minimum of three times per pass.

6.1.2.3 Towfish Height

The hydrographer shall operate the side scan sonar system with a towfish height above the bottom of 8 percent to 20 percent of the range scale in use. For any towfish height below 8 percent of the range scale in use, the effective scanning range is defined to equal 12.5 times the towfish height, provided adequate echoes have been received.

In areas with excessive bathymetry variability or when hull mounted systems are used, the hydrographer shall ensure that coverage and object detection are met. When the towfish height has exceeded the maximum threshold, either the hydrographer needs to take extra care in examining the data for contacts with reduced shadow lengths or re-acquire the data at an appropriate depth. Likewise if the minimum towfish height is not met, additional lines (or splits) may be required to meet coverage requirements.

6.1.2.4 Horizontal Range

The achievable horizontal range of a side scan sonar is a function of several parameters. Among these are sonar conditions, sea bed composition, the range scale in use, side scan sonar system characteristics, and towfish height. Actual conditions in the survey area will determine the effective range of a particular side scan sonar system. The maximum allowable range scale for any towed side scan sonar is 100 m.

If the effective range scale of the side scan sonar is reduced due to external factors, then the representation of the swath coverage should be reduced accordingly. For example, changes in the water column or inclement weather may distort the outer half of the 100 m range scale. In this case, only 50 m of effective range could be claimed.

6.1.3 Quality Control

6.1.3.1 Confidence Checks

Confidence checks of the side scan sonar system shall be conducted at least once daily. These checks should be accomplished at the outer limits of the range scales being used based on a target near or on the bottom. Each sonar channel (i.e., port and starboard channels) shall be checked to verify proper system tuning and operation. Confidence checks can be made on any discrete object, offshore structure, or bottom feature which is convenient or incidental to the survey area. Targets can include wrecks, offshore structures, navigation buoy moorings, distinct

trawl scours, or sand ripples.

Confidence checks can be made during the course of survey operations by noting the check feature on the sonargram. If a convenient or incidental target is not available, a known target may be placed on or near the bottom and used for confidence checks. Confidence checks shall be an integral part of the daily side scan sonar operation and shall be annotated, including time of check, in the side scan sonar acquisition and processing logs (Section 8.2.3).

6.1.3.2 Side Scan Sonar Contacts

In depths of water less than or equal to 20 m, contacts shall be picked that have computed target heights (based on side scan sonar shadow lengths) of at least 1 m. In depths of water greater than 20 m, contacts shall be picked that have computed target heights rising above the bottom at least 5 percent of the depth. Other contacts may be picked if the sonargram signature (e.g., size, shape, or pattern qualities) is notable.

All contacts identified shall be developed with a multibeam echosounder using the object detection or complete coverage grid resolutions (defined in Section 5.2.2.2 and 5.2.2.3), as assigned in the Project Instructions to determine the least depth of the contact. The least depth measurement should be determined from a beam within 30 degrees of nadir unless multiple passes were made over the contact. When a contact is correlated to multibeam data acquired concurrently with side scan sonar operations, the contact shall be developed further if the correlating sounding is sourced from one of the multibeam system's outer beams. If a side scan sonar contact will lead to a FFF feature, follow the FFF feature development guidance in Section 7.3.3.

If a contact must be developed by a single beam echosounder, dive investigations shall be used to determine the contact's depth with a diver's least depth gauge when it is practical. The shoaler depth of the two methods shall be used for contact's reported depth. A dive investigation may be conducted to supplement data from a multibeam echosounder development.

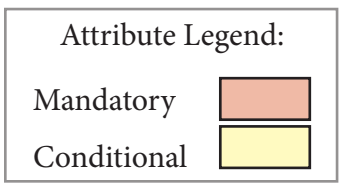
For a 200% SSS with concurrent object detection multibeam survey, when multiple contacts are located during the first 100% side scan coverage of an area, the hydrographer may determine that is more efficient to survey the area completely with the multibeam echosounder rather than survey the second 100% and develop each contact individually. In this case the hydrographer shall meet the requirement for object detection stated in Section 5.2.2.2.

In areas where the water depth and the size of the area containing multiple contacts make this approach prohibitive an alternative gridding method may be used. Once 200% coverage has been achieved and all contacts correlated, the hydrographer may divide the area into 400 square meter investigation cells and develop the most significant contact in each investigation cell. If the developed contact's measured height off the bottom is significantly less that the contact height from the sonar record and is less than the next most significant contact height in the grid cell the hydrographer shall develop the next most significant contact.

6.1.3.3 Side Scan Sonar Contact Attribution

The following is a list of required NOAA Extended Attributes for Side Scan Sonar contact points to be delivered in the side scan sonar contact file (Section 8.2.2).

The following Attribute Legend shall be used for the subsequent table:



$CSYMB (Cartographic Symbol)	S-57 object required for side scan sonar contact points in the side scan contact file	
Acronym	**SSS Contact Information**	**Description**
cnthgt	Contact Height	Computed contact height
images	Images	Images associated with a contact †
userid	Contact Number	Unique identification number of the contact (e.g. 0001, 0002, etc.)
remrks	Remarks	Additional comments not captured in other attributes
prmsec	Primary/Secondary	Indicates status of contact during correlation

† Images:

- *Accepted formats: JPEG, PNG, GIF, TIFF*
- *SSS contact images must have a unique identification name*
- *Multiple images for one contact shall be semi-colon delimited*
- *All SSS contact images shall be placed in the Multimedia folder. A copy of the side scan contact images should remain in the CARIS HDCS folder if CARIS software is used for processing.*

6.1.3.4 Side Scan Sonar Contact Correlation

The hydrographer shall examine and correlate targets between successive side scan sonar coverages (i.e., compare the first 100 percent with the second 100 percent sonar coverage). If applicable, the hydrographer shall examine the multibeam data and correlate anomalous features or soundings with the side scan sonar data. Anomalous features or targets which appear consistently and correlate in each type of data record provide increased confidence that acquisition systems are working correctly and help to confirm the existence of these features or targets. The hydrographer shall cross reference and remark on each target correlation in the conditional "remrks" extended attribute or the discretionary "prmsec" attribute.

6.1.3.5 Identification of Features

The hydrographer shall use the SSS Contact File, in conjunction with an analysis of echosounder least depths and BAG attributes (standard deviation, uncertainty, etc), to identify features which may require a development and inclusion in the FFF (Section 7.3).

6.2 Multibeam Echosounder Seafloor Backscatter

All multibeam echosounder surveys require concurrent time series backscatter acquisition to supplement the utility of hydrographic data for non-charting purposes.

6.2.1 Coverage

When specified in the Hydrographic Survey Project Instructions, seafloor backscatter data will be evaluated for gaps in backscatter coverage. A backscatter gap (holiday) has the same definition as the multibeam echosounder holiday (Sections 5.2.2.2 and 5.2.2.3).

6.2.2 Acquisition Parameters and Requirements

6.2.2.1 Accuracy

When specified in the Project Instructions, verification may be required to 'ground truth' seafloor backscatter data. Sampling locations should be judiciously selected to verify areas of obvious or apparent bottom composition change or to address specific requirements in the Project Instructions. Special handling instructions beyond normal bottom sample requirements will be specified in the Project Instructions.

Any understanding of the reported backscatter accuracy shall be recorded in the form of a backscatter offset or beam pattern. Any indication of misreported settings versus actual used settings (i.e. reported transmit power used versus actual transmit power) shall also be reported for the particular systems in use during the survey.

6.2.2.2 Acquisition Parameters

The adjustment of multibeam settings should be minimized to limit the likelihood of artifacts in the resulting backscatter products. All real time acquisition parameters that are needed to conduct post processing need to be included with the digital data. Backscatter samples shall be collected so as to allow for contiguous samples across the beam footprint for each seafloor detection, but the backscatter coverage shall not exceed 1.5 times the beam footprint.

6.2.2.3 Requirements

Efforts shall be made to avoid multibeam receiver acoustic saturation of the backscatter data.

7 Features

Contents

7.1 Feature Definition

A feature can be any anthropogenic or natural object that may merit individual cartographic representation (e.g. rocks, wrecks, obstructions).

The minimum size of a feature that is required to be found and represented in the submitted surface is different for water depths in object detection (i.e. features ≥ 1 m x 1 m x 1 m) and complete coverage (i.e. features ≥ 2 m x 2 m x 1 m) requirements, see Sections 5.2.2.2 and 5.2.2.3, respectively.

7.2 Composite Source File and Project Reference File

A Composite Source File (CSF) and Project Reference File (PRF) shall be provided with the Project Instructions. If no PRF/CSF is provided, contact the HSD/NSD Project Manager or COR for advice on how to proceed with feature verification. The CSF is an S-57 attributed (Section 7.5) data set compiled from applicable sources (ENCs, preliminary ENCs, and geographic cells), providing the field unit with the largest scale and most up to date shoreline data. The CSF is the foundation for the Final Feature File (FFF) deliverable (Section 7.3).

The PRF is a NOAA Extended attributed (Section 7.5.2) data set containing reference layers such as survey limits, junctions (Section 7.2.2), recommended bottom sample locations and features which are specifically targeted for investigation (e.g. Maritime Boundary Points, Section 7.2.1).

The PRF features are represented by the following S-57 feature objects:

REFERENCE FEATURE	S-57 OBJECTS	DESCRIPTION
Investigation Items	CRANES	Lidar, Maritime Boundary investigation items
Survey Limits	TESARE	Outline survey limits
Junction Limits	TWRTPT	Outline of junction survey
Bottom Samples	SPRING	Recommended bottom sample locations

The PRF features are described with the following NOAA extended attributes:

REFERENCE FEATURE	ATTRIBUTION	DESCRIPTION
Maritime Boundary	asgnmt	Assigned or For Info Only
	invreq	Description requirements
	sftype	Maritime Boundary
Lidar	asgnmt	Assigned
	remrks	Lidar remarks and description
	sftype	Lidar investigation
Survey Limits	invreq	Survey, Priority, Name
Junctions	invreq	Survey, Platform, Year, Scale
Bottom Samples	asgnmt	Assigned
	invreq	Description of requirements

7.2.1 Maritime Boundary Points

Maritime Boundary Investigations are required because OCS is responsible for depicting the maritime zones: 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.

The maritime boundary verification requests are compiled by HSD/NSD Project Managers or COR and delivered with the Project Instructions in the PRF as the S-57 Object Crane (CRANES). The NOAA Extended Attributes Special Feature Type (sftype) is populated with "MARITIME BOUNDARY", Assignment (asgnmt) is populated with "Assigned" for rocks requiring verification and "For Info Only" for existing maritime boundary points which do not require verification. In addition, Investigation Requirements (invreq) is populated with a brief description of the verification requirements. A further description of verification requirements is as follows:

The maritime boundary points are placeholders (similar to suggested bottom sample locations) which indicate a location where the hydrographer is responsible for verifying the existence of the furthest offshore feature that is dry at MLLW (i.e. has a height relative to MHW). Verification techniques may include 100% MBES coverage to define the maritime boundary, taking detached positions with a range and bearing, or by direct occupation with a portable GPS system. The detached position should consist of latitude, longitude, height, and appropriate S-57 attribution for that feature. Verification also includes taking a digital photograph of the feature to be included in the NOAA Extended Attribute "images" and filed in the Multimedia folder. No further verification for defining the maritime boundary is required once the furthest offshore feature that is dry at MLLW is determined.

The accuracy for maritime boundary points shall meet the minimum horizontal position accuracy requirement set forth in Section 3.2.

If the assigned Maritime Boundary Point is not found or is not dry at MLLW, then the next furthest offshore feature that is dry at MLLW shall be verified. The hydrographer shall not extend their maritime boundary point search outside of their assigned survey limits. The hydrographer shall use the existing baseline points ("For Info Only" Maritime Boundary points located in the PRF) to support maritime boundary point determination. The field unit shall contact HSD/NSD Project Manager or COR with any questions regarding addressing assigned maritime boundary points.

7.2.2 Junctions

Junctions are defined as areas where two surveys overlap. A Prior Junction is between the current survey and a survey that was conducted prior to the current survey project but using modern techniques (i.e. typically 2000 to present). A Current Junction is between sheets of the current year survey project.

The PRF file includes current surveys in the S-57 object TESARE with the survey, priority, and name located in the customized attribute, invreq. The PRF file includes prior surveys in the S-57 object TWRTPT with the prior survey, platform, year, and scale located in the customized attribute, invreq. Prior survey grids, and their respective DRs, will be provided to the field units in the survey project files. If a Prior Junction grid is missing, contact the HSD/NSD Project Manager or COR.

The prior and current surveys share a boundary in the PRF file. The field unit must ensure junction overlap is acquired for both Prior Junctions and Current Junctions. Junction overlap varies by depth and coverage technique but is defined the same for both Prior Junctions and Current Junctions (see below).

Junction Overlap

Prior Junction and Current Junction overlap shall be approximately one bathymetric swath width at the nominal depth of junction. The field unit shall ensure there are no unexplained junction holidays. If the field unit is unsure about a specific junction overlap requirement, contact the HSD/NSD Project Manager or COR.

Junctions shall be evaluated for completeness (i.e. required junction overlap) and relative agreement of depths. When possible, junction evaluations shall be performed at the same resolution. The hydrographer shall evaluate junction agreement and discuss the method and results in Section B of the DR (Section 8.1.4).

7.2.3 Bottom Characteristics

The character of the bottom shall be determined for nautical charting, particularly in harbors, designated anchorages, and in other areas where vessels may anchor. In addition to furnishing information for selecting anchorages, charted bottom characteristics assist fisherman in selecting areas where fish may be found while avoiding places where equipment may be damaged.

In general, sampling the surface sediment layer is usually adequate to define the bottom characteristics for charting. Clamshell bottom snappers or similar bottom samplers should be used to obtain as large a sample as possible. If a more detailed study of the ocean floor is required the project instructions will specify the type of sampler to use.

When a field unit is assigned to conduct bottom samples, the field unit should review the bottom sample plan provided within the Hydrographic Survey Project Instructions to the survey data acquired. The field unit should contact HSD/NSD Project Manager or COR to discuss modifying the bottom sample plan if the data suggest more appropriate locations for the bottom samples (e.g. depth at specified sampling location is > 80 m, backscatter data indicate homogeneous bottom type, etc.). The survey data will often better differentiate varying bottom characteristics within the survey area when compared to the sample plan provided. This may increase or decrease the sample density but should closely maintain the same numbers of samples per survey as originally assigned.

In areas where bottom samples are not required but where the general trend of the newly surveyed depths has changed significantly since prior surveys, the field unit shall contact HSD/NSD Project Manager or COR as appropriate to determine if bottom samples are necessary and to define the sample density.

When sampling is required, the hydrographer shall record position for each sample obtained. In addition, each

sample shall be described and completely attributed in the S-57 feature file. Refer to Section 7.5.1 for more detailed guidance on S-57 attribution of bottom samples.

7.3 Final Feature File

The Final Feature File (FFF) is the feature deliverable for an individual survey (i.e. HXXXXX_FFF). The FFF shall be delivered in S-57 .000 format. The FFF shall contain attributed information on specific objects that cannot be portrayed in a simple depth grid (Section 7.5). General soundings, contours, depth areas and area meta objects shall not be included in the FFF as these objects will be derived from finalized surfaces during chart compilation. In rare cases, an isolated sounding may be part of the FFF if it is a navigationally significant shoal and/or needs additional attribution. All Danger to Navigation features (Section 1.6) shall be included in the FFF with position and elevation reflecting the application of final correctors. Features to include in the FFF include are defined below:

7.3.1 Assigned Features

All Composite Source File (CSF) features with the NOAA extended attribute 'asgnmt' populated with 'Assigned' shall be addressed and included in the FFF. The investigation requirement attribute, 'invreq,' will provide more information on how to address an assigned feature based on its feature class. The following general guidance shall also be used to address an assigned feature:

- Assigned features located inshore the 0.8 mm buffer: address if assigned by HSD/NSD Project Manager or COR. These are rare and would likely be a maritime boundary point or a feature considered navigationally significant.

- Assigned features located between the field-surveyed NALL and the 0.8 mm buffer: address by including all assigned features in the FFF with 'descrp'= "Not Addressed" and 'remrks'= "Retain as charted, not investigated due to being inshore of NALL." If a feature in this zone is deemed navigationally significant and is safe to approach, the feature may be more thoroughly investigated.

  Note: Navigational significance depends on several factors: location, proximity to shore, proximity to other features, and the marine traffic patterns/usage in the area. Ideally the person making the determination of navigational significance has extensive experience using nautical charts for navigation and can convey that perspective to the personnel conducting the field survey work. This is typically the NOAA vessel Commanding Officer (Chief-of-Party), Field Operations Officer, Hydrographer-in-Charge, or the contractor's Lead Hydrographer.

- Assigned features located within survey coverage, offshore of the NALL: address by including in the FFF with appropriate attribution (Section 7.3).

  Note: Assigned submerged rocks within survey coverage, offshore of the NALL may be addressed by including in the FFF with 'descrp' = delete and 'recomd' = categorization as rock or sounding left to cartographic discretion. No feature development or designated sounding is required in this case. If, however, the hydrographer determines it is necessary to continue to represent a submerged rock as S-57 object UWTROC instead of bathymetric soundings/curves, a feature development and designated sounding is required and the updated rock feature shall be included in the FFF with appropriate attribution.

Unassigned Features

All Composite Source File (CSF) features with the NOAA extended attribute 'asgnmt' populated with 'Unassigned' will be located outside of the sheet limit provided in the PRF. These features do not need to be addressed by the

field unit and shall not be included in the FFF. The field unit has the option of addressing an 'Unassigned' feature if it is deemed navigationally significant and safe to approach. Contact the HSD/NSD Project Manager or COR as needed.

For Info Only Features

All Composite Source File (CSF) features with the NOAA extended attribute 'asgnmt' populated with 'For Info Only' will be located within and outside of survey coverage. These features do not need to be addressed by the field unit and shall not be included in the FFF. They are sourced from the ENC or geographic cells and are simply included in the CSF for the hydrographer's awareness during survey operations. If applicable, the hydrographer shall note discrepancies of these features in the DR (Section 8.1.4 D.1 Chart Comparison).

7.3.2 New Features

The following guidance shall be followed with respect to newly discovered features and their inclusion in the FFF: A feature, by definition in Section 7.1, may merit individual cartographic representation. Departures from the below new feature guidance shall be individually discussed in the DR.

- All new anthropogenic features (e.g. obstructions, wrecks, etc.) that at least meet the appropriate minimum required feature size for the assigned coverage requirement (e.g. 1 m x 1 m x 1 m and greater for object detection) shall be included in the FFF.

- All new, submerged, natural features (i.e. rocks with attribute WATLEV=3) that meet the appropriate minimum required feature size for the assigned coverage requirement shall be appropriately represented in the submitted surface (Section 7.3) but shall not be included in the FFF. Exception: all named rocks within the survey area shall be appropriately represented in the surface and included in the FFF.

- All new natural features, exposed at tidal datum (i.e. WATLEV = 1, 2, 4, or 5) that pose a danger to surface navigation shall first be considered for a Danger to Navigation submission (Section 1.6) and also included in the FFF.

- Features with any horizontal dimension greater than 1.0 mm at survey scale shall be treated as area features and delineated appropriately. Features with lesser horizontal dimensions shall be positioned and attributed as point features.

7.3.3 Feature Developments

All submerged features required for inclusion in the FFF (Section 7.3) with a descrp = new or descrp = update (Section 7.5.2) that are detected with bathymetry shall be further developed to better estimate a reliable least depth. A development can be achieved with multibeam water column, divers least depth gauge, wire drag, mechanical sweep, or an additional acquired line of multibeam data oriented perpendicular to the mainscheme hydrography.

Note: Feature developments, as described above, have different requirements than SSS contact developments, as described in Section 6.1.3.2. Only a subset of SSS contacts will potentially become FFF features (Section 7.3).

7.3.4 Feature Disprovals

If a feature that needs to be addressed is not detected in the field, a formal feature disproval shall be undertaken. The field unit should reference the investigation requirement attribute, invreq, and contact HSD/NSD Project Manager or COR if it is unclear if a feature disproval is required. In certain cases (e.g. 100% SSS with concurrent

multibeam), a disproval search radius will be assigned in the Project Instructions. This search radius will be based on the status of the charted feature (e.g. PA, PD, ED) and the survey scale. If the formal disproval indicates the feature does not exist, the disproved feature shall be included in the FFF with the appropriate NOAA extended attribution (i.e. descrp=delete).

Feature disproval techniques for an object detection survey:

- Object detection multibeam (Section 5.2.2.2) or
- 200% side scan sonar coverage that conforms to Section 6.1.1

Feature disproval techniques for a complete coverage survey:

- Complete coverage multibeam (Section 5.2.2.3) or
- 200% side scan sonar coverage that conforms to Section 6.1.1

  Note: 100% side scan sonar coverage is not sufficient to disprove a feature.

7.3.5 Aids to Navigation

The hydrographer shall investigate all U.S. Coast Guard (USCG) and privately maintained fixed and floating aids to navigation located within the survey limits. Upon inspection of the most recent edition of the largest scale chart of the survey area and the latest edition of the USCG Light List (available online at http://www.navcen.uscg.gov/?pageName=lightlists), the hydrographer shall confirm the aid's characteristics at time of investigation and determine whether the aid adequately serves the intended purpose for which it was established. The results of all aid to navigation (ATON) investigations shall be summarized in the DR (Section 8.1.4 D.2).

On Station

If located on station and serving its intended purpose, USCG maintained aids and privately maintained fixed and floating aids to navigation shall included in the FFF with descrp = retain.

