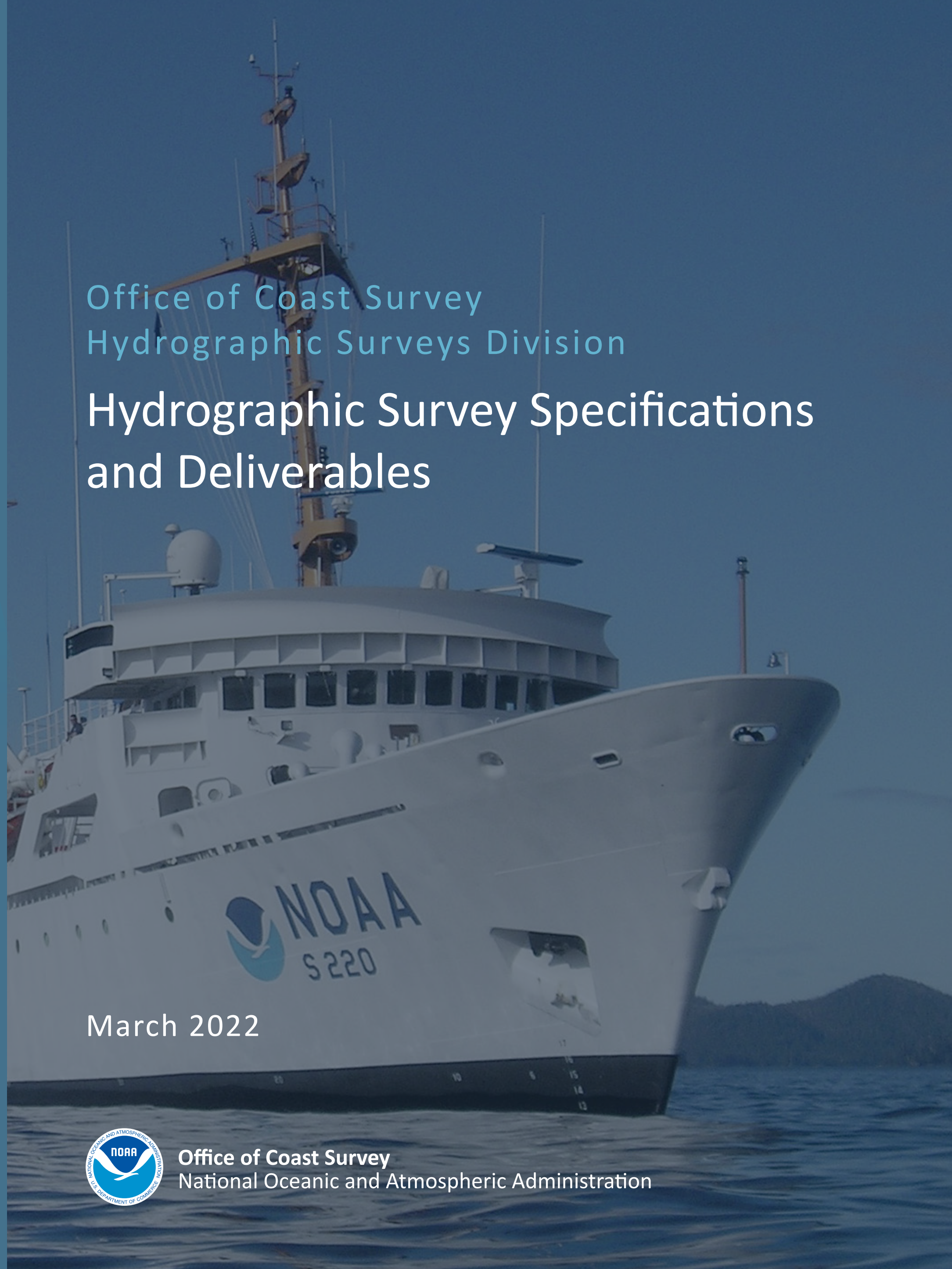

Office of Coast Survey
Hydrographic Surveys Division

Hydrographic Survey Specifications and Deliverables

March 2022

Office of Coast Survey
National Oceanic and Atmospheric Administration

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, Sixth Edition, March 2020, 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. 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.

Field units may find the Pydro suite of software developed by NOAA and the University of New Hampshire's Center for Coastal and Ocean Mapping (CCOM) HydrOffice useful in planning, acquiring, processing, and reporting on hydrographic surveys. There is no requirement for contractors to use this software. The Pydro application, information, and documentation can be found at: https://nauticalcharts.noaa.gov/data/tools-apps.html.