Off Station

If the hydrographer determines that an aid to navigation is located off station, is damaged to the extent that it does not serve its intended purpose or its characteristics are incorrectly charted, the hydrographer shall report the information in the form of a Danger to Navigation (Section 1.6) and include the ATON in the FFF (Section 7.3.5) with correct attribution. The Navigation Manager for the survey area shall be CC'ed on the Danger to Navigation submission.

Uncharted

If an uncharted fixed or floating aid to navigation is discovered within the survey area, the hydrographer shall obtain a position meeting Section 2.2 specifications on the aid and report the new ATON promptly to the Navigation Manager and submit a Danger to Navigation Report (Section 1.6). Include geographic position, characteristics, apparent purpose, and by whom the aid is maintained (if known). The uncharted ATON shall be included in the FFF (Section 7.3.5). If an uncharted aid to navigation is temporary in nature or repositioned frequently, do not submit a DTON report, do not include the ATON in the FFF, but do note its existence in DR Section 8.1.4 D2.

Specific Requirements

Other fixed and floating aids to navigation and landmarks within the survey area may require specific positioning methods which will be provided in the Project Instructions.

7.4 Designated Soundings

The hydrographer has the responsibility to review the surface and ensure that it reflects the conditions in the survey area. Even in cases where the appropriate resolution was selected, it is possible that the grid may fail to portray some navigationally significant depths and features. At the hydrographer's discretion, a sounding may be "designated", meaning it will override the gridded surface and force the model to recognize an estimated reliable least depth. These are also known as golden soundings.

Designated soundings are created primarily to 1) facilitate FFF feature management (see below) but selectively 2) they may be created in areas of critical underkeel clearance to override the gridded surface model to recognize an estimated least depth (Section 5.2.1.2.3).

1. Feature Management - The criteria for designated soundings created to aid in feature management:

a. A designated sounding shall be selected over submerged addressed features required for inclusion in the FFF (i.e. descrp = new or descrp = update), as defined in Section 7.3.

b. Survey Scale: When the distance between two features that would otherwise warrant individual designation is less than 2 mm at the scale of survey (e.g. 20 m for 1:10,000 scale) then only the shoalest of those features shall be designated and included in the FFF.

c. In some cases, often in rocky nearshore areas, the least depths of many features in a relatively small area may fail to be preserved, even by very high resolution gridded surfaces. In these instances, the hydrographer shall designate the least depths on the most significant, shoalest features as required by the navigational use of the area and the scale of the survey. Only those features that meet the feature definition in Section 7.1 (i.e. may merit cartographic representation) shall be included in the FFF.

2. Override the gridded surface model - Section 5.2.1.2.3.

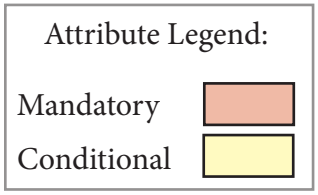
7.5 Feature Attribution

Features shall be attributed using the International Hydrographic Organization (IHO) Special Publication 57 (IHO S-57), the IHO Transfer Standard for Digital Hydrographic Data. The IHO intends for the standard to be used for the exchange of digital hydrographic data between hydrographic offices, and for the distribution of hydrographic data to manufacturers, mariners and other data users. It was developed so that the transfer of all forms of hydrographic data would take place in a consistent and uniform manner. IHO Special Publication 57 may be downloaded at www.iho.shom.fr.

These Specifications will not attempt to include all possible S-57 objects and attribution that may be used to support hydrographic survey data. They shall identify the objects and attribution that are required for NOAA hydrographic survey data. If the hydrographer has any questions on the appropriate attribution for an object, they should contact the HSD/NSD Project Manager or COR for clarification.

7.5.1 S-57 Attribution

The following Attribute Legend shall be used for the subsequent tables in Section 7.5.1:



All FFF (see Section 7.3) features shall have the attribution of SORIND and SORDAT populated. Exception for LNDARE feature class: only descrp = new and descrp = update LNDARE features are required to have SORIND and SORDAT populated.

Disproved and Retained features (i.e. descrp=delete and descrp=retain) will always maintain the original SORDAT and SORIND from the CSF.

Attribute	Description	
All Feature Objects	All surveyed objects will have the following attributes populated.	
SORIND	Source Indication	Information about the source of the object
• *Country Code - US* • *US Authority code - US for OSC* • *Source - graph* • *ID code - registry number* • *Ex: US,US,graph,H12345*		
SORDAT	Source Date	The last day of survey acquisition formatted as YYYYMMDD
Instances which require altering SORDAT and SORIND: • New feature • Modification to the geographic position of a feature • Modification to the geometry (shape) of a feature • Modification to the geographic primitive of a feature (e.g. point becomes line) • Modification to a feature's S-57 object class • Modification or addition to a feature's attribution		
Note: • *There shall not be any spaces after comma separated values in SORIND*		

The following table includes mandatory and conditional S-57 Attribution requirements for the most common features found in an FFF (Section 7.3) as well as some specific guidance in the note sections for each feature class. The table includes the following feature classes: SOUNDG, WRECKS, UWTROC, OBSTRN, PILPNT, MORFAC, SBDARE, COALNE, SLCONS, LNDARE, and LNDELV. If a field unit has a question regarding attribution for a FFF feature class not listed, contact the HSD/NSD Project Manager or COR for guidance.

Note: Features that have been formally disproved (Section 7.3) will maintain the original S-57 attribution.

Object	Attributes	
	Acronym	Description
SOUNDG (Sounding)	TECSOU *	(Technique of sounding measurement)
	QUASOU **	(Quality of sounding measurement)

Note:

- *Only soundings for DTONs or other significant shoals should be included in the feature file.*
- *All depth units are in meters with at least decimeter precision.*

* ***Technique of Measurement for Height or Depth (TECSOU)***	***S-57 Attribute ID***
VBES (single beam) alone	*'1' found by echo-sounder*
Side Scan Sonar alone	'2' found by side scan sonar
Multibeam alone	'3' found by multibeam
Skunk Striping (full coverage SSS with partial coverage multibeam)	'3' found by multibeam, with CATZOC reflecting lack of full coverage
Diver depth	'4' found by diver
LIDAR alone	'7' found by laser
Heights on rocks or islets using range finder or visual estimation	'12' found by leveling

***QUASOU: All sounding features that were surveyed using a multibeam echo sounder, single beam echosounder, or lidar to NOAA/IHO standards are assumed to be QUASOU Depth Known. In these cases QUASOU should be left null. Attribute QUASOU only in the cases outlined below:*

- *Depth Unknown: Use this category for obstruction area objects, such as foul areas, where "Unknown" is used for VALSOU and WATLEV.*

- *Least Depth Known: Shall be populated with point objects (i.e. wrecks, rocks, and obstructions) under these circumstances:*
  - *Depth derived using Multibeam Echosounder (MBES) System*
  - *Diver investigation using Diver Least Depth Gauge (DLDG)*
  - *Manual Depth Measurement Equipment using lead line or sounding poles*
  - *Sounding "designated" from the Surface*
  - *Feature height derived by leveling*

- *Value Reported (not confirmed): Use this category for Side Scan Sonar contacts in which a sonar depth is not acquired and which the side scan contact has not been investigated.*

Object	Attribute	
	Acronym	**Description**
Features:	For all sounding-based features, see instructions for populating TECSOU and QUASOU attributes under DEPTHS, above.	
WRECKS (wreck)	CATWRK	(Category of wreck)
	WATLEV	(Water level effect)
	VALSOU	(Value of sounding)
	TECSOU	(Technique of sounding measurement)
	QUASOU	(Quality of sounding measurement)
Note: *Reference Appendix F for WATLEV attribution.*		
UWTROC (Underwater/Awash/Covers & Uncovers Rock)	VALSOU	(Value of sounding)
	WATLEV	(Water level effect)
	QUASOU	(Quality of Sounding Measurement)
	TECSOU	(Technique of sounding measurement)
Note: *Reference Appendix F for WATLEV attribution.* • *If several assigned rocks are found to be part of a inshore rocky area, the hydrographer may elect to delineate the area as foul area (OBSTRN area with CATOBS = Foul Area) and forgo investigating each individual rock (i.e. descrp=Not addressed, remrks= "Rock is part of foul area"). The hydrographer shall address any rocks that they feel are navigationally significant within the foul area.*		
OBSTRN (Obstruction)	VALSOU*	(Value of sounding)
	WATLEV**	(Water level effect)
	QUASOU	(Quality of Sounding Measurement)
	TECSOU	(Technique of sounding measurement)
	CATOBS	(Category of Obstruction)
	NATSUR	(Nature of Surface)
** <u>For line or area objects</u> - VALSOU should represent the shoalest depth representing the feature or within the area obstruction and should match either the shoalest grid node or designated data point. VALSOU should be left blank if depth not available.* ***<u>For line or area objects</u> - If VALSOU is not known, use WATLEV = "Unknown". If a VALSOU least depth is given, use WATLEV = Covers and Uncovers, Awash or Always Submerged.* *Reference Appendix F for WATLEV attribution.* *OBSTRN CATOBS =2 (wellhead) guidance:* *1. If wellhead is found and considered a danger to navigation, develop the feature (7.3.3), designate the feature (7.4), submit it as a DTON (1.5), and include it in the FFF (7.3).* *2. If wellhead is found and merits individual cartographic representation, develop the feature (7.3.3), designate it (7.4), and submit in FFF (7.3). Note: if the wellhead is deeper than 20 m then it is unlikely to merit individual cartographic representation.* *3. If wellhead is found and does not merit cartographic representation, do not investigate it as a feature. Include it in the FFF with "descrp = delete" and "remrks=wellhead addressed as represented in the surface"* *4. If the wellhead is not found, in cases where 100% SSS with concurrent multibeam is being used as the primary coverage technique, a 50 m disproval search radius using a technique described in Section 7.3.4 is necessary. Include in the FFF with descrp = delete.*		

PILPNT (Pile)	CATPLE	(Category of pile)
	CONDTN	(Condition)

Note:

- *MBES data on pilings supporting and abutting piers and superstructures shall be rejected. The piers or structures shall be surveyed as shoreline construction (SLCONS) features.*
- *If a PILPNT is found to be submerged, the object shall be classified as an OBSTRN with CATOBS = 1. Reference Appendix F for WATLEV attribution.*

MORFAC (Mooring/Warping facility)	CATMOR	(Category of mooring/warping facility)
	BOYSHP	(Buoy shape)
	COLOUR	(Color)
	COLPAT	(Color pattern)
	CONDTN	(Condition)
	NATCON	(Nature of construction)
	STATUS	(Status)

Note: *If a MORFAC is found to be submerged, the object shall be classified as an OBSTRN with CATOBS = 1 Snag/Stump. Reference Appendix F for WATLEV attribution.*

SBDARE (Seabed area) *Point Objects*	NATSUR*	(Nature of surface)
	NATQUA*	(Nature of Surface - Qualifying Terms)
	COLOUR	(Color)

** Multiple characteristics, colors and qualifiers may be used. The constituents should be comma separated in order of predominance using the S-57 ID number. See Appendix H for further details on encoding bottom samples.*

Note:

A complete description of a bottom sample consists of: one adjective describing the grain size or consistency; one adjective designating the color; and one noun naming the class of bottom material. If the sample consists almost entirely of one constituent, only one noun shall be used. If the sample consists of two or more constituents, the nouns for the primary constituents shall be used and arranged in order of their predominance. For example, if a sample of fine black sand contains a smaller portion of broken shells and a couple of pebbles, the bottom characteristic shall be recorded as follows:

fne bk S brk Sh

Sediments are typed according to the size of the particles. Table 1, located in Appendix H, is a general guide for classification of sands and courser particles. It is not intended that the dimension be measured. A careful estimation by eye is satisfactory. Technically there are two classes of material finer than sand. These are silt and clay. For practical purposes, silt and clay are classified under the general term of, mud.

Consistencies of bottoms determined by feeling with lead line or sounding pole (without visual examination of the material) should usually be described as "hard" or "soft". The term "rocky" may be used only when it is known positively that the bottom is bedrock or consists of material larger than gravel, although a specimen was not obtained for examination. "Rock" is only used when solid rock or a rock ledge is visible to the hydrographer.

The return of an empty sampler is not a sufficient reason to label the bottom as "hard or "soft". If a bottom sample was attempted but no sample was recovered the NATSUR will be categorized as Unknown. Do not use the NATQUA "hard" attribute for unsuccessful samples.

SBDARE (Seabed area) *Line and Area Objects*	NATSUR*	(Nature of surface)
	WATLEV	(Water Level Effect) - reefs, ledges and rocky seabed areas
	WATLEV	(Water Level Effect) - rocky seabed areas that extend to shore
	NATQUA	(Nature of Surface - Qualifying Terms)

** Use NATSUR = rock for rocky seabed areas*

Note:

- *SBDARE line or area objects may be used to characterize areas with numerous discrete submerged rocks (rather than encoding individual rock features) and/or areas of the seafloor that are rocky in nature. The extents of the area should be delineated and characterized as SBDARE (seabed area), and the attribute NATSUR (nature of surface) encoded as "rock". See Sections 5.2.1.2.3 and 7.4 for more guidance on designating soundings in rocky areas.*

COALNE (Coastline)	CATCOA	(Category of Coastline)

Note: *descrp = new or descrp = update COALNE features require CATCOA attribute populated*

SLCONS (Shoreline construction)	CATSLC	(Category of shoreline construction)
	CONDTN	(Condition)
	WATLEV	(Water level effect)

Notes:

descrp = new or descrp = update SLCONS features require CATSLC attribute populated

Data under charted man made features (e.g. piers, anchor chains) will be rejected and not included in delivered products. This includes the MBES data on pilings supporting and abutting piers and superstructures. The exceptions to this rule are data under bridges and other features above the surface of the water that do not impede waterborne traffic and small marina style "finger" piers that are supported by standard pilings. In the case of "finger" piers, the pier structure should be rejected but the seafloor shall remain in the data. All assigned and any new (within sheet limit) piers or structures shall be surveyed as shoreline construction features and included in the FFF.

LNDARE (Land area) *Point, Line, or Area*	Used to characterize islets. Should be accompanied by LNDELV point or line object, denoting the highest point of the feature. LNDARE point objects accompanied by LNDELV point objects must share exact geographic positions to the maximum allowable precision by the S-57 encoding software using a "Copy Feature Geometry" or similar tool. See WATLEV Attribution Figure F.1 in Appendix F for vertical height requirements by geographic area. Islets with a horizontal distance greater than 1.0 mm at survey scale shall be delineated as an area feature.

Note: *descrp = new or descrp = update LNDARE features require LNDELV attribute populated*

LNDELV (Land elevation)	ELEVAT*	(Elevation)

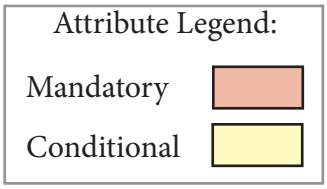
*Elevation is relative to the MHW datum

Note: *descrp = new or descrp = update LNDARE features require LNDELV attribute populated*

7.5.2 NOAA Extended Attribution

The hydrographer shall attempt to provide as much additional information as possible on a feature to facilitate the Hydrographic Branches in final chart compilation of the survey. The additional information shall be included with the feature in the NOAA Extended Attributes instead of the Descriptive Report. NOAA Extended Attribution is not part of the IHO S-57 Standard but is classified as mandatory and conditional using the guidance in this section.

The following Attribute Legend shall be used for the subsequent tables in Section 7.5.2:



Assigned (Section 7.3.1), new (Section 7.3.2), and disproved (Section 7.3.4) features require these mandatory NOAA Extended Attributes:

Attribute	Description		
descrp	Description	Portrays the field charting action.	
		New	New features or new position
		Update	Modification to attribution, geometry, and/or feature object class. Exception: change of geometry for line and area features
		Delete	Disprovals or erroneous features
		Retain	Addressed items that are represented properly on the chart. Included a remark for informational purposes as necessary
		Not Addressed	'Assigned' items from the HSD/NSD Project Manager or COR which were not addressed. Include remark describing why the feature was not addressed

New/Delete vs. Update:

1. Charted feature is found in new position via multibeam, lidar, vessel-mounted laser scanning, or any remote sensing system capable of generating a georeferenced point cloud sufficient to differentiate features a survey scale, regardless of proximity to charted feature:
   - descrp = Delete for charted feature (delivered from CSF)
   - descrp = New for surveyed feature (derived from grid sounding for multibeam and lidar, derived from point cloud for laser scanning)
2. Charted feature is found via visual observation or handheld laser range finder, within 10 m of the charted feature:
   - descrp = Update (populate surveyed height/depth of feature, not position)
3. Charted feature is found via visual observation or handheld laser range finder, greater than 10 m from the charted feature:
   - descrp = Delete for charted feature (delivered from CSF)
   - descrp = New for surveyed feature (derived from visual observation or handheld laser range finder)
4. Charted line or area feature geometry has changed.
   - descrp = Update; then manually edit the geometry

   Note: if the new area extents border the edge of bathymetry, instead of manually editing the geometry, the hydrographer may use 'recomd' = edit the geometry to extents of bathymetry

   OR when extensive geometry changes are needed:
   - descrp = Delete for incorrectly charted feature
   - descrp = New for correctly surveyed feature

remrks	Remarks		Provides additional information about features that is not captured elsewhere in the digital data (e.g. S-57 attribution)
Note: • *See Section 7.3.1 for descrp/remrks of assigned features located between the surveyed NALL and 0.8 mm buffer.* • *Do NOT include exact geographic positions (Latitude and Longitude), least depths, etc.*			
recomd	**Recommendations**		Charting Recommendations – As needed, include information to ensure proper charting of a feature.
Note: • *Only required for new features and charted feature disprovals.* • *Do NOT include exact geographic positions (Lat.- Long.), least depths, etc.*			
sftype	Special Feature Type		Indicates a feature with a special designation
		ATON	ATON investigations
		DTON	Dangers to Navigation
		Maritime Boundary	Maritime Boundary investigations
		Lidar Investigation	Lidar investigations
Note: Only required for special feature type objects			
dbkyid	Database Key ID	Unique ID for use in relational database	
images	Images	Images associated with a feature (i.e. MBES or SSS screen-grabs or digital photos)	
Note: • *Required for DTON, WRECKS, OBSTRN*, OFSPLF, maritime boundary points, and significant baring/ exposed features. WRECKS images shall include the approximate dimensions of the wreck. *Images are not required for foul areas (OBSTRN CATOBS = foul area).* • *The required format for all images (including 2-D graphics, 3-D graphics and photos) shall be JPEG, PNG, GIF, or TIFF.* • *Images shall have a unique identifier name.* • *Multiple images for one feature shall be semi-colon delimited.* • *All images (including SSS contact images) and photographs shall be placed in the Multimedia folder. A copy of the side scan sonar contact images shall remain in the CARIS HDCS folder if CARIS software is used for processing.* • *Do not include images in the S-57 PICREP attribute.*			
obstim	Observed Time	Observed time in the format YYYYMMDDThhmmss	
Note: • *Required for contractor DTON submission (see Section 1.6)*			

7.5.3 NOAA Discretionary Attribution

The following is a list of additional NOAA Extended Attributes that are discretionary.

Attribute	Description		
acqsts	Acquisition Status	A tracking tool used during data processing that ensures features are fully investigated as necessary.	
		Investigate	Indicates that further field examination and analysis are required.
		Resolved	Indicates that field examination and analysis is completed.
asgnmt	Assignment Flag	Indicates assignment status of items delivered to the field by the HSD/NSD project manager or COR.	
		Unassigned	Not assigned
		Assigned	Assigned
		For Info Only	For Information Only
Note: • *See section 7.3.1 for how to address assigned features* • *For Information Only features are for reference only and do not need to be verified or addressed by the field unit.*			
cnthgt	Contact Height	Contact height of side scan sonar contacts.	
invreq	Investigation Requirements	Specific investigation requirements defined by the HSD/NSD Project Manager or COR.	
Example of invreq: • *Specific requests from customers about particular features, or questionable features that may warrant extra attention.* • *The survey limit feature (TESARE) includes: H number, Priority, Sheet Name.*			
keywrd	Keyword	Customized word used for processing or querying data.	
prkyid	Primary Key ID	Provides a means for manual correlation. The primary key ID can be populated for the secondary feature with the primary feature's Database key ID.	
prmsec	Primary/Secondary Status	Indicates the status of the feature during feature or contact correlation.	
		Primary	Principal feature that can be associated with one or more secondary features.
		Secondary	Indicates that the feature is correlated to the primary.
		Pending	Indicates that further analysis or examination is required.
userid	User ID	Provides a unique identifier.	

8 Deliverables

Contents

8.1 Field Reports

Reported horizontal positions shall be recorded in meters, with a precision of at least decimeters (see Section 5 regarding requirements for vertical (depth) positions). This precision shall be maintained throughout the processing pipeline and be maintained in the digital data.

All field units (in-house and contract) shall adhere to the hydrographic survey report naming conventions and format. Hydrographic survey report digital files submitted to and handled by HSD/NSD shall be delivered in separate reports and follow the standard naming convention as listed below:

Descriptive Report:

- Main Body
  (Sections A through D) in XML DR format:
  - Format: <Survey Registry Number>_DR.xml
  - Example: “H12345_DR.xml”

- Full Report
  (Cover Sheet, Title Sheet, Sections A through E) in Portable Document Format (PDF):
  - Format: <Survey Registry Number>_DR.pdf
  - Example: “H12345_DR.pdf”

- Appendices in Portable Document Format (PDF):

  I. Water Levels:
  - Format: <Survey Registry Number>_Tide_Request.pdf
  - Example: "H12345_Tide_Request.pdf"

  - Format: <Survey Registry Number>_Tide_Note.pdf
  - Example: "H12345_Tide_Note.pdf"

  (If applicable)
  - Format: <Survey Registry Number>_Vertical_Control_Memo.pdf
  - Example: "H12345_Vertical_Control_Memo.pdf"

  - Format: <Survey Registry Number>_VDATUM_Validation_Report.pdf
  - Example: "H12345_ VDATUM_Validation_Report.pdf"

  - Format: <Survey Registry Number>_Transmittal_Letter.pdf
  - Example: "H12345_ Transmittal_Letter.pdf"

  II. Supplemental Survey Records and Correspondence:
  DTON Files (Use unique sequential numbering scheme for multiple reports):
  - Format: <Survey Registry Number>_DTON_Report_unique#.pdf
  - Example: "H12345_DTON_Report_1.pdf"

  - Format: <Survey Registry Number>_DTON_NDB_Verification_unique#.pdf
  - Example: "H12345_DTON_NDB_Verification_1.pdf"

  Other Correspondence (if applicable):
  - Format: <Survey Registry Number>_Description_Correspondence.pdf
  - Example: "H12345_Bomb_Ordinance_Area.pdf"

Separates:

- I. Acquisition and Processing Logs in Portable Document Format (PDF):
  - Format: <Survey Registry Number>_Aquisition_and_Processing_Logs.pdf
  - Example: "H12345_ Aquisition_and_Processing_Logs.pdf"

- II. Digital Data in Portable Document Format (PDF):
  Crossline Comparisons:
  - Format: <Survey Registry Number>_Crossline_Comparison.pdf
  - Example: "H12345_Crossline_Comparison.pdf"

  Sound Speed Data Summary:
  - Format: <Survey Registry Number>_Sound_Speed_Data_Summary.pdf
  - Example: "H12345_Sound_Speed_Data_Summary.pdf"

Descriptive Report Supplemental Reports:

- Data Acquisition and Processing Reports in Portable Document Format (PDF):
  - Format: <Project Number>_DAPR.pdf

- Example: “OPR-A123-KR-10_DAPR.pdf”

- Data Acquisition and Processing Report Appendices in Portable Document Format (PDF):
  - Format: <Project Number>_DAPR_Appendices.pdf
  - Example: “OPR-A123-KR-10_DAPR_Appendices.pdf”

- Horizontal and Vertical Control Reports in Portable Document Format (PDF):
  - Format: <Project Number>_HVCR.pdf
  - Example: “OPR-A123-KR-10_HVCR.pdf”

In rare instances it may be necessary for a field unit to submit a revised version on a hydrographic survey report. This occurs most often when the DAPR submitted with the first survey of a long project (as required in Section 8.1.5.1) does not include all information required for later surveys.

Field units shall take all practical steps possible to avoid revision and resubmission of reports. However, when revisions are necessary, the following guidance shall apply:

- The revised report shall fully supersede all previous versions.
  For example, if a DAPR is submitted with the first survey of a project, and subsequently revised for the second survey, the revised DAPR shall apply to both surveys and replace the original submission

- Revised reports shall be identified by inclusion of a revision number in the name as follows:
  - Format: <Report Base Name>_rev<revision number>.<suffix>
  - Example 1: “OPR-A123-KR-10_DAPR_rev1.pdf” (the first revision of the DAPR for OPR-A123-KR-10; fully supersedes “OPR-A123-KR-10_DAPR.pdf”)
  - Example 2: “H12345_DR_rev2.xml” (the second revision of the DR file for H12345; fully supersedes “H12345_DR_rev1.xml” and “H12345_DR.xml”)

8.1.1 Progress Reports

8.1.1.1 Weekly Progress Reports

The purpose of the weekly progress report is to keep the project managers and Coast Survey staff apprised of ongoing fieldwork. The field unit shall submit a weekly progress report during field operations, no later than Monday (close-of-business), each week of field acquisition, emailed to the assigned HSD/NSD Project Manager or COR with a CC to progress.sketches@noaa.gov.

Weekly Progress Report Contents:

a. Brief narrative summarizing the past week’s activities and the anticipated plans for the coming week. The narrative shall discuss all activities related to mobilization/demobilization, control station installation, and data acquisition progress. Other major issues (e.g. significant weather delays, equipment failures, etc.) that may affect acquisition milestones shall be discussed.

b. An up to date coverage map geoTIFF that is 5 MB or less with a white background, projected to the project’s NAD83 UTM zone. Naming convention shall follow:
   OPR_X###_XX_## _<month>_<day>.tiff

c. Graphic showing the up to date coverage map, the project sheet limits, an appropriate chart, and a simple title block indicating the appropriate contractor/field unit name, plain language project name, and date of

coverage. See example in figure, below. Naming convention shall follow:
OPR-X###-XX-##-_<month>_<day>.pdf

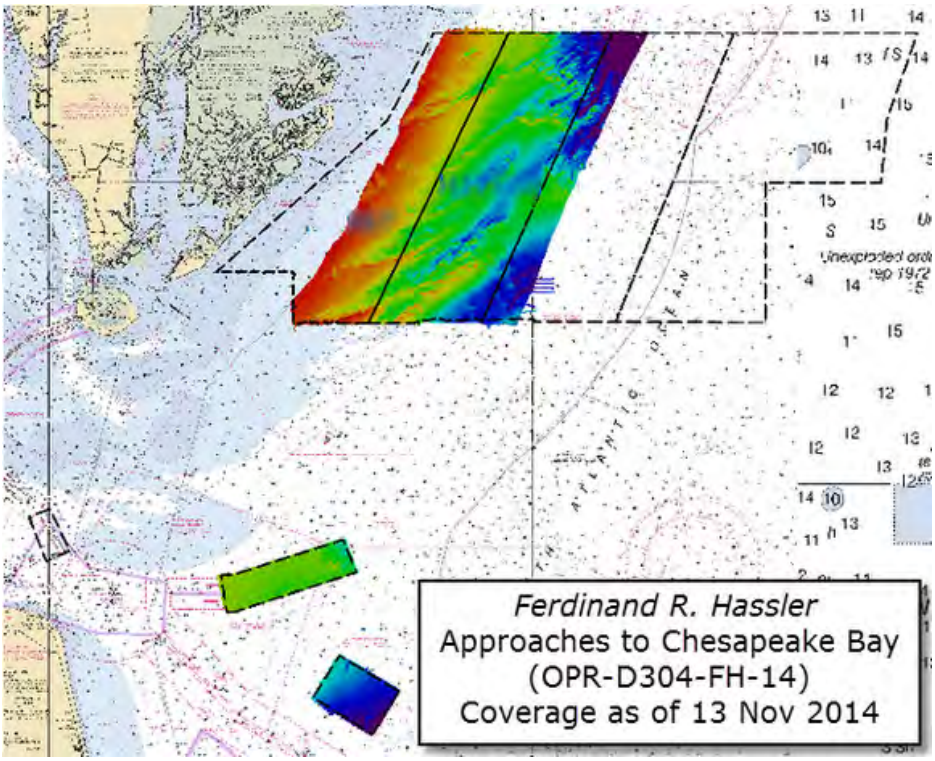


Figure 8.1: Example of a weekly progress report graphic per 8.1.1.1.c.

8.1.1.2 Monthly Progress Report

The hydrographer shall report Monthly Survey Progress digitally as one Excel file in accordance with the guidance below by the fifth day of the month following survey operations. NOAA field units shall submit the report via email to progress.sketches@noaa.gov. Contractors shall submit the report via TOMIS, Task Order Management and Information System. To assist in the submission of this information, HSD/NSD will provide each ship and contractor with documented instructions and a Monthly Report Excel Template with separate tabs as indicated below.

a. Survey Progress Estimate – This will be used to track estimated monthly survey progress by survey within a given month. 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.

b. Project Statistics - This will be used to track monthly statistics by project such as linear nautical miles by vessel and system, items investigated, control stations and bottom samples.

c. Vessel Utilization - This will be used to track vessel utilization on a daily basis such as Days At Sea (DAS), planned and actual operational hours, and reason for down time .

8.1.2 Survey Outline

After completion of all field work for a given survey sheet, the hydrographer shall provide a survey outline that shows the extent of hydrography completed for the registered survey (e.g. H number). This outline shall bound the extent of continuous survey data judged by the hydrographer to be adequate to supersede the chart. Along shore,

the survey outline shall be coincident with the NALL as surveyed in accordance with the Project Instructions and Section 1 of this document.

Careful attention should be paid in the near shore area to ensure that features and bathymetry inshore of the NALL are not included. The survey outline need not include all discrete features contained in the S-57 feature file deliverable (i.e. a rocky area or ledge may extend inshore of the survey outline). Also, the Survey Outline should not inscribe high water features positioned inshore of the NALL (e.g., Aids to Navigation).

The only exception to this is coverage acquired pursuant to investigation of assigned items from HSD/NSD, which should be inscribed by the Survey Outline, and LIDAR surveys. The survey outline for a LIDAR survey shall be coincident with the MHW.

The final survey outline shall normally be a single, completely enclosed polygon bounding the final surveyed area as described above. In cases where this area includes an unsurveyed region (e.g., an island), the survey outline file will also include an interior limit (i.e., 'donut hole') following the NALL around this area. In cases where the survey includes a detached surveyed area (e.g., an assigned item with a search radius that does not intersect the main body of the survey), the final survey outline file shall include a separate polygon for the detached area.

The final survey outline should be compiled as the S-57 Feature Object Class M_COVR in a .000 format in the WGS84 datum, unprojected. The outline shall not be include in the FFF. The M_COVR feature shall be attributed as follows:

Object	Attribute	
	Acronym	Description
M_COVR (Coverage)	Used for survey outline.	
	CATCOV	(Category of coverage)
	INFORM	(Inform)
	NINFOM	(Information in national language)
***INFORM**: shall be populated with the following information separated by semi-colon in this order:* • *Platform; State; Scale* *Example: FH; MD; 20,000* ***NINFOM**: shall be populated with the technique of sounding measurement.* • *Use the terms: Lidar, MBES, VBES, or SSS.* • *If more than one technique was used separate the techniques by a semi-colon. Example: MBES; SSS.*		

Final survey outlines shall be submitted via email survey.outlines@noaa.gov with a CC to the HSD/NSD Project Manager or COR.

The final survey outline should be submitted as soon as practical after completion of field work. If the outline has not been submitted within 30 days of completion of field work, the hydrographer shall contact HSD/NSD Project Manager or COR to explain the delay and provide an estimate for delivery. Any large differences (± 10%) between the total square miles reported via the Survey Progress Report for the survey and the area defined by the survey outline should be explained in the cover e-mail. Email the outline to survey.outlines@noaa.gov.

8.1.3 Coast Pilot

A field verification of Coast Pilot information, referred to as a Coast Pilot Review, shall be conducted for each assigned survey area. Additionally, information relating to the general operations area (e.g. areas frequently

transited and facilities utilized during imports) should be reviewed and verified or updated to whatever extent practicable.

A Coast Pilot Field Report will be provided by HSD/NSD. This report may contain specific questions about items in the Coast Pilot that require field verification or clarification. In addition, this report may contain the actual paragraphs from the Coast Pilot that are affected by the survey area.

Coast Pilots are updated on a weekly basis. Updated Coast Pilots can be downloaded from the Coast Pilot website (http://www.nauticalcharts.noaa.gov/nsd/cpdownload.htm). The hydrographer shall first download the latest edition of Coast Pilot and compare against the information contained in the Coast Pilot Field Report. In the event of a conflict between the two sources, the review shall be completed using the information in the downloaded Coast Pilot.

A Coast Pilot Review Report 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 an updated edition of the Coast Pilot was used, this shall be noted. In this report, the hydrographer shall respond to each question posed in the Coast Pilot Field Report. If the hydrographer is not able to address a specific question, that shall also be noted. In addition, the hydrographer shall make reasonable attempts to verify the text of the actual Coast Pilot paragraphs that are affected by the survey during field operations. Updates shall be made as follows:

- Deletions to the existing text shall be shown as strikethroughs.
- Recommended revisions, including any new information that would be beneficial to the mariner, shall be shown in red text.
- Existing text that has been reviewed and verified to be correct during field unit operations shall be changed to green text.
- Existing text that could not be verified or refuted during operations shall remain in black.

The consolidated Coast Pilot Review Report shall be submitted in a PDF format and shall include answers to the specific questions, updates to the actual paragraph text, and the original Coast Pilot Field Report. This file shall be named <Project Number>_Coast Pilot Review Report.pdf (Example: "OPR-A123-KR-15_Coast Pilot Review Report.pdf") and submitted via email to OCS.NDB@NOAA.GOV and Coast.Pilot@NOAA.GOV (with a CC to the HSD/NSD Project Manager or COR).

8.1.4 Descriptive Report (DR)

A Descriptive Report (DR) is required for each hydrographic survey, unless otherwise stated in the Project Instructions. The Project Instructions will specify if a DR Memo or DR Summary (Appendix K) is acceptable instead of the standard DR. If the DR format is unclear for a survey, contact the HSD/NSD Project Manager or COR.

The primary purposes of a Descriptive Report are to: 1) help cartographers process and evaluate the survey; 2) assist the compilers producing or revising charts; 3) document various specifications and attributes related to the survey and its by-products; and 4) provide a legal description of the survey standards, methods, and results. The cartographers will have no knowledge of the particulars of a survey, other than what is documented in the Hydrographic Survey Project Instructions or Statement of Work, digital survey data, Descriptive Report, and supplemental reports referenced in the Descriptive Report. The Descriptive Report is archived as a historical and legal record for the survey.

The Descriptive Report supplements the survey data with information that cannot be depicted or described in the digital data. The Descriptive Report describes the conditions under which the survey was performed, discusses

important factors affecting the survey's adequacy and accuracy, and focuses upon the results of the survey. It contains required information on certain standard subjects in concise form, and serves to index all other applicable records and reports.

The Descriptive Report shall be submitted electronically in both XML and Adobe PDF format as described below. The XML file shall be validated against the latest version of the XML DR schema available at https://www.nauticalcharts.noaa.gov/hsd/xmldr/. The PDF file shall be generated using the latest version of the XML DR stylesheet. The schema will define the required structure, order, and information to be included in the DR. The stylesheet will ensure that the PDF files are formatted in a consistent manner. NOAA field units shall generate the DR using the most recent version of the Pydro XML DR Application. Contractors will be provided an XML schema and stylesheet by their COR.

The XML file shall be named according to the Registry Number of the Survey (ex: H12345_DR.xml). All images and other linked files shall be included in a folder named "SupportFiles" and shall be reference in the XML file using relative path names. Both the XML file and the SupportFiles folder shall be submitted as a single zip file, named according to the Registry Number of the Survey (ex: H12345_DR.zip).

Submit the entire Report (Cover Sheet, Title Sheet, Sections A through E) in a single PDF file. The appendices shall be submitted as a separate PDF file.

The Descriptive Report shall not be encrypted, secured, or locked.

The following information is required in each Descriptive Report in the order listed below:

COVER SHEET & TITLE SHEET

The Cover Sheet is used to identify the survey, while the Title Sheet is often referred to for information pertaining to the survey. Both the Cover Sheet and the Title Sheet shall be populated from information entered into the Metadata section of the XML DR.

The following metadata will be included in the Project Letter Instructions: Project Number, Project Name, General Locality, Field Unit, Registry Number, Sheet ID, Sublocality, State, Country, and Scale.

For "Vessel", enter the name and hull number of the surveying vessel. The name(s) listed after "Surveyed by" are the personnel who supervised sounding operations and/or data processing.

The "Remarks" section should contain any additional information, including the purpose of the survey and survey area information that will identify the project or clarify the entries above. Other Descriptive Reports or special reports containing information or data pertinent to the survey that are not listed in Section E of the Descriptive Report text should be referenced here. Note the time zone used during data acquisition (e.g., All times are recorded in UTC). If applicable, list the name and address of the contractor and any major subcontractors. If applicable, include the UTM zone number.

Descriptive Report TEXT

General statements and detailed tabulations of graphically evident data, such as inshore rocks, shoals, or coral heads already shown in the S-57 final feature file should normally not be included in the Descriptive Report. Hydrographic characteristics of the survey area such as nearshore features, shoreline, currents, water levels, and changes to the chart that are otherwise not clearly defined by the digital products should be completely described in the Descriptive Report.

Include all information required for complete understanding of the field records. When referring to a hydrographic feature in the S-57 final feature file, give the latitude and longitude of the feature. Discussions and explanations should be written in a clear and concise manner. Avoid using geographic names in the text of the Descriptive Report that do not appear on the nautical chart. Avoid verbosity.

Note on Cultural or Historic Submerged Features

Features on the seafloor may be discovered which are of potential cultural or historical significance and require special consideration. These include wrecks of ships or aircraft, recognizable debris from wrecks, or other items which may appear anthropogenic in origin and have some associated cultural or historical significance. Any feature determined to be a Danger to Navigation shall be immediately reported through the standard DTON reporting process.

The (potential) cultural or historic significance of any feature shall not be discussed nor identified by name in the Descriptive Report. Data and information from these features must always be protected and may only be released in accordance with OCS policies and procedures or as specified in the Project Instructions or other written instructions from OCS. These features should be included in the Final Feature File with an image, SSS or bathymetry.

A. AREA SURVEYED

Provide general information about the area surveyed, the quality of the survey, and the survey coverage. In addition, include the dates of the survey, the square nautical miles (SNM), and the linear nautical miles (LNM) acquired during the survey.

- Survey Limits shall be entered in decimal degree format.
- The Coverage Graphic shall be inclusive of the survey area. The information related to the present survey should be clearly shown and highlighted in some way to draw attention to its location within the project area. A second small scale graphic should be included if necessary to provide additional geographic context of where the survey is located.
- When appropriate, simple statements indicating adherence to the Project Instructions, Statement of Work, or HSSD are acceptable (e.g. "Survey Limits were acquire in accordance with the requirements in the Project Instructions and the HSSD.")
- Linear nautical miles that are deleted for any reason shall not be included.
- Specific dates of data acquisition shall reflect the days of work for the referenced survey only, not the total project.

B. DATA ACQUISITION AND PROCESSING

B1. Equipment

List by manufacturer and model number only the major systems used to acquire survey data or control survey operations (e.g., single beam sonar, multibeam sonar, side scan sonar, lidar system, vessel attitude system, positioning system, sound speed system). Include a brief description of the vessel (e.g., length overall and draft). A detailed description of the systems used to acquire survey data or control operations shall be included in the project-wide Data Acquisition and Processing Report (Section 8.1.5.1).

Include in a narrative description, with figures when useful, of any deviations from the vessel or equipment configurations described in the Data Acquisition and Processing Report.

B2. Quality Control

Discuss the internal consistency and integrity of the survey data.

- Crosslines - State the percentage of crossline miles as compared to main scheme miles. Evaluate their general agreement. If the magnitude of the discrepancy varies widely over the sheet, make a quantitative evaluation of the disagreements by area. Explain the methods used to reconcile significant differences at crossings, and give possible reasons for crossline discrepancies that could not be reconciled. See Section 5.2.4.3 for additional information.

- Uncertainty - Discuss the uncertainty values of the submitted CARIS generated surfaces (uncertainty or CUBE) and/or BAG(s). Explain and/or justify any areas that have an uncertainty greater than the IHO levels allowed as described in Section 5.2.2.

- Junctions - Junctions are defined in Section 7.2.2 and include both Prior Junctions and Current Junctions. This section of the DR shall include an evaluation of junction overlap for each junction (Prior and Current) and a summary of each junction's relative agreement of depths within each survey's respective TVU. The Current Junction analysis only needs to be described in one of the two DRs.

  The hydrographer shall demonstrate that the difference between the two data sets are less than $\sqrt{2} * TVU$ on a 95% CI basis. If the differences are greater, the hydrographer shall identify, with a quantitative evaluation, the disagreement area by area and identify possible reasons for the discrepancies that could not be reconciled. Include recommendations for adjustments to soundings, features, and depth curves, if applicable.

- Sonar Quality Control Checks - Discuss whether there were any deviations from the Quality Control Checks described in the DAPR. In there were no deviations, a simple statement is adequate (e.g. "Sonar system quality control checks were conducted as detailed in the quality control section of the DAPR.").

- Equipment Effectiveness - Discuss any unusual conditions encountered during the present survey which would downgrade or otherwise affect the equipment operational effectiveness. Discuss any deficiencies that would affect the accuracy or quality of sounding data. Document these conditions, including how and when they were resolved. If the equipment operated as expected, a simple statement is adequate (e.g. "There were no conditions or deficiencies that affected equipment operational effectiveness.").

- Factors Affecting Soundings - Describe any other factors that affected corrections to soundings, such as sea state effects, the effect of sea grass or kelp, and unusual turbidity, salinity, or thermal layering in the water column. When appropriate, a simple statement indicating that none of these factors were present (e.g. "There were no other factors that affected corrections to soundings.").

- Sound Speed Methods - Provide a brief discussion on how the sound speed instruments (CTD, Moving Vessel profiler, Thermosalinograph etc.) were used and describe the frequency of the SVP casts. If appropriate, describe how the survey area was zoned to account for sound speed variations from differing water masses.

- Coverage Equipment and Methods - Discuss the specific equipment and survey methods used to meet the requirements for object detection and coverage for different areas of the survey. If applicable, a simple statement indicating adherence to the DAPR is acceptable (e.g. "All equipment and survey methods were used as detailed in the DAPR.")

B3. Corrections to Echo Soundings

- Corrections - Discuss any deviations from those described in the Correction to Echo Soundings section of the Data Acquisition and Processing Report. If applicable, a simple statement indicating adherence to the DAPR is acceptable (e.g. "All data reduction procedures conform to those detailed in the DAPR.")

- Calibrations - Discuss the results of any sounding system calibration (e.g. patch test) conducted after the initial system calibration that affect the survey data and were not included in the Data Acquisition and Processing Report. Comment on the reason a new calibration was conducted. If applicable, a simple statement indicating adherence to the DAPR is acceptable (e.g. "All data reduction procedures conform to those detailed in the DAPR.")