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

- "Shall" or "must" means the procedure or standard is mandatory.
- "Should" means the procedure or standard is recommended.
- "May" means that the procedure or standard is optional.

- "Will" means futurity of action only and does not indicate any degree of requirement for application of a procedure or meeting a standard.

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 HSSD Hydroforum located at https://sites.google.com/a/noaa.gov/ocs-hydrography/hssdfpmxml-dr-updates. This is a centralized location to collaborate on and manage HSSD change requests. Change requests by contractors shall be made by contacting the COR who will update the HSSD ticket system. 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 https://nauticalcharts.noaa.gov/publications/standards-and-requirements.html.

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 April 2021

Several clerical changes have been made in the 2021 Edition of this document. Significant technical and organizational changes are summarized below:

Chapter 1 Introduction

- Section 1.6.3 DTON Reporting to NOAA, major updates to section
- Section 1.7.3 Non-Dangerous Pipelines Submission to NOAA, updated deliverable

Chapter 4 Tides and Water Levels Requirements

- Section 4.2.2 Data Collection Platform (DCP) and Transmissions, updates and new location for this information
- Section 4.2.3 Water Level Sensors, updated referenced websites
- Section 4.3.3.2 GNSS Tide Buoys, major additions to section on planning, sensor specifications, and hull and mooring specifications

Chapter 5 Depth Soundings

- Section 5.2.3.3 Speed of Sound Corrections, updated calibration timeline of sound speed profilers

Chapter 6 Acoustic Backscatter

- Section 6.1.3.3 Side Scan Sonar Contacts, removed use of diver's least depth gauge when developing a contact with single beam echo sounder

- Section 6.2.2 Acquisition Parameters and Requirements, updated all subsections including the addition of the requirement to process MBES backscatter data
- Section 6.2.3 Backscatter Data Processing, new section
- Section 6.2.4 Deliverables, new section

Chapter 7 Features

- Section 7.3.6 Aids to Navigation, removed reporting requirement for on station ATONs
- Section 7.5.1 S-57 Attribution, clarified TECSOU and QUASOU requirement for soundings, clarified WATLEV for empty VALSOU, clarification of OBSTRN encoding for foul ground
- Section 7.5.2 NOAA Extended Attribution, clarified image filename requirements, removed requirement for recommendations entry for new and delete features

Chapter 8 Deliverables

- Section 8.1.1.1 Weekly Progress Reports, clarified cumulative weekly grid requirements
- Section 8.1.2 Survey Outline, added Survey Outline as a field unit deliverable to the branch

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 (which may also be referred to simply as "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 3.5-meter depth contour. Note that in the cases where the 3.5-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.

On some occasions the hydrographer may be tasked with investigation of specific items 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.) 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 Project Instructions.

Environmental Compliance Requirements and Deliverables

All NOAA or contractor 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 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 (Appendix J). 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 Project Instructions and shown in Appendix J, 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 report all Dangers to Navigation (DTON) to the appropriate authority. Timeliness is a critical issue in reporting DTONs. 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 or inadequately charted (e.g., missing, off station, adrift, destroyed, damaged, leaning, mis-characterized, and if lighted, burning dimly or extinguished) aids to navigation, unless temporary in nature or repositioned frequently (Section 7.3.5)

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.

Uncharted wrecks that are submitted as DTONs shall be attributed and reported as obstructions in the DTON submission package. These features shall be re-attributed as wrecks in the Final Feature File that is provided in the survey deliverables. This approach ensures that potentially sensitive features are not added to the chart without undergoing review by the State Historic Preservation Officer.

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 DTON Reporting to Non-NOAA Source Authorities

NOAA is not the source authority for some charted features such as controlling depths in federal channels, Aids to Navigation (ATONs), bridge heights, and pipelines. The reporting procedures for these types of dangers are described in this section.

1.6.2.1 Federal USACE Channels

The USACE is the source of controlling depths in federal channels on NOAA charts. 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 with a carbon copy to the HSD Branch Chief at email hsd.chief.ops@noaa.gov or NSD branch chief at chief.nrb.ocs@noaa.gov, as appropriate. The HSD/NSD Project Manager or COR will inform the Navigation Manager via email with a carbon copy to CAB.Chief@noaa.gov and ocs.nbs@noaa.gov. The Navigation Manager shall 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.

1.6.2.2 Aids to Navigation (USCG)

The USCG Local Notice to Mariners and the USCG Light List are the sources of charted Aids to Navigation on NOAA charts.