B4. Backscatter

Discuss whether backscatter data was acquired and include any additional comments. If applicable, a simple negative statement is acceptable (e.g. "Backscatter was not acquired for this survey.")

B5. Data Processing

- Software Updates - List any new software updates or additions that were not discussed in the DAPR. State the NOAA Extended Attribute files version number used during feature management processing (e.g. "NOAA Extended Attribute Files V#_#").

- Surfaces - Provide details of all submitted CARIS generated surfaces (uncertainty or CUBE), SSS mosaics, and/or BAG(s).

C. VERTICAL AND HORIZONTAL CONTROL

Provide a summary of the methods used to determine, evaluate, and apply tide or water level corrections to echo soundings on the survey. Discuss any additional information, not already included in the HVCR. When appropriate, a simple statement referencing the HVCR is acceptable (e.g. "Additional information discussing the vertical or horizontal control for this survey can be found in the accompanying HVCR.") See Section 8.1.5.2 for additional information to be provided in the project Horizontal and Vertical Control Report.

C.1 Vertical Control
State the vertical datum used for the survey. Indicate which vertical control methods were used during the survey (Discrete Zoning, TCARI, ERZT, VDatum, and/or Constant Separation). List any NWLON or subordinate tide stations used during the survey. List any tide buoys used during the survey. If appropriate, state the names of the water level and tide corrector files that were used, as well as the dates that Final Tides were submitted and received. If preliminary zoning was used, describe how it was determined to be accurate and describe any changes that were made to the preliminary zoning scheme. If appropriate, state the name of the ellipsoid-to-chart datum file.

C.2 Horizontal Control
State the horizontal datum used for the survey. Indicate which horizontal control methods were used during the survey (PPK, PPP, RTK, WAAS and/or DGPS). List any CORS or user installed base stations used during the survey. Explain in detail any difficulties that may have degraded the expected position accuracy.

D. RESULTS AND RECOMMENDATIONS

D.1 Chart Comparison

Compare the survey with all of the largest scale corresponding bathymetric products available (e.g. Electronic Navigational Charts (ENCs)) to prove or disprove any exceptional natural seafloor or features attained by the survey coverage. For each category, a simple statement can be included in instances when all features exist as charted or no features exist in the category, or no investigation was assigned. In instances when there was no investigation of assigned existing features, provide an explanation of why the investigation was not conducted.

- Methods - Discuss the methods used for the chart comparison in sufficient detail to demonstrate that the chart comparison was accomplished adequately.

- Charts - Comment on the degree of general agreement with charted soundings and discuss general trends, such as shoaling or deepening occurring in the survey area. A detailed evaluation of every charted sounding is not required. Identify the chart by number, scale, edition number, edition date, dates of the most recent Local Notice to Mariners and Notice to Mariners. In addition, Notices to Mariners affecting the survey area which were issued subsequent to the date of the Hydrographic Survey Project Instructions and before the end of the survey must be specifically addressed. Identify the last Weekly and Local Notices to Mariners compared to during the survey by notice number and date. Any Notice that prompts a chart comparison item must be identified by its Notice to Mariners number and date. A general chart comparison between survey depths and charted soundings should be conducted.

- Maritime Boundary Points - Discuss any Maritime Boundary features that were investigated during this survey.

- Charted Features - Discuss any charted features or soundings that contain the label PA, ED, PD, or Rep (see Chart No. 1 for definitions.). The source of the charted feature should be listed, if known. Describe the condition and distinguishing characteristics of all items mentioned.

- Uncharted Features - Discuss all new features not addressed as a DTON, as defined in Section 1.6. Describe the condition and distinguishing characteristics of all items mentioned.

- Shoal and Hazardous Features - Conduct a detailed comparison between the survey data and all charted shoals and potentially hazardous features. Describe the methods of investigation and include the least depths for significant changes. State whether any Danger to Navigation Reports were submitted for this survey.

- Channels - List and discuss comparisons of survey depths with controlling depths, tabulated depths, and reported depths of all maintained channels. Also discuss soundings in designated anchorages, precautionary areas, safety fairways, traffic separation schemes, pilot boarding areas, and along channel and range lines.

- Bottom Samples - Briefly discuss the results of any bottom samples acquired during the survey.

D.2 Additional Results

The field unit shall not list individual features or their coordinates in this section. Any features where the existence (including new features), position, minimum clearance, condition, or status deviate from the chart shall be included and attributed in the Final Feature File. The investigation requirement attribute, invreq, should be referenced for specific feature class guidance for inclusion, or not, in the FFF. For each category, a simple statement can be

included in instances when all features meet their intended purpose, or all features exist as charted, or no features exist in the category. In instances when there was no investigation of existing features, provide an explanation of why the investigation was not conducted.

- Prior Surveys - If applicable, briefly discuss any prior survey comparisons. In general, prior survey comparisons are not required by field personnel, but may be used at the discretion of the hydrographer for quality control purposes.

- ATON (Section 7.3.5) - Discuss aids to navigation which do not serve their intended purpose, are damaged, or whose characteristics do not match the chart or Light List. Conversely, state that remaining (or all) aids to navigation in survey area were confirmed to be on station and serving their intended purpose. If applicable, discuss uncharted aids to navigation that are not included in the FFF because they were deemed temporary in nature or repositioned frequently.

- Overhead Features - Discuss any bridges, overhead cables, and overhead pipelines. Any clearances that are provided shall be determined by the survey party or by an authoritative source (e.g., the U.S. Coast Guard or U.S. Army Corps of Engineers). Include written documentation, if available, and photographs with the survey records. Invalid or uncharted overhead clearance information, or ongoing construction of bridges or overhead cables and pipelines, constituting a potential danger to navigation, should be reported to the U.S. Coast Guard and the U.S. Army Corps of Engineers.

- Submarine Features - Discuss any submarine cables, submarine pipelines, tunnels, and any associated crossing signs on the shoreline.

- Platforms - Briefly discuss any drilling structure, production platform, and well head within the survey area (excluding temporary jack up rigs) and note any large discrepancies from the charted positions.

- Ferry Routes and Terminals - Discuss any ferry routes and ferry terminals if not shown on the chart or contemporary NOS remote sensing maps.

- Abnormal Seafloor or Environmental Conditions - Provide information of significant scientific or practical value resulting from the survey. Unusual submarine features such as abnormally large sand waves, shifting or migrating shoals, mounds, valleys, and escarpments should be described. Discuss anomalous tidal conditions encountered, such as the presence of swift currents not previously reported. Discuss any environmental conditions encountered which have a direct bearing on the quality and accuracy of the hydrographic data.

- Construction of Dredging - Discuss any present or planned construction or dredging in the survey area that may affect the survey results or nautical charts.

- New Survey Recommendations - Recommend new surveys for any adjacent areas that need them. As appropriate, include recommendations for further investigations of unusual features or sea conditions of interest that go beyond routine charting requirements.

- Inset Recommendations - Recommend insets to be shown on the published chart of the area, if requested by chart users or needed for clarity.

E. APPROVAL SHEET

The approval sheet with a digital signature shall be included in the PDF file. It is important to note that there is a

distinct difference between a true digital signature and a digitized signature. The latter is simply an image or other capture of a person's pen-and ink signature. By using a document scanner or an electronic pen capture device, a person's signature may be digitized. However, simply attaching this type of signature to an electronic document is not the same as attaching a digital signature.

A digital signature, by contrast, appends a cryptographic "key" to the document that can be used to verify the identity of the signer (authentication), ensure that no changes have been made to the document since signing (integrity), and ensuring that the signer cannot deny having signed the document (non-repudiation). Until such time as an organization-wide digital signature solution is implemented, the nature of self-signed digital signatures will limit authentication and non-repudiation capabilities of the system. The mechanism of applying the digital signature may include a digitized version of a person's signature, or it may not.

The approval sheet shall contain the following statements:

- Approval of the deliverable files, Descriptive Report, digital data, and all accompanying records. This approval constitutes the assumption of responsibility for the stated accuracy and completeness of the hydrographic survey.

- Indication of the completeness of the survey and adequacy for its intended purpose. Recommendation of additional work is required.

- The amount and degree of personal supervision of the work.

- Additional information or references helpful for verifying and evaluating the survey.

List all reports and data not included with the survey records or Descriptive Report that have been submitted to the Hydrographic Branch or to another office (e.g., Data Acquisition and Processing Report, Vertical and Horizontal Report, Tides and Water Levels Package, Coast Pilot Report). Include date of the report or date of submission.

If appropriate, other personnel responsible for overseeing or directing operations on this survey sheet may also sign the Approval Sheet.

DESCRIPTIVE REPORT APPENDICES

The Appendices shall be submitted as a separate PDF file.

I. WATER LEVELS Include the following (if applicable):

- Field Tide Note (Section 4.6.1).
- Final Tide Note to include the final tidal zoning and final tide reducers used to reduce the data to chart datum (Section 4.6.4)
- Abstract of Times of Hydrography (lists every day during which hydrography was conducted and the start and end times hydrography was conducted each day)
- A copy of the transmittal letter for project water level data submitted to CO-OPS
- A copy of the "Request for Approved Tides/Water Levels" letter
- Any other correspondence directly relating to tides and/or water levels
    - Vertical Control Memo
    - VDATUM Validation Report

II. SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

Include any additional survey records not previously addressed in the Descriptive Report, Appendices or Separates such as seep and exposed pipeline correspondence. Also, include the DTON recommendation file (PDF file only) and verification e-mail from NDB (e.g. DREG registration e-mail). Contractors shall receive courtesy copies of these files from the Hydrographic Branch. Any survey related communications, including email and phone calls shall also be included.

SEPARATES TO BE INCLUDED WITH THE SURVEY DATA

The following Separates shall be submitted with each survey. The Separates shall be submitted in a digital format and reside in the Separates folder as noted in Appendix J.

I. ACQUISITION AND PROCESSING LOGS

Include all acquisition and processing logs in digital format from the present survey. Include positioning confidence checks and sounding system comparison checks.

II. DIGITAL DATA

Crossline Comparisons

Include the summary plot analysis as a function of beam number if conducted for the main scheme/crossline intersections as required in Section 5.2.4.3 and 5.3.4.3 if applicable. Include any other crossline quality reports required by Hydrographic Survey Project Instructions.

Sound Speed Data Summary

Submit a list that can be imported into a GIS for office verifiers to analyze the distribution and frequency of the SVP casts. This deliverable should identify the positions and dates of all casts used; the maximum cast depth; and the dates/times for which the profiles were applied. CARIS users can fulfill this requirement with the submission of the SVP data that is within the CARIS project. Contractors and NOAA field units should refer to the location where the digital sound speed files are located, and include a directory listing of the files.

A vessel with a Moving Vessel Profiler (MVP) may use thousands of profiles for a single survey. In such cases, a table of each individual cast is not required. Instead, replace the table with a brief discussion on how the MVP was used (frequency, which areas of the survey, vessels and/or lines it was used, etc.) If individual casts were conducted as well, those casts should be included in a table.

Include confidence check results. Include copies of sound speed profiler calibration report(s), if calibration occurred after submission of the Data Acquisitions and Processing Report (DAPR).

8.1.5 Descriptive Report Supplemental Reports

8.1.5.1 Data Acquisition and Processing Report

For NOAA field units, the Data Acquisition and Processing Report (DAPR) is an annual report that shall be submitted before, or not later than, the submission of the first survey of the field season. The DAPR shall be sent to the Chief, Hydrographic Systems and Technology Branch (HSTB) and the appropriate Hydrographic Branch specified in the Hydrographic Survey Project Instructions. NOAA field units shall issue subsequent DAPR versions

upon effecting a significant change to any item(s) retained in the report. For Contractors, the DAPR is a project-wide report that shall be submitted before, or not later than, the submission of the first survey of the project. The DAPR shall be sent to the COR and appropriate Hydrographic Branch specified in the Hydrographic Survey Project Instructions with each survey. Field units and contractors shall nor encrypt, secure, or lock the DAPR or HVCR reports.

The DAPR is separated into three sections: Equipment, Quality Control and Corrections to Echo Soundings. These sections shall contain a detailed discussion on the information addressed below.

A digital copy of the main text of the DAPR shall be provided in Portable Document Format (PDF).

Include a cover sheet which contains the following general information:

Cover Sheet

Include the survey year, field unit/contractor, Chief of Party/Lead Hydrographer, date and version (see Figure E.1 in Appendix E).

A. Equipment

Describe the major operational systems used to acquire survey data or control survey operations. Include the manufacturer, firmware version, model number and serial number of all equipment. Indicate how the equipment was used, as well as any operational settings. If applicable, indicate most recent calibrations and accuracy checks. Include a description of the vessel(s) used to acquire survey data.

Specifically discuss echo sounding and lidar systems and operations in this section, as well as other depth determination systems such as diver depth gauges, lead lines, sounding poles, etc. Include discussion of system specifications (e.g., range scales, number of beams, resolution and along track coverage) and indicate most recent system calibrations and accuracy checks. State whether correctors were determined and describe any nonstandard procedures used.

Discuss the computer hardware and software used for all data acquisition and processing, and provide a complete list of all software versions and dates.

B. Quality Control

Describe all data acquisition and processing methods, procedures, and parameters used.

Specifically discuss data processing routines for converting raw sounding data to the final bathymetric grid deliverables. Attach processing flow diagrams. Include a description of the methodology used to maintain data integrity, from raw sounding data to final soundings. Any methods used to derive final depths, such as cleaning filters, sounding suppression parameters, data decimation parameters, gridding parameters, and surface computation algorithms, shall be fully documented and described in this section. Discuss how the surface computation methodology (e.g., radius of propagation, uncertainty weighting, etc.) is consistent with object detection requirements.

Discuss the methods used to minimize the errors and uncertainties associated with depth determination, and provide details of how total propagated uncertainty (TPU) is computed for each sounding (Section 5.2.3.5 or 5.3.1.2 for multibeam and lidar, respectively). Any deviation from this requirement shall be explained here.

Discuss how under the navigation surface concept individual soundings are propagated or combined into a node that is consistent with any specific object detection requirements for the project.

Methods and standards used to examine side scan sonar data should be noted and a description of processing procedures should be provided. Include the methods used for establishing proof of swath coverage and the criteria used for selecting contacts. Additionally, include a brief description of how the review of side scan sonar data meets object detection and accuracy requirements as per Section 6.1.2. Any compression method used in the review of the side scan display must be discussed (e.g., whether an average or maximum pixel intensity within a regularly-spaced across track interval X meters is used).

C. Corrections to Echo Soundings

This section addresses the methods used for the determination of all corrections to echo soundings. Describe the methods used to determine, evaluate, and apply the following corrections to echo soundings, including the uncertainties for each item:

- Instrument corrections
- All vessel configuration parameters, offsets, and layback. Include pictures or figures of the equipment as installed on board
- Static and dynamic draft measurements
- Roll, pitch and heading biases and navigation timing errors. State the manufacturer, model, accuracy, and resolution of positioning and attitude sensor(s). Discuss accuracy and alignment test procedures and results. Include copies of system alignment, accuracy and calibration reports
- All sound speed data applied to echo soundings, including sound speed profiles and surface sound speed measurements
- Discuss the source of tide or water level correctors used for data processing and final sounding reduction

D. Approval Sheet

The Chief of Party or Lead Hydrographer shall furnish a digitally signed statement of approval for all information contained within the Data Acquisition and Processing Report using the procedures prescribed in Section E under the Descriptive Report Approval Sheet.

If appropriate, other personnel responsible for overseeing or directing operations on this project report may also sign the Approval Sheet.

Data Acquisition and Processing Report Appendices

The Appendices shall be submitted as a separate Portable Document Format (PDF) file from the DAPR and in a digital format only.

1. Vessel Reports: Include vessel offset reports, vessel layback reports, and dynamic draft reports.
2. Echosounder Reports: Include echosounder system accuracy test (”confidence check”) and system alignment test (”patch test”) reports. Additionally, include data processing flow diagrams. If applicable, include manufacturer calibration reports.
3. Positioning and Attitude System Reports: Include positioning and attitude sensor calibration reports (e.g. GAMS calibration report) and system configuration reports (e.g. POS/MV configuration report).
4. Sound Speed Sensor Report: Include sound speed calibration reports.

8.1.5.2 Horizontal and Vertical Control Reports

Horizontal and Vertical Control Reports are project-wide reports which shall be submitted before, or not later than, the submission of the last survey in project area.

A digital copy of the main text of the Horizontal and Vertical Control Report shall be provided in Portable Document Format (PDF).

Include a cover sheet which contain the following general information:

Cover Sheet - Include the type of survey(s), state, general locality, year and months, project number, vessel(s), field unit/contractor*, and Chief of Party-Lead Hydrographer.
*Note: Subcontractors may be referenced in the body of the report

A. Vertical Control

The Vertical Control section of the project Horizontal and Vertical Control Report shall document all Tide and Water Level activities that took place as part of this project. Specific information pertaining to an individual survey sheet and the Request for Approved Tides letter shall be documented in the Descriptive Report for the individual survey. This section shall contain a discussion of:

- All stations established by the field unit (include gauge model/type). Give station number, latitude longitude, and the dates/times of operation.
- The method by which correctors for the field data were obtained and applied.
- The time meridian used to annotate the tide records.
- A list of any unusual tidal, water level, or current conditions.
- The height and time corrections, and zoning if different from that specified in the Project Instructions.
- Ellipsoidal benchmark positioning techniques and procedures

B. Horizontal Control

The Horizontal Control section of the project Horizontal and Vertical Control Report shall document Hydrographic Position Control activities that took place as part of this project. Specific information pertaining to an individual survey sheet shall be documented in the Descriptive Report for the individual survey.

For horizontal control stations established by the field unit, describe the survey methods used to establish the station, and state the standards of accuracy used. Include position accuracy plots (Section 3.2). For all horizontal control stations established by the field unit, list:

- The latitude to at least the nearest 1/100th of a second.
- The longitude to at least the nearest 1/100th of a second.
- The station elevation (ellipsoidal height).
- The geodetic station name and year it was established.
- Briefly, describe the methods and adequacy of positioning system confidence checks.

C. Approval Sheet

The Chief of Party or Lead Hydrographer shall furnish a digitally signed statement of approval for all information contained within the Horizontal and Vertical Control Report using the procedures prescribed in section E under the Descriptive Report Approval Sheet.

If appropriate, other personnel responsible for overseeing or directing operations on this project report may also sign the Approval Sheet.

8.2 Side Scan Sonar Deliverable

8.2.1 Side Scan Sonar Mosaic

For an object detection survey with a 200% side scan requirement, a separate side scan mosaic for each 100 percent coverage shall be used as a graphic means for demonstrating bottom coverage. Naming convention should follow HXXXX_SSS_1m_100 and HXXXXX_SSS_1m_200.

For a complete coverage survey, if SSS is used for the specified radius of a feature disproval, a separate side scan mosaic for the second 100 percent disproval radius lines shall be submitted as a separate mosaic. Naming convention should follow HXXXXX_SSS_1m_100 to demonstrate complete coverage for the entire survey area and HXXXXX_SSS_Disproval for the features disproved with SSS.

All object detection and complete coverage SSS mosaics should be generated into a single georeferenced image file for the entire survey coverage area. Pixel resolution of the side scan mosaics should be 1 m by 1 m. The hydrographer shall submit a digital file of each 100% coverage (Section 8.3.3).

The border shall be white in color and is specified to be Red, Green, and Blue (RGB) color palette index established to color 255. The side scan mosaic intensity values shall be displayed in gray scale.

8.2.2 Side Scan Sonar Contact File

A Sonar Contact file of contacts (Section 6.1.3.2) shall be delivered in a .000 file format and submitted in the Side_Scan_Sonar_Contacts folder (Appendix J). The side scan sonar contact points shall be delivered as the S-57 feature object cartographic symbol ($CSYMB) with the attribution described in Section 6.1.3.3.

8.2.3 Data Acquisition and Processing Logs

All sonargrams and data acquisition/processing comments including daily confidence checks (Section 6.1.3.1) shall be submitted digitally in data acquisition and processing logs. The hydrographer shall ensure all comments which may later serve to reconstruct the SSS operation are included in these logs. Time references shall be made in Coordinated Universal Time (UTC).

8.3 Digital Data Files

The survey data will be supplied in a digital format. Hard copy plots and hard copy printouts of reports are not required.

This section is provided as a summary for the major digital deliverables that may be required for a typical hydrographic survey. Not all sections will apply to all surveys. Deliverables shall follow the appropriate Data Directory Structure in Appendix J. If a folder is intentionally left empty, place a Readme.txt file in the folder stating as such. For both single beam and multibeam data, separate digital deliverables into two data types: raw and processed. Raw should be uncorrected or with exception of online corrections. Processed data should include the CARIS HDCS format or GSF (Generic Senor Format). Field units and contractors shall email a PDF of the Letter Transmitting Data to the HSD/NSD Project Manager or COR.

8.3.1 Media

Digital data shall be submitted on USB 3.0 compatible hard drives following the data directory structure in Appendix J. Each registered survey shall be submitted on a separate USB drive unless prior agreement is obtained from the HSD/NSD Project Manager or COR. Survey data shall be accompanied by NOAA Form 61-29 Letter Transmitting Data, see Appendix I. The hydrographer shall work with NOAA to ensure no compatibility problems exist after data submission.

Field units are responsible for maintaining off site backups of the raw data until the HSD/NSD Project Manager or COR notifies the field unit that the submitted data has been officially accepted.

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. Both field units and contractors shall perform a check sum and generate a UNIX/LINUX hexadecimal formatted MD-5 hash of the content of the entire directory structure and include it in the digital data submission. The relative directory data structure must be used to allow verification at the Hydrographic Branch.

Data shall be submitted to the Hydrographic Branch listed in the Project Instructions. All data submittals shall be send attention to the Chief of that Hydrographic Branch.