Type 1 and Type 2 Aids to Navigation
If any type of aid to navigation that is listed in the USCG Light List and the USCG considers as Type 1 and Type 2 is found to be uncharted, missing, or repositioned, the hydrographer shall report it to the USCG using the USCG Navigation Center's Online ATON Discrepancy Report Form at https://www.navcen.uscg.gov/?pageName=atonOutageReport. A PDF copy of the report submitted to the Navigation Center (select "printer friendly version") shall be immediately emailed to the HSD/NSD Project Manager or COR and Navigation Manager and listed in DR Appendix II.

Type 3 Aids to Navigation
If any private navigation aid that the USCG considers as Type 3, and not included in the USCG Light List, is found to be uncharted, missing, or repositioned, the hydrographer shall report it through the Marine Chart Division's ASSIST customer service chart reporting system: https://www.nauticalcharts.noaa.gov/customer-service/assist/. Report the private aid to navigation using the 'Report an Error' tab, providing the reporting person's email address, attributing the geographic location of the discrepancy, selecting the type of user, describing the error, selecting the product type, attributing the observation date, and attaching any images or documents. The ASSIST system will respond with an email from ocs.customersupport@noaa.gov that shall be immediately emailed to the HSD/NSD Project Manager or COR, Navigation Manager, and listed in DR Appendix II.

1.6.2.3 Bridge Heights (USCG)

The USCG is the source of bridge heights on NOAA charts. If a bridge height is found to be inaccurate or missing from a chart during field work, the hydrographer shall inform the local USCG District's Bridge Program via email with the pertinent information, with a carbon copy to the HSD/NSD Project Manager or COR and the Navigation Manager. The email addresses for the each USCG District Bridge Program are found at: http://www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Marine-Transportation-Systems-CG-5PW/Office-of-Bridge-Programs/District-Bridge-Contacts/. All relevant correspondence shall be listed in DR Appendix II.

1.6.3 DTON Reporting to NOAA

1.6.3.1 NOAA Field Unit Reporting

NOAA field units shall submit all NOAA DTONs via email directly to Marine Chart Division's (MCD) Nautical Data Branch at email address ocs.ndb@noaa.gov, with a carbon copy to the HSD/NSD Project Manager, HSD Branch Chief at hsd.chief.ops@noaa.gov or NSD Branch Chief at chief.nrb.ocs@noaa.gov, as appropriate, the Chief of the appropriate Hydrographic Branch, the appropriate Regional Navigation Manager and ocs.nbs@noaa.gov.

- The email subject line shall adhere to the following convention:
    - <registry number> DTON ##
    - e.g., H12345 DTON 03
- The body of the email shall list the following metadata in the following order:
    - General Locality
    - Sub-locality
    - Project Number
    - Registry Number
    - Field Unit

NOAA field unit DTON recommendations shall be attached to the email as an S-57 .000 feature file per 1.6.3.2 with an accompanying multimedia zip file.

All correspondence pertaining to DTON submission shall be listed in DR Appendix II.

1.6.3.2 DTON Feature S-57 .000

The S-57 .000 feature file may contain points, lines, or area features.

- The feature file shall adhere to the following naming convention:
    - <registry number>_DTON_##
    - e.g., H12345_DTON_03.000
- The feature file shall be attributed in accordance with HSSD Section 7.5 and the following requirements:
    - Special Feature Type (sftype) = DTON
    - Images (images) = each feature shall be accompanied with one chartlet image portraying an overview of the feature with the largest-scale ENC as the background. Images of sonar data (e.g., multibeam or side scan imagery) shall not be included.
    - Observed Time (obstim) = undefined
    - Source Date (SORDAT) = date the item was surveyed in the format YYYYMMDD. The SORDAT in the Final Feature File (FFF) shall be the last day of survey acquisition in the format YYYYMMDD
- Chartlet images shall be in the format JPEG, PNG, GIF, or TIFF
- Chartlet images shall be compressed in a single zip file with the following naming convention
    - <registry number>_DTON_##_Multimedia
    - e.g., F00123_DTON_01_Multimedia.zip

1.6.3.3 Contractor DTON Submission

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

Contractor DTON recommendations shall be submitted as an S-57 .000 feature file attributed in accordance with HSSD Section 7.5. The S-57 feature reporting shall adhere to 1.6.3.2 with the following exception: the contractor should submit sonar images of multibeam and side scan sonar images as supporting data. All images and chartlets shall be submitted in a multimedia zip file.

All correspondence pertaining to DTON submission shall be listed in DR Appendix II.