Chief, Pacific Hydrographic Branch
NOAA
Room 1001A, Routing N/CS34
Building 3
7600 Sand Point Way NE
Seattle, WA 98115-6349

Chief, Atlantic Hydrographic Branch
NOAA
Routing N/CS33
439 West York Street
Norfolk, VA 23510-1114

8.3.2 Bathymetric Data

The hydrographer's bathymetric data format shall provide complete traceability for all positions, soundings, and correctors including sensor offsets, biases, dynamic attitude, sound speed, position, sensor position, date and time, vertical datum reducers, and sounding data from acquisition through postprocessing. Data quality and edit flags must be traceable.

"Full resolution" data are defined as all data acquired and logged during normal survey operations. Information and specifications on CARIS HIPS and SIPS and data formats may be obtained from CARIS at 506-458-8533.

Full Resolution Echosounding Data

The hydrographer shall submit full resolution echosounding data in a format readable by CARIS HIPS and SIPS version 9 or above. Full resolution echosounding data shall be delivered fully corrected for tides, sound speed, vessel offsets, draft and dynamic draft. These corrections may be made within CARIS, with data submitted as a complete CARIS project (including HDCS files, sound speed files, Vessel Configuration, CARIS tide files, etc.). CARIS HIPS and SIPS users shall not utilize the "Carry over raw data files" to the HDCS project structure during

raw data conversion capability unless an exemption is approved by the HSD/NSD Project Manager or COR. Field units shall deliver all surfaces in the Surfaces_&_Mosaics folder (See Appendix J).

Alternately, non-CARIS users may submit fully corrected, such that it will be read in CARIS HIPS and SIPS using a 'zeroed' Vessel Configuration file (.vcf or .hvf) and a 'zero' tide file (.tid), etc.

Full Resolution Lidar Data

The contractor shall submit the full resolution lidar data in CARIS compatible format. The submission will include the appropriate CARIS converter, lidar data before conversion, and all necessary CARIS files so that NOAA can reconvert all files, if desired. Field units shall deliver all surfaces in the Surfaces_&_Mosaics folder (See Appendix J).

CARIS BASE Surface and/or BAG

The final depth information from the survey will be composed of a collection of grids. This collection of grids must reflect the state of the seafloor at the time of the survey, with resolution and attribution as described in Section 5.2, and/or the Project Instructions. The hydrographer must take steps to ensure that all data has been correctly processed and that appropriate designated soundings have been selected (Section 5.2.1.2.3 and Section 7.4). The collection of grids representing the final reviewed results of the hydrographic survey shall be submitted as CARIS BASE or BAG surfaces. CARIS' format for the Navigation Surface is a Bathymetry Associated with Statistical Error (BASE) surfaces, either an Uncertainty or CUBE Surface. CARIS users shall include the version number used during the creation of the surfaces in the Comments section during Step 1 of the BASE Surface Creation Wizard. Non-CARIS users may submit their Navigation Surfaces as a Bathymetric Attributed Grid (BAG).

All grids must adhere to the following naming convention: <Survey registry number>_<sounding type>_<units of resolution>_<vertical datum>.bag.
Sounding types are 'MB' for multibeam echo sounder, 'VB' for single beam echo sounder, and 'LI' for lidar.

- All user shall submit finalized grids by resolution and sounding type:
  <Survey registry number>_<Sounding Type>_<units of resolution>_<Vertical Datum>_Final.BAG/.CSAR

  Examples:
  H11000_MB_50cm_MLLW_Final.bag/.csar
  H11000_VB_4m_MLLW_Final.bag/.csar
  H11000_LI_3m_MLLW_Final.bag/.csar

- CARIS users shall also submit the source .CSAR surfaces. This deliverable is not required for field units that do not use CARIS software for grid creation.
  Example:
  H11000_MB_50cm_MLLW.csar

Field units shall deliver all surfaces in the Surfaces_&_Mosaics folder (See Appendix J). Field units shall not submit combined BAG or CSAR grids.

Multibeam Calibration Data

The hydrographer shall submit data used for determining navigation time latency, pitch, roll, and yaw biases in a separate directory on the submitted drive. The data format shall be such that CARIS HIPS version 9 or above can convert the data, thus making it compatible as described earlier in this Section.

Other Bathymetric Data

Bathymetry from other sources (e.g., diver's least depth gauge, lead line, sounding pole, etc.) shall be submitted in a format readily understood and compatible with CARIS HIPS and SIPS version 9 or above. As with other sources of bathymetric data, these soundings shall be delivered fully corrected for all offsets, biases, sound speed, and other factors, with corresponding uncertainty estimates. These data shall also be included in the final grids as necessary and appropriate.

8.3.3 Side Scan Sonar Data

The hydrographer shall submit digital side scan data in a format readable by CARIS SIPS version 9 or above or SonarWiz. Digital side scan sonar shall be geocoded using the towfish position (towfish position corrected). Information and specifications on CARIS SIPS and data formats may be obtained from CARIS. Information and specifications on SonarWiz data formats may be obtained from SonarWiz.

Side Scan Contact Images

The hydrographer shall submit digital images of all side scan contacts within the contact file (Section 8.2.2) and in the Multimedia folder. Digital images shall be in a standard image format (e.g., .tif, .gif, .jpg, png).

Side Scan Mosaics

The hydrographer shall submit a digital image file for each 100 percent coverage. The digital image file shall be in a standard georeferenced image format (Section 8.2.1). Field units shall deliver all mosaics in the Surfaces_&_ Mosaics folder (Appendix J).

8.3.4 Backscatter Deliverables

The hydrographer shall submit raw multibeam backscatter data in a format readable by IVS Fledermaus Geocoder Toolbox. The raw multibeam backscatter data shall be delivered in the Preprocess MBES folder (Appendix J).

8.3.5 ERS Data Deliverables

Any logged raw data acquired to achieve ERS work as part of normal survey operations shall be included in the 'full resolution' deliverable data requirements of 8.3.2. This may include rover raw GNSS data, rover inertial data, and temporary GNSS base station files. Note that any user-maintained base stations require OPUS reports and QC check reports as described in Section 3.

Required ERS deliverables do not include information that is otherwise achieved by or in cooperation with the U.S. government, such as GNSS orbit and clock information and NOAA CORS.

Additional ERS deliverables are:

- For all non-NOAA CORS base station file data utilized, preferably in Receiver Independent Exchange Format (RINEX); otherwise, non-proprietary receiver "binary" format suffices
- Datum separation model file, even if the same as the one provided with the PI/SOW; deliver in one of the following formats in the Water Level folder (Appendix J).
  - Comma separated values: decimal latitude, decimal longitude, separation in meters
  - NGS GEOID BIN format
  - Corrector Surface layer in the Bathymetric Attributed Grid (BAG)

The OPUS sessions used to establish control shall include the option to "share my solution" when a permanent benchmark is involved (OPUS solutions of temporary marks are not shared).

8.3.6 Other Data

Tide and Sound Speed Data

The hydrographer shall submit tide data and sound speed data applied to all multibeam depths on the project data drives. The hydrographer shall identify the data format and all data element descriptions (e.g., ASCII text file or Excel spreadsheet file; date/time referenced to UTC, tide relative to MLLW datum to the nearest centimeter). All tide data required by Section 4.6 shall be sent directly to the appropriate CO-OPS office.

NCEI Sound Speed Data

Sound speed data must be submitted to NCEI following the NetCDF template format outlined on the NCEI website at http://www.nodc.noaa.gov/access/dataformats.html. Field units may use Velocipy to export a NetCDF file by selecting the NODC box upon export and specifying the export directory. Project, survey, NOAA Unit and instrument fields must be populated. The resulting file will have an .nc file extension. Each submission to NCEI should only contain data from one project. Additionally, the submission zip filename should contain the project number and timestamp of submission (e.g. OPR-B370-NRT5-16_20150420.zip).

- NOAA Field Units: Submit files to NCEI via email attachment to NODC.submissions@noaa.gov with a courtesy copy to the HSD/NSD Project Manager.

- Contractors: Submit NetCDF files to NCEI via email attachment to NODC.submissions@noaa.gov or via the S2N tool on the NCEI website. Include the COR on all correspondence.

Vessel Configuration File

The hydrographer shall submit a CARIS HIPS and SIPS compatible Vessel File (HVF) for each vessel used during survey operations in the VesselConfig folder (Appendix J). CARIS-compatible HVF shall contain those static and dynamic correctors, offsets and uncertainties which are to be applied to the "Full Resolution Multibeam Data" set submitted as referenced in Section 8.3.2. All submitted data is fully corrected.

An all zero vessel file can be used. In such a case, the hydrographer must provide details on what values were derived for all the static and dynamic correctors, offset and uncertainties and other information that is usually contained within a HVF in the DR and/or DAPR. Information and specifications on the HVF format may be obtained from CARIS.

Metadata

The following reports shall be included on the submitted data drive in a clearly labeled directory;

- The Appendices and Separates to the DR in Portable Document Format (PDF).
- The Data Acquisition and Processing Report in Portable Document Format (PDF).
- The Horizontal and Vertical Control Report in Portable Document Format (PDF).

Final Feature File

The S-57 final feature file shall be included on the submitted drive in the Final Feature File folder (Appendix J).

Supporting Data

- Any associated image files to support S-57 feature file objects shall be located in the Multimedia folder.
- Other interim data products that may help the Hydrographic Branch verify the survey and understand the pipeline from acquisition to final product.

List of Appendices:

Appendix A: Tide Station Report and Water Level Measurement System Site Report

NOAA FORM 77-12 (5-80)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMIN.

TIDE STATION REPORT

STATION NAME | STATION NUMBER

INSTRUCTIONS: This form is to be fully completed and submitted on station installation and at annual inspection/maintenance. (All information will be verified correct and measurements retaken.) At other station visits and on removal, only changes need be recorded in the appropriate blocks.

LATITUDE | LONGITUDE | TIME MER.

TYPE OF STATION: ☐ PRIMARY ☐ SECONDARY ☐ TERTIARY | REC'D BY NOS HQ

WHARF
NAME
OWNER'S NAME AND LOCAL CONTACT
BUSINESS ADDRESS/TELEPHONE NUMBER

PROJECT: ☐ CONTROL ☐ BOUNDARY ☐ CIRCULATORY ☐ HYDROGRAPHIC ☐ OTHER
☐ TEMPERATURE & DENSITY MEASUREMENTS AT THIS STATION
☐ ESTABLISHED ☐ INSPECTED ☐ REMOVED
BY: | DATE
APPROVED BY | DATE

TIDE OBSERVER
NEW ☐ YES ☐ NO
NAME | TELEPHONE NUMBER (Include Area Code.) HOME ( ) | BUSINESS ( )
HOME ADDRESS | DATE HIRED (If new) | PAY/MO.

TIDE HOUSE & PLATFORM
SIZE AND BRIEF DESCRIPTION OF INSTALLATION INCLUDING PLATFORM, ACCESS INFO (Combination, contact, hours...)
☐ Continued on reverse.

TIDE STAFF/ETG
☐ PORTABLE ☐ ELECTRIC ☐ FIXED | ☐ FIBERGLASS ☐ OTHER ☐ VITRIFIED | HINGED ☐ YES ☐ NO | STAFF/ETG CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION
LIMITS OF GRADUATIONS | TOTAL MEASURED LENGTH BETWEEN THE LIMITS OF GRADUATIONS FT. | GRADUATION CORRESPONDING TO ROOSTOP/ETG WEIGHT FT. | INITIALS
PRECISE LOCATION, METHOD OF SECURING STAFF, TYPE AND CONDITION OF ROD STOP, AND ADDITIONAL REMARKS
☐ Continued on reverse.

GAGES
PRIMARY
TYPE AND MANUFACTURER | SERIAL NUMBER | GAGE CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION
POWER SOURCE ☐ COMMERCIAL ☐ BATTERY ☐ SOLAR ☐ OTHER | FLOAT/ORIFICE DIAMETER INS. | RANGE/SCALE | ☐ NEGATOR SPRING ☐ COUNTERWEIGHT

BACK-UP
TYPE AND MANUFACTURER | SERIAL NUMBER | GAGE CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION
POWER SOURCE ☐ COMMERCIAL ☐ BATTERY ☐ SOLAR ☐ OTHER | FLOAT/ORIFICE DIAMETER INS. | RANGE/SCALE | ☐ NEGATOR SPRING ☐ COUNTERWEIGHT
☐ ADDITIONAL GAGES! (Give details on reverse.)
REMARKS
☐ Continued on reverse.

FLOAT WELL
MATERIAL | INTAKE ☐ FIXED/MOLDED ☐ REMOVABLE | WELL CHANGED ☐ YES ☐ NO | DATE OF INSTALLATION
LENGTH (Overall) FT. | LENGTH (To Intake) FT. | INSIDE DIAMETER INS. | INTAKE MAT'L. | INTAKE SIZE (Hole diameter) INS. | ORIFICE POSITION
INSPECTION, CONSTRUCTION, INSTALLATION DESCRIPTION AND REMARKS | INTAKE CLEANED ☐ YES ☐ NO | OUTSIDE CLEANED ☐ YES ☐ NO | NO. OF SECURING CLAMPS
☐ Continued on reverse.

SUPERSEDES PREVIOUS EDITION. EXISTING STOCK MAY BE DESTROYED UPON RECEIPT OF REVISION.

Figure A.1: NOAA Form 77-12 Tide Station Report

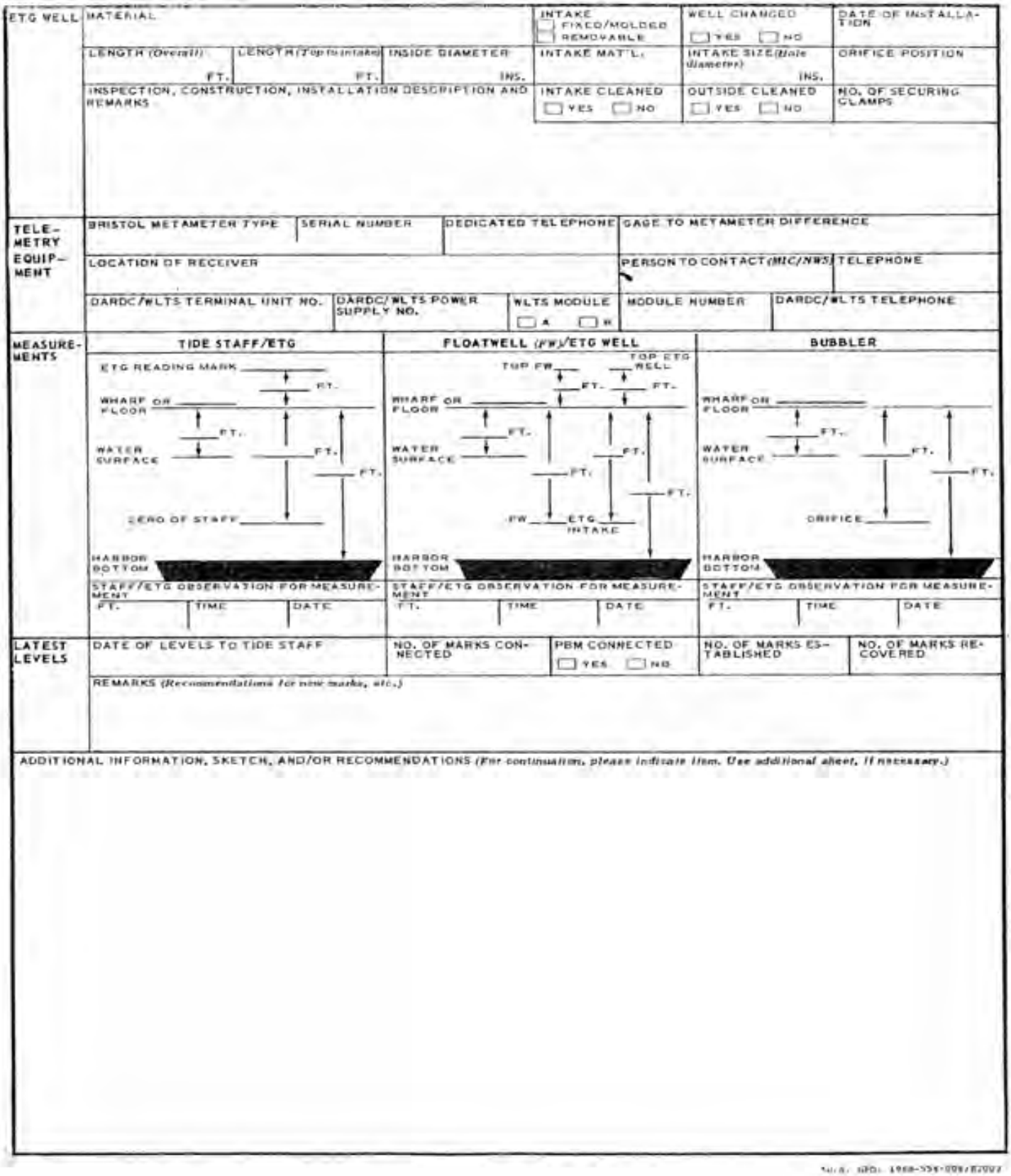


Figure A.2: Tide Station Report (cont.)

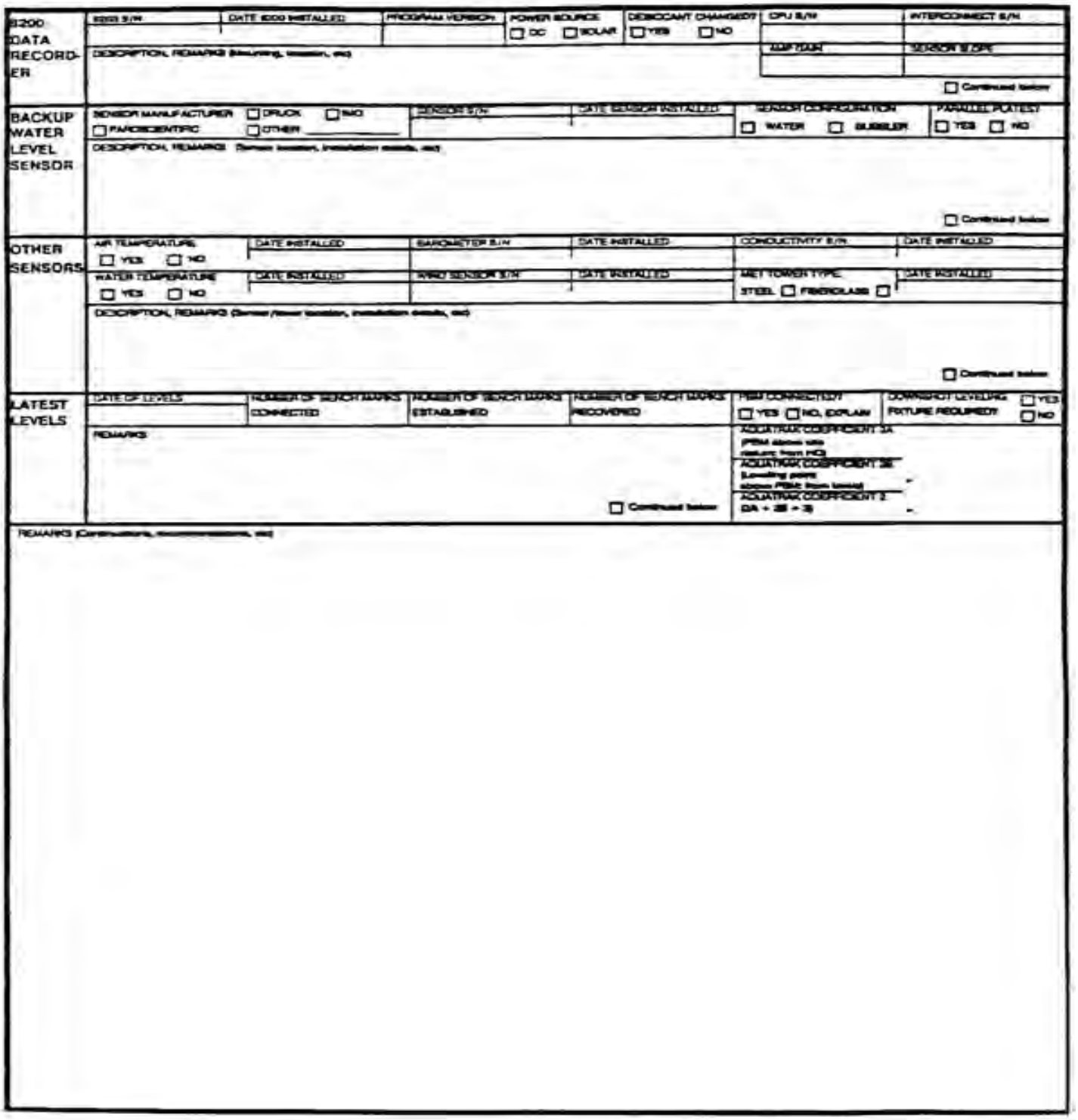
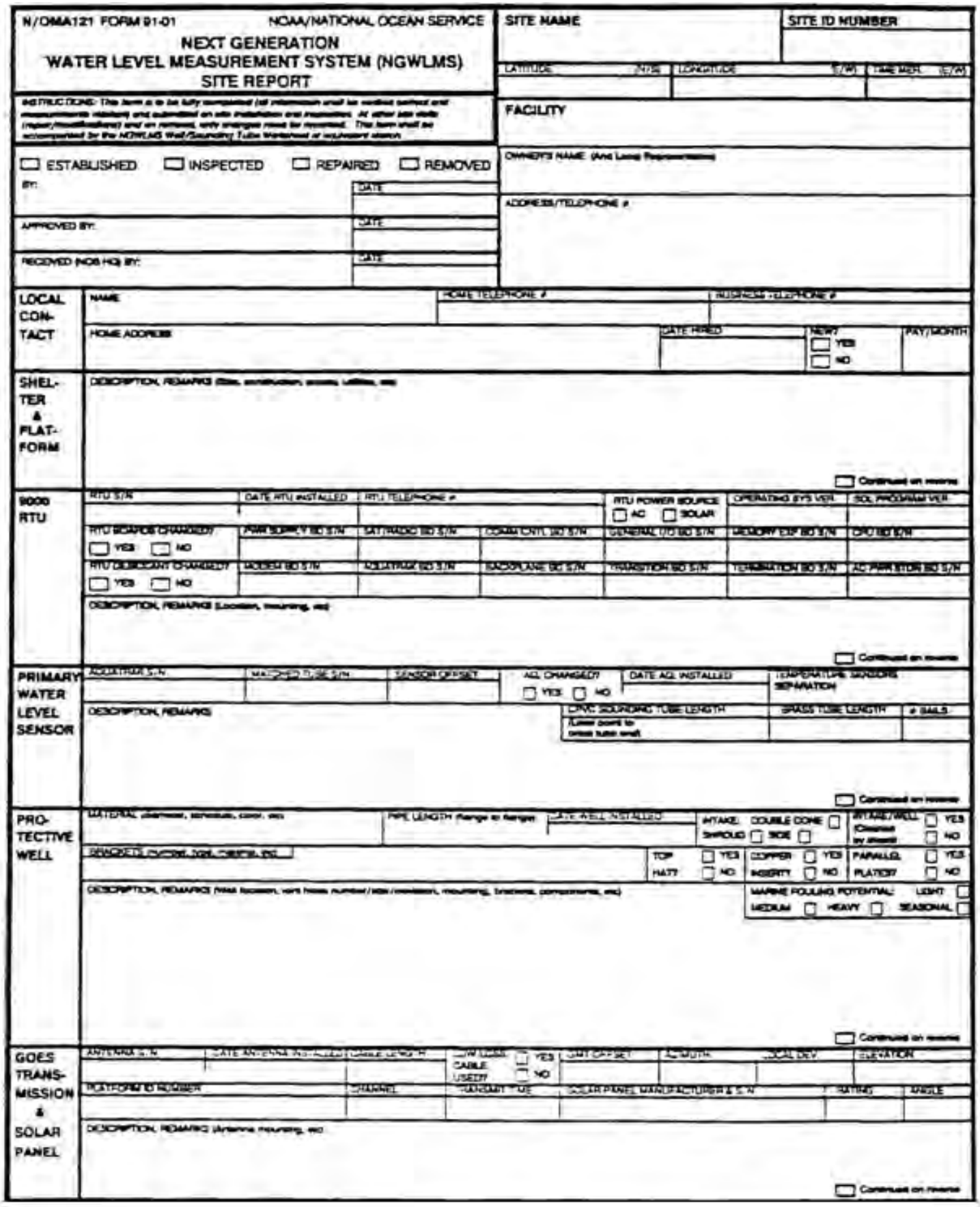


Figure A.3: Tide Station Report (cont.)


N/OMA121 FORM 91-01 NOAA/NATIONAL OCEAN SERVICE

NEXT GENERATION
WATER LEVEL MEASUREMENT SYSTEM (NGWLMS)
SITE REPORT

SITE NAME | SITE ID NUMBER

LATITUDE N/S | LONGITUDE E/W | TIME MEAS. (L/Z)

INSTRUCTIONS: This form is to be fully completed (all information must be verified correct and measurements validated) and submitted on site installation and inspection. At other site visits (repair/modification) and on removal, only changes need be reported. This form shall be accompanied by the NOWLAS Well/Sounding Tube Worksheet or equivalent sketch.

FACILITY

☐ ESTABLISHED ☐ INSPECTED ☐ REPAIRED ☐ REMOVED

BY: | DATE

APPROVED BY: | DATE

RECEIVED (NOS HQ) BY: | DATE

OWNER'S NAME (And Local Representative)

ADDRESS/TELEPHONE #

LOCAL CONTACT

NAME | HOME TELEPHONE # | BUSINESS TELEPHONE #

HOME ADDRESS | DATE HIRED | NEW? ☐ YES ☐ NO | PAY/MONTH

SHELTER & PLATFORM

DESCRIPTION, REMARKS (Size, construction, access, utilities, etc)

☐ Continued on reverse

9000 RTU

RTU S/N | DATE RTU INSTALLED | RTU TELEPHONE # | RTU POWER SOURCE ☐ AC ☐ SOLAR | OPERATING SYS VER. | SDL PROGRAM VER.

RTU SCAPS CHANGED? ☐ YES ☐ NO | PWR SUPPLY BD S/N | SAT/RADIO BD S/N | COMM CNTL BD S/N | GENERAL I/O BD S/N | MEMORY EXP BD S/N | CPU BD S/N

RTU DESIGNANT CHANGED? ☐ YES ☐ NO | MODEM BD S/N | DEVITRAK BD S/N | RADIO/LINE BD S/N | TRANSITION BD S/N | TERMINATION BD S/N | AC PWR STOR BD S/N

DESCRIPTION, REMARKS (Location, mounting, etc)

☐ Continued on reverse

PRIMARY WATER LEVEL SENSOR

ADDENDUM S/N | MANUFACTURER S/N | SENSOR OFFSET | ADJ CHANGED? ☐ YES ☐ NO | DATE ADJ INSTALLED | TEMPERATURE SENSORS SEPARATION

DESCRIPTION, REMARKS

DRUM SOUNDING TUBE LENGTH (Lower point to cross tube weld) | GRASS TUBE LENGTH | # BAILS

☐ Continued on reverse

PROTECTIVE WELL

MATERIAL (diameter, schedule, color, etc) | PIPE LENGTH (Range to Range) | DATE WELL INSTALLED | INTAKE: DOUBLE CONE ☐ SHROUD ☐ SIDE ☐ | INTAKE/WELL (Cleaned by divers) ☐ YES ☐ NO

PERFORATIONS (HOW, SIZE, SPACING, ETC) | TOP ☐ YES HAT? ☐ NO | COPPER ☐ YES INSERT? ☐ NO | PARALLEL ☐ YES PLATES? ☐ NO

DESCRIPTION, REMARKS (Well location, vent hose number/size/orientation, mounting, brackets, components, etc) | MARINE FOULING POTENTIAL: LIGHT ☐ MEDIUM ☐ HEAVY ☐ SEASONAL ☐

☐ Continued on reverse

GOES TRANSMISSION & SOLAR PANEL

ANTENNA S/N | DATE ANTENNA INSTALLED | CABLE LENGTH | LOW LOSS CABLE USED? ☐ YES ☐ NO | UNIT OFFSET | AZIMUTH | LOCAL DEV. | ELEVATION

PLATFORM ID NUMBER | CHANNEL | HEXADECIMAL ID | SOLAR PANEL MANUFACTURER & S/N | RATING | ANGLE

DESCRIPTION, REMARKS (Antenna mounting, etc)

☐ Continued on reverse

Figure A.4: N/OMA121 Form 91-01 Next Generation Water Level

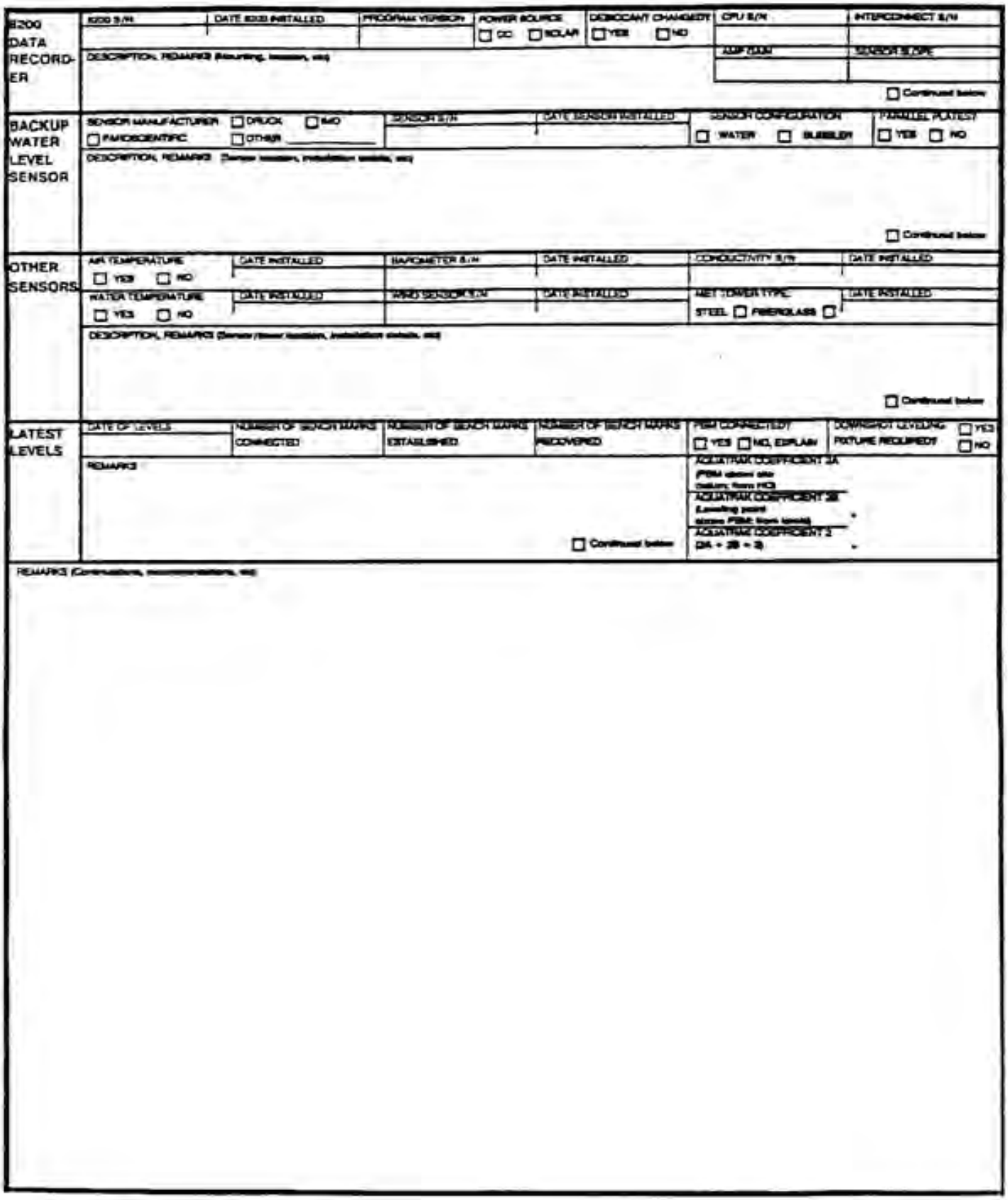


Figure A.5: Next Generation Water Level (cont.)

Appendix B: Abstract of Times of Hydrography for Smooth Tides or Water Levels

Project: OPR-P385-KR[1] Registry No.: H-xxxxxx[1]
Contractor Name:
Date:
Sheet Letter: [1]
Inclusive Dates: [2]
Field work is complete.

Time (UTC)

Day[3]	Start[4]	End[4]	Year

[1]Project Number, Registry Number, and Sheet Letter from SOW Or Hydrographic Survey Letter Instructions.

[2]Dates of the first and last days of data acquisition.

[3]Day of the year (e.g. April 30, 1998 = 120)

[4]Start and end time of hydrography for the day.

Figure B.1: Abstract of Times of Hydrography for Smooth Tides or Water Levels

Appendix C: Example Request for Smooth Tides/Water Levels Letter

TO: NOAA, National Ocean Service
Chief, Requirements and Engineering Branch
SSMC4, Station 6515, N/CS41
1305 East-West Highway
Silver Spring, MD 20910-3281

FROM: <Hydrographer>

SUBJECT: Request for Approved Tides/Water Levels

Please provide the following data:

1. Approved Tides/Water Level Note
2. Final Zoning in MapInfo format (or the Hydrographer may request the data in ArcView format)
3. Six Minute Water Level Data posted to CO-OPS web site.

Transmit the data to:
<Insert hydrographer's name and shipping address>

These data are required for the processing of hydrographic survey:

Project: OPR-xxxx-KR
Registry Number: H-xxxxxx
Sheet Letter: A
Locality: xxxxxxxxxxxxxx

A progress Sketch or chartlet showing the survey area and Abstract of Times of Hydrography are attached.

Tide/water level data are required within 45 days of this receipt. If this schedule cannot be met, please advise HSD Operations at 301-713-2702 x112.

Figure C.1: Example Request for Smooth Tides/Water Levels Letter

Appendix D: Danger to Navigation Report

H12471 DtoN#1 Uncharted OFSPLF

Registry Number: H12471
State: Louisiana
Locality: Approaches to Mississippi Sound
Sub-locality: 11 nm South of Horn Island
Project Number: OPR-J348-KR-12
Survey Dates: 10/10/2012 - 01/24/2013

Charts Affected

Number	Edition	Date	Scale (RNC)	RNC Correction(s)*
11373	50th	08/01/2012	1:80,000 (11373_1)	USCG LNM: 1/22/2013 (1/22/2013) NGA NTM: 4/9/2011 (2/2/2013)
11366	11th	01/01/2008	1:250,000 (11366_1)	[L]NTM: ?
11360	43rd	11/01/2008	1:456,394 (11360_1)	[L]NTM: ?
1115A	43rd	11/01/2008	1:456,394 (1115A_1)	[L]NTM: ?
11006	32nd	08/01/2005	1:875,000 (11006_1)	[L]NTM: ?
411	52nd	09/01/2007	1:2,160,000 (411_1)	[L]NTM: ?

* Correction(s) - *source: last correction applied (last correction reviewed--"cleared date")*

Features

No.	Name	Feature Type	Survey Depth	Survey Latitude	Survey Longitude	AWOIS Item
1.1	H12471 DTON #1 Uncharted Communication Tower	GP	[None]	29° 59' 00.6" N	088° 34' 59.9" W	---

Figure D.1: Example of Danger to Navigation Report

1.1) H12471 DTON #1 Uncharted Communication Tower

DANGER TO NAVIGATION

Survey Summary

Survey Position:	29° 59' 00.6" N, 088° 34' 59.9" W
Least Depth:	[None]
TPU (±1.96σ):	**THU (TPEh)** [None] ; **TVU (TPEv)** [None]
Timestamp:	2013-024.19:23:44.000 (01/24/2013)
Dataset:	H12471_DtoN_01.000
FOID:	US 0000047691 00001(02260000BA4B0001)
Charts Affected:	11373_1, 11366_1, 1115A_1, 11360_1, 11006_1, 411_1

Remarks:

OFSPLF/remrks: DtoN 1.1 is an uncharted U. S. Air Force Communication Tower.

Feature Correlation

Source	Feature	Range	Azimuth	Status
H12471_DtoN_01.000	US 0000047691 00001	0.00	000.0	Primary

Hydrographer Recommendations

[None]

S-57 Data

Geo object 1:	Offshore platform (OFSPLF)
Attributes:	CATOFP - 3:observation / research platform
	CONVIS - 1:visual conspicuous
	INFORM - US Air Force Communication Tower
	SORDAT - 20130124
	SORIND - US,US,graph,H12471

Office Notes

This danger submission is preliminary. No data has been provided to AHB for verification. Feature will be reviewed and verified once the survey data has been submitted. Reference attached PDF document concerning the communication tower submitted by US Dept. of Interior.

Figure D.2: Example of Danger to Navigation Report

Feature Images

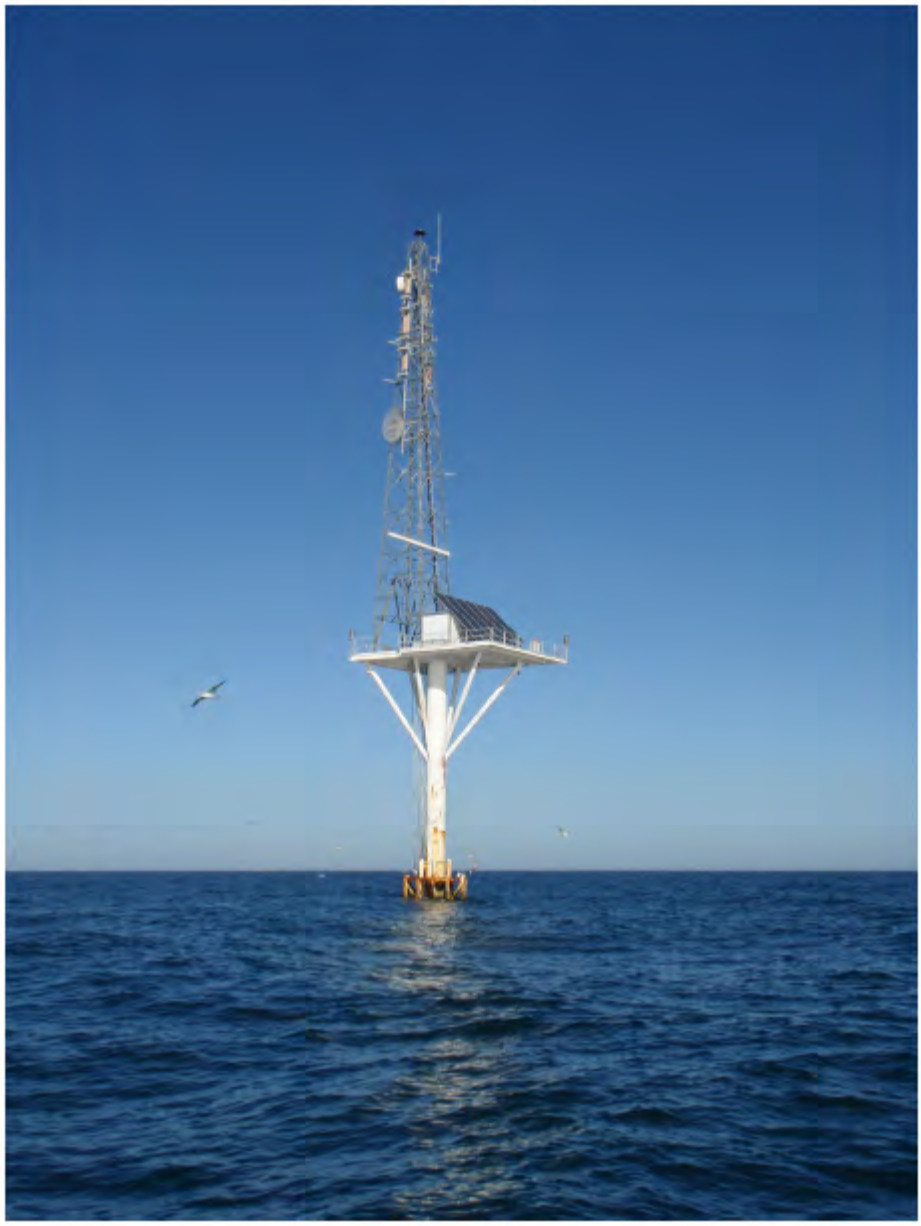
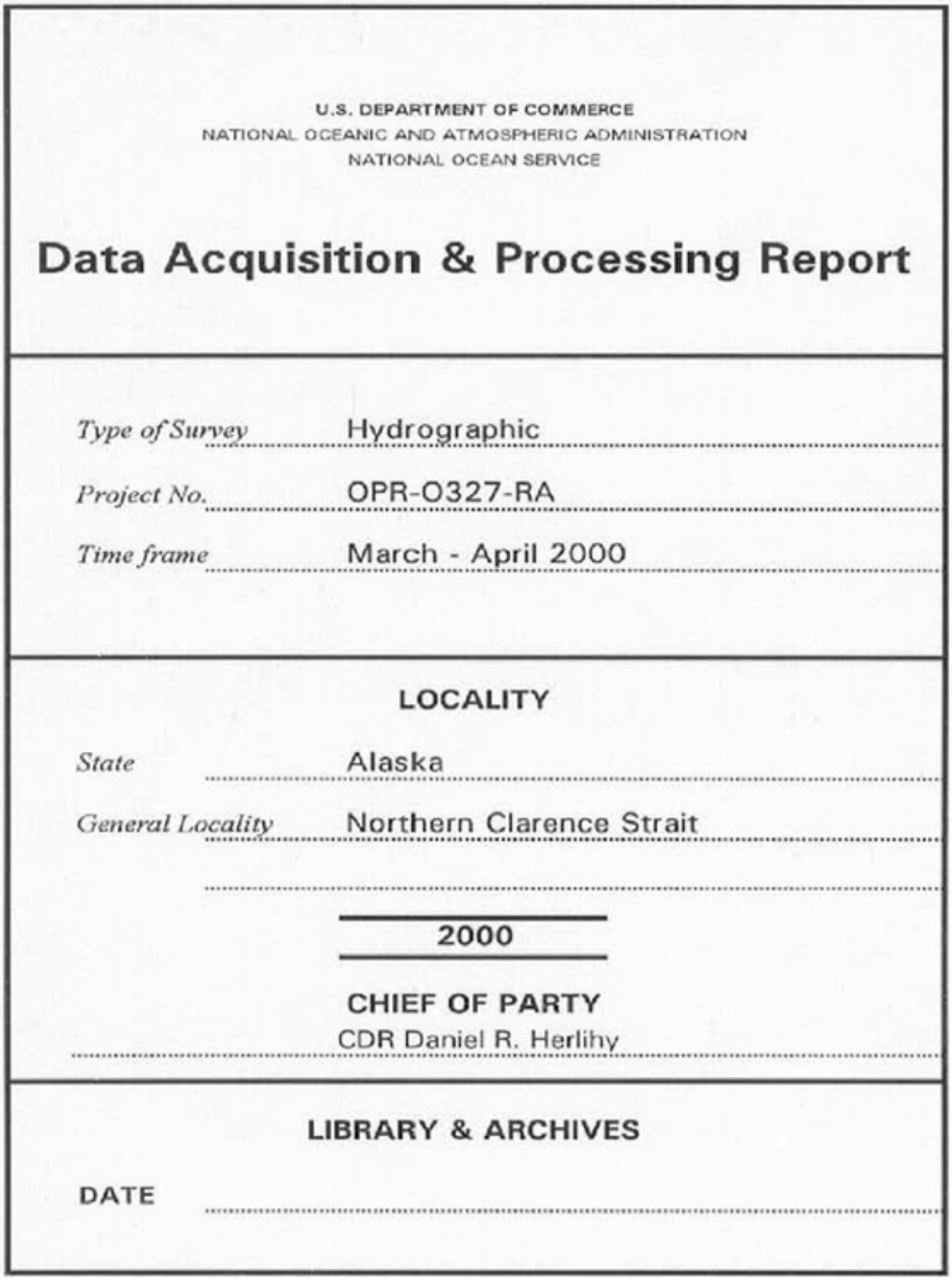


Figure 1.1.1

Figure D.3: Example of Danger to Navigation Report

Appendix E: Data Acquisition and Processing Report



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

Data Acquisition & Processing Report

Type of Survey Hydrographic

Project No. OPR-O327-RA

Time frame March - April 2000

LOCALITY

State Alaska

General Locality Northern Clarence Strait

2000

CHIEF OF PARTY
CDR Daniel R. Herlihy

LIBRARY & ARCHIVES

DATE

Figure E.1: Data Acquisition and Processing Report

Appendix F: WATLEV Attribution

Atlantic Coast and Gulf of Mexico

Classification	Always Underwater	Awash	Covers & Uncovers	Always Dry
Elevation (VALSOU or HEIGHT)	> 1ft (0.3048m) below MLLW	< 1ft (0.3048m) above MLLW to 1ft (0.3048m) below MLLW	1ft (0.3048m) above MLLW to 1ft (0.3048m) above MHW	>1ft (0.3048m) above MHW
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none

*A rock becomes an islet at 1 foot (0.3048 meters) above MHW. LNDARE point or area objects are used to characterize islets. Elevation for islets is encoded using the object LNDELV, with attribute ELEVAT, and are shown relative to the MHW datum.
**When the depth of an obstruction or wreck is greater than 1 foot (0.3048 meters) above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to MHW datum. In this situation, WATLEV and VALSOU are left null.