1.6.3.4 Hydrographic Branch Submission of Contractor DTON

The Hydrographic Branches shall review the contractor submitted DTON .000 feature file, update the attribution as required, and apply any other updates according to their discretion (e.g., remove features which do not pose an imminent danger to navigation). The Hydrographic Branches shall submit the DTON to the Nautical Data Branch at ocs.ndb@noaa.gov with a carbon copy to the HSD Project Manager or COR, the Chief of the appropriate Hydrographic Branch, the appropriate Regional Navigation Manager, and ocs.nbs@noaa.gov.

The email subject and body shall follow the convention listed in 1.6.3.1, and the DTON submission feature file shall follow the convention in 1.6.3.2.

The Hydrographic Branches shall 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, it shall be explained in the body of the submission email.

1.6.4 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 Seep and Pipeline Reporting

1.7.1 Seep and Pipeline Reporting to BSEE or Other Source Authorities

Seeps and unburied charted and uncharted pipelines shall be reported to the Bureau of Safety and Environmental Enforcement via email to pipelines@bsee.gov or NPMS@dot.gov for the Great Lakes with a carbon copy to the HSD/NSD Project Manager or COR and the Navigation Manager. The body of the email 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. All relevant correspondence shall be listed in DR Appendix II.

Sample text for seep and pipeline emails 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.

Subject: H13456 Gulf of Mexico Unburied Pipeline
Body: While conducting hydrographic survey operations, the NOAA Ship Thomas Jefferson discovered an unburied pipeline on January 1, 2018, within survey area H13456. The exposed pipeline is approximately 90 feet in length with starting coordinates of latitude XXX/longitude XXX and ending at latitude XXX/longitude XXX, bearing 120 degrees.

1.7.2 Dangerous Pipeline Reporting to NOAA

All uncharted pipelines that pose a danger to navigation shall be reported as obstructions (point features) directly to NOAA using the process described in Section 1.6.3. All charted and uncharted 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.

1.7.3 Non-Dangerous Pipeline Reporting to NOAA

Uncharted exposed or elevated pipelines that are not considered DTONs shall be reported to the Marine Chart Division (MCD) Nautical Data Branch. This reporting may include some of the same pipelines reported to BSEE.

NOAA Field Units shall submit all uncharted, non-dangerous, exposed pipelines via email directly to Nautical Data Branch as follows:

- The body of the email shall list the following metadata in the following order:
  - General Locality
  - Sub-locality
  - Project Number
  - Registry Number
  - Field Unit
- Screen Captures of side scan sonar images, multibeam images, or chartlets (if applicable) of the exposed pipeline in JPEG, PNG, GIF, or TIFF format
- An S-57 .000 feature file of the pipeline

The S-57 files and images shall be submitted to the Nautical Data Branch at email address ocs.ndb@noaa.gov, with courtesy copies to the HSD/NSD Project Manager or COR.

Contractors shall submit non-dangerous exposed pipelines via email 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). The contractor pipeline reporting shall be submitted as follows:

An S-57 .000 feature file of the pipeline 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.
- NOAA attribute 'images' shall be populated and shall include associated images such as side scan sonar images, multibeam images, and chartlets of the pipeline.

The Hydrographic Branches will review the Pipeline.000 feature file, import the .000 file into Pydro, and create the PDF file and S-57.000, which will then be forwarded to the Nautical Data Branch at ocs.ndb@noaa.gov.

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 Global Navigation Satellite System - GNSS) is not the same as UTC.

2.2 Horizontal Datum

All horizontal positions of processed data and related data products (e.g., grids and mosaics) in the coterminous United States, Alaska and Puerto Rico shall be referenced to the North American Datum of 1983 (NAD83) 2011 realization 2010 (NAD83(2011)2010.0), or later; in Hawaii or on the Pacific Plate shall be referenced to NAD83 (PA11) realization 2010.0, or later; and in the Marianas Plate shall be referenced to NAD83 (MA11) realization 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 and junctional 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 are 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 are reduced accordingly.

2.3.2 Survey Platform Positioning (Control)

On-datum positioning specifications are divided into two categories, which are 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 The National Spatial Reference System (NSRS)

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

Non-NOAA CORS differential sites shall utilize historical tidal benchmarks as far as practicable, rather than opting for a temporary mark. The hydrographer shall conduct a certification on non-NOAA CORS to ensure that no multipath or other site specific problems exist. The integrity of the geodetic tie of non-NOAA CORS installations to the NSRS 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 differential correction services, such as the USCG DGPS, FAA WAAS, and certain state and commercial systems, have integrated 24-hour monitoring and quality assurance similar to the NOAA CORS network, which may fulfill both the certification and periodic check requirement above.