Pacific Coast and Alaska

Classification	Always Underwater	Awash	Covers & Uncovers	Always Dry
Elevation (VALSOU or HEIGHT)	> 2ft (0.6096m) below MLLW	< 2ft (0.6096m) above MLLW to 2ft (0.6096m) below MLLW	2ft (0.6096m) above MLLW to 2ft (0.6096m) above MHW	> 2ft (0.6096m) above MHW
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none

*A rock becomes an islet at 2 feet (0.6096 meters) above MHW. LNDARE point or area objects are used to characterize islets. Elevation for islets is encoded using the object LNDELV, with attribute ELEVAT, and are shown relative to the MHW datum.
**When the depth of an obstruction or wreck is greater than 2 feet (0.6096 meters) above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to MHW datum. In this situation, WATLEV and VALSOU are left null.

Figure F.1: WATLEV Attribution

Great Lakes (LWD = Low Water Datum)

Classification	Always Underwater	Awash	Covers & Uncovers	Always Dry
Elevation (VALSOU or HEIGHT)	> 2ft (0.6096m) below LWD	< 2ft (0.6096m) above LWD to 2ft (0.6096m) below LWD	2ft (0.6096m) above MLLW to 4ft (1.2192m) above LWD	> 4ft (1.2192m) above LWD
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none

*A rock becomes an islet at 4 feet (1.2192 meters) above MHW. LNDARE point or area objects are used to characterize islets. Elevation for islets is encoded using the object LNDELV, with attribute ELEVAT, and are shown relative to the MHW datum.

**When the depth of an obstruction or wreck is greater than 4 feet (1.2192 meters) above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to MHW datum. In this situation, WATLEV and VALSOU are left null.

Figure F.2: WATLEV Attribution

Appendix G: NOAA Extended Attributes Schema

NOAA Extended Attributes Schema

NOAA has created extended attributes in the acquisition and processing software to provide further flexibility than can be obtained via the S-57attribute standards. The following extended attributes are global to all S-57 object classes.

Acronym	Name	Description	ISO8211 ID	Type
acqsts	Acquisition status	Status of acquisition	2007	(E)numeration
asgnmt	Assignment status	Indicates whether a feature is (un)assigned	2001	(E)numeration
cnthgt	Contact height	Contact Height	2008	(F)loat
dbkyid	Database key ID	Unique ID for use in relational database	1041	Free text (S)tring
descrp	Description	Field recommended charting action	2000	(E)numeration
images	Images	List of comma-delimited file name(s); do not include path(s)	2003	Free text (S)tring
invreq	Investigation requirements	Specific instructions for investigation requirements	2009	Free text (S)tring
keywrd	Keyword	List of comma-delimited user keyword(s)	2006	Free text (S)tring
onotes	Office notes	Office notes	2004	Free text (S)tring
prmsec	Primary / secondary correlation status	Indicates whether a feature is the primary contact or a secondary view	2002	(E)numeration
prkyid	Primary key ID	For Secondary feature(s); the Primary feature dbkyid	2010	Free text (S)tring
recomd	Recommendations	Charting recommendations	1119	Free text (S)tring
remrks	Remarks	Remarks	1118	Free text (S)tring
sftype	Special feature type	Indicates special features	2005	(E)numeration

Figure G.1: NOAA extended attributes parameters

Acronym	ISO8211 Code	Enumeration ID	Meaning
descrp	2000	1	New
		2	Update
		3	Delete
		4	Retain
		5	Not Addressed
asgnmt	2001	1	Unassigned
		2	Assigned
		3	For Info Only
prmsec	2002	1	Primary
		2	Secondary
		3	Pending
sftype	2005	1	ATON
		2	AWOIS
		3	DTON
		4	MARITIME BOUNDARY
		5	LIDAR INVESTIGATION
acqsts	2007	1	Investigate
		2	Resolved

Figure G.2: Expected input values for NOAA enumeration attributes

Appendix H: Bottom Classification

Type	Term	Grain Diameter (mm)
Sand	Fine	0.1-0.3
	Medium	0.3-0.5
	Coarse	0.5-1.0
Stones		50-250
Boulder		≥ 250

Figure H.1: Sediment Classification by Size

Encoding for Bottom Samples

Bottom characteristics are limited in usefulness for charting purposes, but other users find the information helpful for a multitude of purposes, such as geologic, fisheries or habitat studies. Only the main constituents of the bottom sample you collect will be applied to the chart. Other constituents, as well as color, and many of your qualifying terms, will be omitted for charting purposes, but archived and made available for other users.

Use the S-57 object SBDARE (Seabed Area) for classification of bottom characteristics. NATSUR (Nature of Surface) is a required attribute for all NOAA bottom samples collected. For NOAA purposes in describing bottom samples the attribute NATQUA (Nature of Surface – Qualifying Terms) may also be used in conjunction with NATSUR, but is not to be used alone. COLOUR may also be used to further describe the NATSUR term.

How to Encode Bottom Characteristics Multiple NATSUR terms may be designated, for example, sand, gravel and shells. For more detailed descriptions the attribute NATQUA may also be used as a descriptive term. For instance, the sand may be NATQUA, coarse and the shells may be NATQUA, broken. *(NOTE: S-57 permits multiple NATQUAs to be applied to any individual NATSUR term. For example, mud may be both 'sticky' and 'soft'. However, for NOAA purposes do not apply multiple NATQUAs to a single NATSUR.)* COLOUR may also be applied to the NATSUR terms. *(NOTE: S-57 limits the use of COLOUR to just the first term, but for NOAA purposes we are applying COLOUR as needed for any or all of the terms.)* See the tables on the following pages for NATSUR, NATQUA and COLOUR options.

Follow these steps for encoding bottom samples.

(1) **NATSUR**: First determine the most appropriate general description of the seabed type using one or more of the choices for attribute NATSUR. List them in order of the most predominate first, comma delimited, using the S-57 ID number.

> Example: For sand, mud and shells where sand is the major constituent, followed by mud, then shells:

NATSUR = sand,mud,shells **(4,1,17)**

(2) **NATQUA**: Next, if clearly discernible, give more specific details for the NATSUR characteristics selected using the attribute NATQUA. NATQUA attributes should be listed in the same order as the NATSUR attributes to which they are associated, and should be comma delimited. For any NATSUR that has no NATQUA qualifier, its place in the list must be left empty and held by a comma.

> Example: Fine sand with mud and broken shells; mud is the only constituent with no qualifier:

NATSUR = sand,mud,shells **(4,1,17)**; NATQUA=fine,,broken **(1,-,4)**

Where the *last* NATSUR term has no qualifier, encode a trailing comma.

> Example: fine sand and mud, (mud has no qualifier):

NATSUR=sand,mud **(4,1),** NATQUA=fine, **(1,-)**

(3) **COLOUR**: Finally, if appropriate, encode COLOUR as above for NATQUA.

> Example: Fine white sand with black mud and broken shells

NATSUR = sand,mud,shells **(4,1,17)**; NATQUA=fine,,broken **(1,-,4)**; COLOUR=white,black **(1,2,)**

Figure H.2: Encoding for Bottom Samples

In ENC viewing software this is how the SBDARE and its attributes will appear for a sample encoded as 'fine white sand, black mud and broken shells'.

Selection

Acronym	Name
SBDARE	Seabed area

Attributes

Acronym	Name	
COLOUR	Colour	white,black,-
NATQUA	Nature of surface - qualifying terms	fine,-,broken
NATSUR	Nature of surface	sand,mud,shells

Many S-57 feature management software applications will automatically format the comma delimiters for NATSUR, NATQUA and COLOUR.

NATSUR (Nature of surface)

ID	Meaning	NATSUR Description
1	mud	Soft, wet earth.
2	clay	Particles of less than 0.002mm; stiff, sticky earth that becomes hard when baked.
3	silt	Particles of 0.002-0.0625mm; when dried on hand will rub off easily.
4	sand	Particles of 0.0625-2.0mm; tiny grains of crushed or worn rock.
5	stone	A general term for rock fragments ranging in size from pebbles and gravel to boulders or a large rock mass.
6	gravel	Particles of 2.0-4.0mm; small stones with coarse sand.
7	pebbles	Particles of 4.0-64.0mm; small stones made smooth and round by being rolled in water.
8	cobbles	Particles of 64.0-256.0mm; stones worn round and smooth by water and used for paving.
9	rock	Any formation of natural origin that constitutes an integral part of the lithosphere. The natural occurring material that forms firm, hard, and solid masses.
11	lava	The fluid or semi-fluid matter flowing from a volcano. The substance that results from the cooling of the molten rock.
14	coral	Hard calcareous skeletons of many tribes of marine polyps.
17	shells	Exoskeletons of various water dwelling animals.
18	boulder	A rounded rock with diameter of 256mm (25.6cm) or larger.

Figure H.3: Encoding for Bottom Samples

NATQUA (Nature of surface, qualifying terms)

ID	Meaning	NATQUA Description
1	fine	Falls within the smallest size continuum for a particular NATSUR term.
2	medium	Falls within the moderate size continuum for a particular NATSUR term.
3	coarse	Falls within the largest size continuum for a particular NATSUR term.
4	broken	Fractured or in pieces.
5	sticky	Having an adhesive or glue like property.
6	soft	Not hard or firm.
7	stiff	Not pliant; thick, resistant to flow.
8	volcanic	Composed of or containing material ejected from a volcano.
9	calcareous	Composed of or containing calcium or calcium carbonate.
10	hard	Firm; usually refers to an area of the sea floor not covered by unconsolidated sediment.

COLOUR

ID	Meaning
1	white
2	black
3	red
4	green
5	blue
6	yellow
7	grey
8	brown
9	amber
10	violet
11	Orange
12	Magenta
13	Pink

Figure H.4: Encoding for Bottom Samples

NATQUA / NATSUR	1 Fine	2 Medium	3 Coarse	4 Broken	5 Sticky	6 Soft	7 Stiff	8 Volcanic	9 Calcareous	10 Hard
1 Mud					x	x	x	x	x	x
2 Clay					x	x	x			x
3 Silt					x	x	x			x
4 Sand	x	x	x			x		x	x	x
5 Stone								x	x	
6 Gravel								x	x	
7 Pebbles								x	x	
8 Cobbles								x	x	
9 Rock								x	x	
11 Lava								x		
14 Coral				x						
17 Shells				x					x	
18 Boulder								x	x	

Figure H.5: NATQUA/NATSUR Allowable Attribute Combination

Appendix I: Survey Data Submission

NOAA FORM 61-29
(12-71)

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

LETTER TRANSMITTING DATA

REFERENCE NO.

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY **(Check)**

☐ ORDINARY MAIL ☐ AIR MAIL
☐ REGISTERED MAIL ☐ EXPRESS
☐ GBL **(Give number)**_____

DATE FORWARDED

NUMBER OF PACKAGES

TO:

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

This package contains [List drive(s) with description (e.g. Seagate 500 GB) and CD number or drive name]
Containing Hydrographic Survey Data Submission "[Type of data (i.e. Field/Raw and Processed Data]":

Checksum

Survey: Hxxxxx
Project: OPR-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000
Name of Checksum File: Hxxxxx.md5

Survey: Hxxxxx
Project: OPR-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000
Name of Checksum File: Hxxxxx.md5

Survey: Hxxxxx
Project: OPR-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000
Name of Checksum File: Hxxxxx.md5

[Add additional comments or notes here]

FROM: (Signature)

RECEIVED THE ABOVE
(Name, Division, Date)

Return receipted copy to:

USDOC NOAA NOS
[Insert field unit address here]

NOAA FORM 61-29 SUPERCEDES FORM C AND GS 413 WHICH MAY BE USED.

U.S. GOVERNMENT PRINTING OFFICE: 1988 - 554-006-61309

Reset

Figure I.1: Survey Data Submission for NOAA Units

NOAA FORM 61-29
(12-71)

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

LETTER TRANSMITTING DATA

REFERENCE NO.

DATA AS LISTED BELOW WERE FORWARDED TO YOU BY **(Check)**

☐ ORDINARY MAIL ☐ AIR MAIL
☐ REGISTERED MAIL ☐ EXPRESS
☐ GBL **(Give number)**_____

DATE FORWARDED

NUMBER OF PACKAGES

TO:

NOTE: A separate transmittal letter is to be used for each type of data, as tidal data, seismology, geomagnetism, etc. State the number of packages and include an executed copy of the transmittal letter in each package. In addition the original and one copy of the letter should be sent under separate cover. The copy will be returned as a receipt. This form should not be used for correspondence or transmitting accounting documents.

This package contains [List drive(s) with description (e.g. Seagate 500 GB) and CD number or drive name]
Containing Hydrographic Survey Data Submission "[Type of data (i.e. Field/Raw and Processed Data]":

Survey: xxxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

Survey: xxxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

Survey: xxxxxx
Project: xxx-xxxx-xx-xx
Size (bytes): 000,000,000
Files: 00,000

[Add additional comments or notes here]

FROM: (Signature)

RECEIVED THE ABOVE
(Name, Division, Date)

Return receipted copy to:

NOAA FORM 61-29 SUPERCEDES FORM C AND GS 413 WHICH MAY BE USED.

• U.S. GOVERNMENT PRINTING OFFICE: 1988 - 554-006-61309

Reset

Figure I.2: Survey Data Submission for Contractors

Appendix J: Data Directory Structure

- **OPR-X###-XX-##**
  - **HXXXXX**
    - **Data**
      - **Descriptive_Report**
        - **Appendices**
          - **I_Water_Levels**
          - **II_Supplemental_Survey_Records_&_Correspondence**
        - **Report**
      - **Preprocess**
        - **Features**
        - **MBES**
        - **Positioning**
        - **SBES**
        - **SSS**
        - **SVP**
      - **Processed**
        - **GNSS_Data**
          - **SBET**
        - **Multimedia**
        - **S-57_Files**
          - **Final_Feature_File**
          - **Side_Scan_Sonar_Contacts**
        - **Sonar_Data***
          - **Surfaces_&_Mosaics**
          - **HXXXXX**
          - **VesselConfig**
        - **SVP**
        - **Water_Levels**
      - **Public_Relations_&_Constituent_Products**
      - **Separates**
        - **I_Acquisition_&_Processing_Logs**
          - **Acquisition_Logs**
          - **Detached_Positions**
          - **Processing_Logs**
        - **II_Digital_Data**
          - **Checkpoint_Summary_&_Crossline_Comparisons**
          - **Sound_Speed_Data_Summary**
  - **Project_Reports**
    - **Data_Acquisition_&_Processing_Report**
      - **Report**
      - **Appendices**
    - **Horizontal_&_Vertical_Control_Report**
      - **Digital_A-Vertical_Control_Report**
      - **Digital_B-Horizontal_Control_Data**
        - **ATON_Data**
        - **Base_Station_Data**
    - **Project_Correspondence**

* CARIS users:
Processed/Sonar_Data/Surfaces_&_Mosaics
Processed/Sonar_Data/HDCS_Data/HXXXXX
Processed/Sonar_Data/HDCS_Data/VesselConfig

Figure J.1: NOAA and Contractor Data Director Structure

Appendix K: DR Memo and DR Summary Templates

DR MEMO TEMPLATE

<Date>

MEMORANDUM FOR: Chief, Atlantic/Pacific Hydrographic Branch

FROM: John Q. Hydrographer
Team Lead, NRTX

SUBJECT: Submission of Survey D00XXX

Memo should include the following information:

Who was the requestor/ customer?
What was the purpose?
What were the products and who were they provided to?
Discuss how soundings are reduced to datum?
Discuss any deviation from the DAPR or make a positive statement that DAPR procedures were followed. Metadata Table

Sample Text: Survey D00XXX was conducted by NRTX in response to Hurricane XXX. The survey came at the request of USCG District X to provide seafloor imagery of the maintained channels to assist in reopening the Port for commercial, deep draft vessels. *Was the purpose achieved? (e.g. survey operations ended on June 15, port opened to all traffic on June 16.)*

NRTX provided paper plots and digital GeoPDFs of the area to USCG District X that included Side Scan Sonar Mosaics and preliminary depths. *The digital version of all products provided to local constituents should be included in the data package submitted to HSD.*

Soundings were reduced to Mean Lower Low Water (MLLW) using observed tides from <tide station> and tide zones provided by CO-OPS from a 2009 survey of this area <include tide zoning file name>. *All tide zone files used shall be included in the data package submitted to HSD.*

All survey systems and methods utilized during this survey were as described in <name of DAPR document>, with the exception of the EdgeTech 4125 side scan sonar system, which was pole mounted off the starboard side of the boat instead of towed. As a result, the towpoint of the side scan for this project was x, y, z, instead of the towpoint listed in the DAPR. The CARIS HIPS Vessel File (HVF) was updated accordingly for this project and is included in the files submitted with this survey.

Reference any DTONs that were submitted, or specifically state that all data was reviewed for DTONs and non were found.

This survey does not <or does> meet charting specifications and is not <or is> adequate to supercede prior data.

In most cases, the data will not be suitable for charting. However, in some cases the data may meet charting specificiations and/or be appropriate to update the chart. For instance, development of a wreck during the response that will likely not be salvaged and should be charted. In such cases, the statement should specifically

state which parts of the survey do meet charting specifications and/or should supercede prior data, as appropriate. This situation should not be common, since if in advance we know the data will be needed on the chart, a DR Summary would have been required.

Sample Meta Data for D00XXX	
Project	S-Dxxx-NRT2-12
Survey	D00XXX
State	Delaware
Locality	Delaware Bay
Sub Locality	Delaware River
Scale of Survey	1:10000
Sonars Used	Klein 3000, R2 Sonic, Odom CV2
Horizontal Datum	North American Datum of 1983 (NAD83)
Vertical Datum	Mean Lower Low Water (MLLW)
Vertical Datum Correction	Verified Observed Tides from Gauge <XXXXXXX>
Projection	Latitude-Longitude (NAD83) - UTM Zone XX
Field Unit	NRT2
Survey Dates	05/11/2012 – 05/12/2012
Chief of Party	John Q. Hydrographer
Submission Date	3/22/2013

DR SUMMARY TEMPLATE

Descriptive Report Summary to Accompany <survey number>	
Project	Sample Text: S-Dxxx-NRT2-12
Survey	Sample Text: D00624
State	Sample Text: Delaware
Locality	Sample Text: Delaware River and Bay
Sub Locality	Sample Text:
Scale of Survey	Sample Text: 1:10000
Sonars Used	Sample Text: Klein 3000, R2 Sonic, Odom CV2
Horizontal Datum	Sample Text: North American Datum of 1983 (NAD83)
Vertical Datum	Sample Text: Mean Lower Low Water (MLLW)
Vertical Datum Correction	Sample Text: Verified Observed Tides
Projection	Sample Text: Latitude-Longitude (NAD83) - UTM Zone XX
Field Unit	Sample Text: NRT2
Survey Dates	Sample Text: 05/11/2012 – 05/12/2012
Chief of Party	Sample Text: John Q. Hydrographer

A. Area Surveyed

Sample Text: This hydrographic survey was acquired in accordance with the requirements defined in the Project Instruction OPR-XXX-XXX-XX.

Specify if HSSD and FPM were requirements and if they were fulfilled. This needs to be understood at the HSD OPS/NSD NRB level. The Project Instructions shouldn't indicate HSSD/FPM are required if they know ahead of time the survey is not going to fulfill it.

Ensure any diversions from PI are clearly documented.

Sample Text: Data was acquired within the following survey limits:

Northeast Limit	Southwest Limit
XX.XX N	XX.XX N
XX.XX W	XX.XX W

<insert graphic overview of area surveyed>

B. Survey Purpose

Sample Text: This survey was conducted in respond to USCG requests for hydrographic surveys to reopen the ports and check for shoaling in Delaware River and Delaware Bay due to the effects of Hurricane SANDY. The survey limits and methods (i.e. sensors used) were determined by the USCG commander and NOAA Navigation Manager on-scene. Data was collected in the most efficient manner to provide USCG information that was critical to make real-time decisions on channel and/or port closures and openings and determine if any shoaling has occurred. Any shoaling determined from this survey are intended to be applied to the nautical chart.

Use this section to describe the purpose of the survey. Give detail on requestor (if outside of OCS) or response

event the survey was in in support of. Include a graphic of survey overview.

C. Intended Use of Survey

Sample Text: This survey is for informational purposes only and is not adequate to supersede prior data. It is not intended for chart compilation.

<OR>

Data is adequate to supersede prior data and is intended for chart compilation.

Make a statement here confirming if the survey is/is not recommended for charting. If not suitable for charting, Section D and F is N/A.

D. Data Acquisition and Processing

Sample Text: Please reference Data Acquisition and Processing Report <DAPR Name> for a complete description of data acquisition and processing systems, survey vessels, quality control procedures and data processing methods.

Mention DAPR if one was submitted. If no DAPR, provide similar details on vessel and systems used to acquire bathymetry, SSS, VBES, SVP, Positioning equipment and software, acquisition and processing software, etc. The Branch's preference is a DAPR in lieu of a description in this section.

E. Uncertainty

Sample Text: The greatest problems associated with achieving the desired accuracy levels were focused in two areas. Arboles Island and St. Ignace Rock were both located in areas with thick kelp patches. The kelp limited coverage and required heavy data editing. Further, Arboles Island and St. Ignace Rock were surveyed exclusively with the tilted RESON 8125 (see blue tracklines in Figures 26 and 27), which is not capable of producing as accurate a sounding set (for hardware related reasons) as the other sonars used in this survey.

Discuss the internal consistency and integrity of the survey data and any other factors that affected the corrections to soundings. Discuss the uncertainty values of the submitted CARIS generated surfaces (uncertainty or CUBE) and/or BAG(s). Explain and/or justify any areas that have an uncertainty greater than the IHO levels allow.

F. Results and Recommendations

Sample Text: The following are the largest scale RNC and ENC, which cover the survey area:

Chart	Scale	Edition	Edition Date	LNM Date	NM Date
ENC	Scale	Edition	Update Application Date	Issue Date	Preliminary?

Provide details on chart comparisons, AWOIS items (if assigned), new features for charting, shoals or potentially hazardous features, DTONs or other relevant information for charting. If not intended for charting, reiterate Section C.

Provide list of submitted surfaces/mosaics. Give a brief sentence or two about the quality of the surfaces – did it meet density requirement? Discuss Uncertainty if MBES. Is there a systematic problem evident in the surfaces (svp, tides, heave artifact, etc)?

Surface Name	Surface Type	Resolution	Depth Range	Surface Parameter	Purpose

G. Vertical and Horizontal Control

Sample Text: The vertical datum for this project is Mean Lower Low Water. Discrete Zoning was the vertical control method used. The following National Water Level Observation Network (NWLON) stations served as datum control for this survey:

Station Name	Station ID
XXXXXX	XXXXXX

Sample Text: The horizontal datum for this project is North American Datum of 1983 (NAD83). Differential GPS (DGPS) was the sole method of positioning. The following DGPS Stations were used for horizontal control:

DGPS Stations
XXXXXX

Provide details on what horizontal positioning methods were utilized.

H. Additional Results

Provide any other details on the survey that are relevant and not discussed elsewhere, such as sound speed issues, HVF issues, systematic survey problems, shoreline investigations conducted, etc.

I. Approval

Sample Text: As Chief of Party, field operations for this hydrographic survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports. All field sheets, this Survey Summary Report, and all accompanying records and data are approved. All records are forwarded for final review and processing to the Processing Branch.

Sample Text: The survey data meets or exceeds requirements as set forth in the NOS
Hydrographic Surveys and Specifications Deliverables Manual, Field Procedures Manual, Standing and Letter Instructions, and all HSD Technical Directives. These data are adequate to supersede charted data in their common areas. This survey is complete and no additional work is required with the exception of deficiencies noted in the Survey Summary Report.

State the opposite if the survey isn't adequate to supersede prior data and shouldn't be used for chart compilation.

Approver Name	Approver Title	Approval Date	Signature

Appendix L: Marine Mammal and Sea Turtle Observation Logs

FORM 11US (POP)

MARINE MAMMAL SIGHTING

NOAA/NMFS/AFSC/NMML
Platforms of Opportunity
7600 Sand Point Way NE
Seattle, WA 98115

Observer(s)	Vessel Name	Cruise Number	Permit Number

year ☐☐ month ☐☐ day ☐☐ local time (24 hr. clock) ☐☐:☐☐ +/- ☐ GMT ☐☐ latitude ☐☐° ☐☐.☐' N/S ☐ longitude ☐☐☐° ☐☐.☐' E/W ☐

Sighting Conditions: ❑ excellent ❑ good ❑ fair ❑ poor

Beaufort ☐ +/- ☐ water temp. ☐☐.☐°C

Species (*Please fill out a form for each species*) _____

confidence ❑ sure ❑ likely ❑ unsure

Sighting Cue _____

Closest Approach (in meters) ☐☐☐☐m

Number Sighted: best estimate ☐☐☐☐ minimum no. ☐☐☐☐ maximum no. ☐☐☐☐

Narrative: Make identifications only on specific features seen. Mention them here. Include body features, markings and coloration, associated organisms, elaborate on behaviors, etc. The most valuable sightings contain a good amount of detailed information.

Sketches: When possible, make a sketch noting pigmentation, anatomical features, scarring, posture, anatomical anomalies, group positioning, etc. (*see silhouettes on other side*).

Photos/Video (optional)

❑ photographs (list filenames) _____

❑ video (list filenames) _____

❑ *Check here if there was more than one species of marine mammal present at this sighting*

BODY LENGTH ESTIMATE

- ❑ <3m (10')
- ❑ 3-8 m (10-25')
- ❑ 8-16 m (25-50')
- ❑ 1&-26 m (50-80')
- ❑ >26 m (>80')

Some common behaviors

(check all that apply)

SMALL CETACEANS

- ❑ Bow riding
- ❑ Leaping entirely out of water
- ❑ Porpoising (swimming fast, body out of the water)
- ❑ Rooster-tailing (usually a Dall's porpoise cue)
- ❑ Slow rolling

LARGE CETACEANS

- ❑ Blow visible from a distance
- ❑ Breaching
- ❑ Flipper slapping
- ❑ Group feeding
- ❑ Lob-tailing
- ❑ Spy-hopping
- ❑ Tail raised on dive
- ❑ Side wake riding
- ❑ Stem wake riding

PINNIPEDS

- ❑ Jug handle (flippers in air)
- ❑ Porpoising (swimming fast, at least partially out of the water)
- ❑ Rafting
- ❑ Spooked from haulout
- ❑ Vocalizing

Fishing Interactions

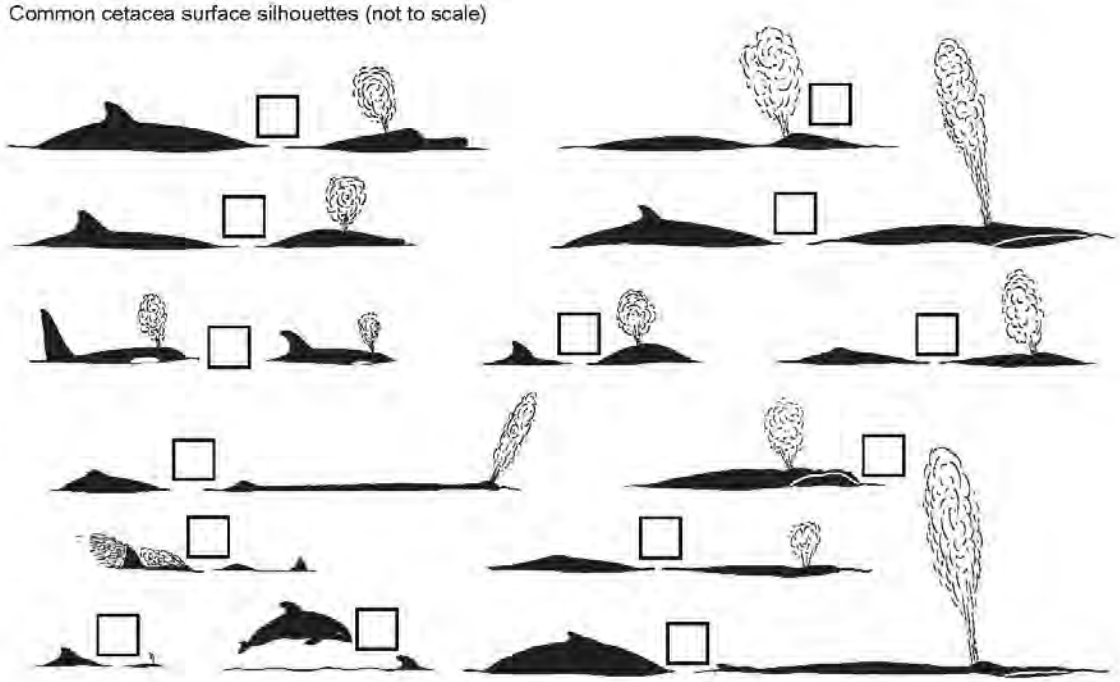
Please fill out the Marine Mammal Interaction and Specimen Form for all fishing interactions

- ❑ Contact with gear
- ❑ Contact with vessel
- ❑ Entangled in gear
- ❑ Feeding on discards
- ❑ Feeding from gear
- ❑ Following vessel while fishing
- ❑ Swimming near gear

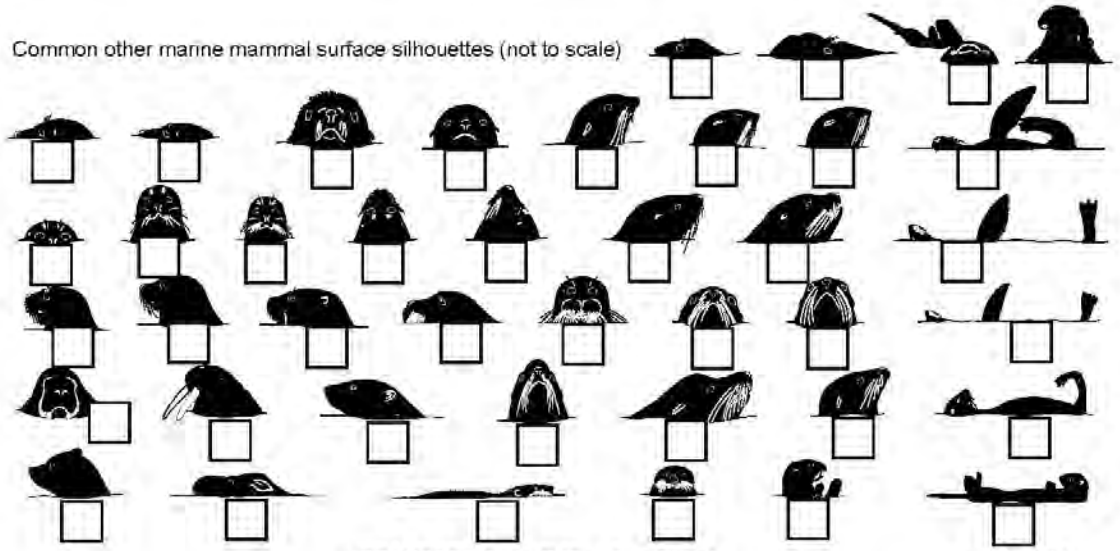
Form 11US : version 1 : 19 June 2013

These are silhouettes of most genera of marine mammals known to occur in and around North America. Subtilties exist between closely related genera. Care should be taken in identifying species. Assessing one's level of confidence with copious notes and observations is more valuable than a brief misidentification. **Please circle appropriate silhouette(s).**

Common cetacea surface silhouettes (not to scale)



Common other marine mammal surface silhouettes (not to scale)



BEAUFORT SCALE (Sea Condition)		*wind*	*wave height*	
0	glassy, calm	0 , 1 kts	calm	
1	light ripple	1 < 4 kts	light air	1/4'
2	small wavelets	4 < 7 kts	light breeze	1/2'
3	scattered whitecaps	7 < 11 kts	gentle breeze	2'
4	small waves, frequent whitecaps	11 < 17 kts	moderate breeze	4'
5	moderate waves, many whitecap	17 < 22 kts	fresh breeze	6'
6	all whitecaps, some spray	22 < 28 kts	strong breeze	10'
7	breaking waves, spindrift	28 < 34 kts	near gale	14'
8	medium high waves, foamy streaks	34 < 41 kts	gale	18'
9	high waves, dense foamy streaks	41 < 48 kts	strong gale	22'
10-12	not meaningful (time to go home)			

SEA TURTLE OBSERVATION LOG

OBSERVER INFORMATION

OBSERVER(S)	VESSEL NAME	PROJECT ID

SIGHTING INFORMATION

DATE	TIME (24 HR) AND TIME ZONE	LATITUDE	LONGITUDE

SEA STATE (BEAUFORT)	SIGHTING CONDITIONS (EXCELLENT, GOOD, FAIR, POOR)	CONFIDENCE OF SIGHTING (SURE/LIKELY/UNSURE)	SIGHTING CUE

ANIMAL INFORMATION

SPECIES (SEE ATTACHED KEY)	SIZE	CLOSEST APPROACH (M)	NUMBER SIGHTED

IF MULTIPLE SPECIES ARE SIGHTED:

SPECIES (SEE ATTACHED KEY)	SIZE	CLOSEST APPROACH (M)	NUMBER SIGHTED

NARRATIVE (E.G., BODY FEATURES, MARKINGS/COLORATION, BEHAVIOR, DISPOSITION [ALIVE OR DEAD])

_____

_____

_____

_____

NOAA OFFICE OF COAST SURVEY
SUBMIT COMPLETED FORM TO OCS.ECC@NOAA.GOV

SEA TURTLE OBSERVATION LOG

_____

_____

_____

_____

_____

_____

_____

BEAUFORT SCALE (SEA CONDITION)		WIND	WAVE HEIGHT	
0	GLASSY, CALM	0-1 KTS	CALM	NA
1	LIGHT RIPPLE	1 < 4 KTS	LIGHT AIR	0.25 FT
2	SMALL WAVELETS	4 < 7 KTS	LIGHT BREEZE	0.50 FT
3	SCATTERED WHITECAPS	7 < 11 KTS	GENTLE BREEZE	2 FT
4	SMALL WAVES, FREQUENT WHITECAPS	11 < 17 KTS	MODERATE BREEZE	4 FT
5	MODERATE WAVES, MANY WHITECAPS	17 < 22 KTS	FRESH BREEZE	6 FT
6	ALL WHITECAPS, SOME SPRAY	22 < 28 KTS	STRONG BREEZE	10 FT
7	BREAKING WAVES, SPINDRIFT	28 < 34 KTS	NEAR GALE	14 FT
8	MEDIUM HIGH WAVES, FOAMY STREAKS	34 < 41 KTS	GALE	18 FT
9	HIGH WAVES, DENSE FOAMY STREAKS	41 < 48 KTS	STRONG GALE	22 FT
10+	GO HOME!			

TAKE PHOTOGRAPHS AND / OR VIDEO IF POSSIBLE.

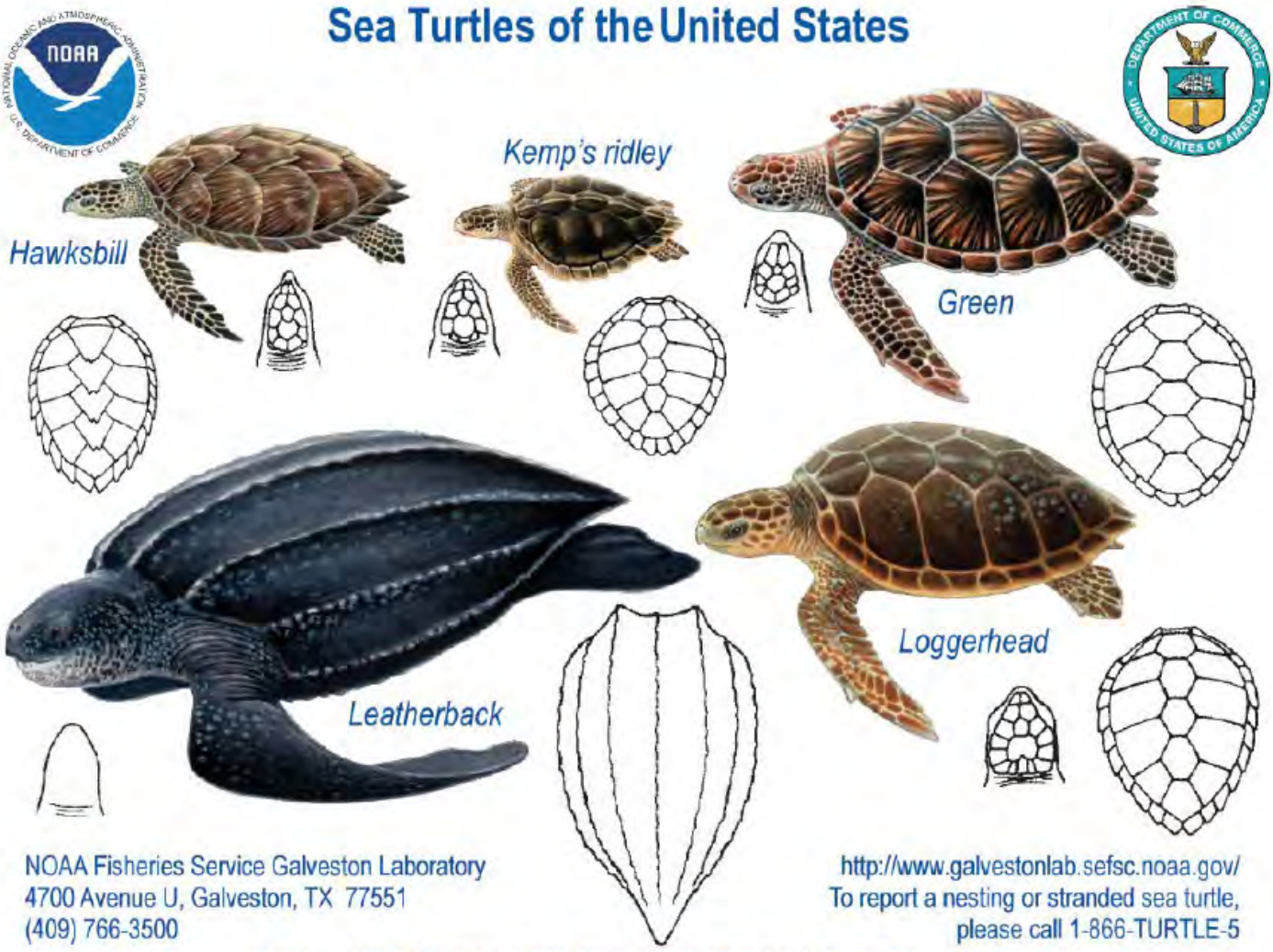
SUBMIT COMPLETED FORMS, PHOTOGRAPHS, AND VIDEOS TO OCS.ECC@NOAA.GOV AND TO THE OCS PROJECT MANAGER / COR.

IN ADDITION, SUBMIT COMPLETED FORMS, PHOTOGRAPHS, AND VIDEOS TO:

CONTACT	FOR SIGHTINGS IN LOCATION
LARISA AVENS, LARISA.AVENS@NOAA.GOV	EAST COAST AND GULF OF MEXICO
JEFF SEMINOFF, JEFFREY.SEMINOFF@NOAA.GOV	WEST COAST
GEORGE BALAZS, GEORGE.BALAZS@NOAA.GOV	HAWAII AND PACIFIC ISLANDS

NOAA OFFICE OF COAST SURVEY
SUBMIT COMPLETED FORM TO OCS.ECC@NOAA.GOV

Sea Turtles of the United States



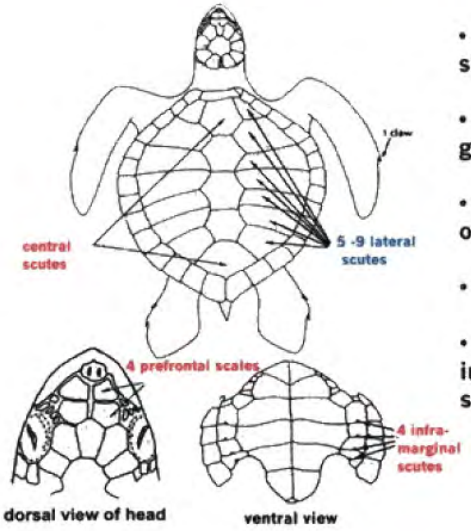
NOAA Fisheries Service Galveston Laboratory
4700 Avenue U, Galveston, TX 77551
(409) 766-3500

http://www.galvestonlab.sefsc.noaa.gov/
To report a nesting or stranded sea turtle,
please call 1-866-TURTLE-5

Image credit: NOAA

Olive ridley turtle

Present on the U.S. west coast, including southern Alaska



- Almost round-shaped shell
- Olive/grayish green color
- Between 5-9 pairs of lateral scutes
- 4 prefrontal scales
- 4 pairs inframarginal scutes

Image credit: NOAA