3.1.1 GNSS Terminology

Terminology used in GNSS-based technologies can be somewhat confusing and labels alone shall not be taken at face value to certify a given system for use in hydrographic positioning. In general, 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. Modern PPP techniques employ a network of GNSS receivers to improve precision, transparent to the user.

The initialism DGPS is used herein to refer to the specific class of techniques in differential GPS/GNSS that achieve meter-level positioning and therefore is usually limited in application to horizontal control. The U.S. Coast Guard (USCG) National DGPS (NDGPS) 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. The NDGPS service was established to meet a USCG requirements mandate that is now satisfied by un-augmented GPS; a staged reduction to discontinue the NDGPS service was published in the March 2018 Federal Register Notice.

Ellipsoid referenced survey (ERS) 3-D control capable of meeting the more stringent vertical positioning requirements necessitates an improvement in GNSS positioning control over that afforded by the meter-level DGPS technology. ERS work leverages the family of methods known as kinematic GPS/GNSS (KGPS), as well as those specialized PPP techniques that are sufficient to meet the NOS specification for vertical control in hydrographic surveys.

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 echo sounders 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 with 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 Ellipsoid Referenced Survey (ERS) Control

In general, 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 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.

NOAA prefers the use of GPS over other GNSS (e.g., GLONASS); however, if the availability of 5 or more GPS satellites is unacceptably infrequent 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 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.

3.4.1 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 transformation

3.4.2 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 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 3.1.1), 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 are equal to that of the vessel (rover) data: 1Hz. Reference station data rates as low as 30 seconds are permitted when carrier-phase interpolation methods are used in inertially-aided GNSS positioning.

3.5 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, if required, shall be included in the appropriate Descriptive Report (DR), Horizontal and Vertical Control Report, and/or Data Acquisition and Processing Report.

Surveys reduced to MLLW using ERS with a verified separation model do not need to have water levels applied.

3.5.1 VDatum SEP Models

NOAA VDatum software is developed jointly by offices within the National Ocean Service (NOS), the Office of Coast Survey (OCS), the National Geodetic Survey (NGS), and the Center for Operational Oceanographic Products and Services (CO-OPS). VDatum transformations utilize a combination of stepwise transformations between geometric (ellipsoidal), orthometric (geoidal), and tidal datum reference frames, leveraging the best available geodetic data, hydrodynamic models and historical tidal datums at each step. Currently, a composite uncertainty value is supplied with each SEP for use in ERS propagated uncertainty calculations. Spatially Varying Uncertainty (SVU) models are being developed in VDatum for future ERS SEP transformations, where gridded combined uncertainty calculations may be utilized.

3.5.2 Ellipsoid Referenced Tidal Datum Model (ERTDM) and Alternate SEP Models

The Office of Coast Survey develops alternate SEP models to enable ERS when VDatum coverage is unavailable. Realization of a non-VDatum SEP is usually achieved through ERTDM (Ellipsoid Referenced Tidal Datum Model): A localized model which follows the same assembly philosophy of VDatum, albeit with alternate source data. ERTDM have previously been called “Poor Man’s VDatum (PMVD)” and “Not So PMVD (NSPMVD)”; the preferred term now is ERTDM. ERTDM SEP uncertainty is modeled as a composite value per the variance sum law of the constituent ellipsoidal and ortho-tidal components. SEP model alternatives to ERTDM include Ellipsoid Referenced Zoned Tides (ERZT) and Constant Value Separation Model.

3.5.2.1 Ellipsoid Referenced Zoned Tides (ERZT)

An alternative ERS datum transformation option in areas lacking a published/verified VDatum or ERTDM model is to tie approved zoned water level models to the ellipsoid. ERZT SEP observations are formed by adding in situ ERS platform water line (ellipsoid) heights to zoned water level correctors (to tidal datum; per direct, discrete-zoned, or TCARI modeling). The final ERZT SEP model shall be formed by combining these observations from all project survey lines traversing the zoned tidal water mass regions. Gridded ERZT SEP nodes within each tide zone or, alternatively, according to a fixed 1 km x 1 km spatial binning, shall be equal to the mean of the contained observations. ERZT uncertainty is the sum of the variance associated with recovery of water line ellipsoid height at the survey platform (including lever arm uncertainty, dynamic draft, etc.) and the uncertainty of the tidal model.

3.5.2.2 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 models may be required, as determined by NOAA and included in the Hydrographic Survey Project Instructions.

3.5.3 ERS SEP QC Requirements

At the discretion of HSD/NSD, after reviewing the a priori uncertainty associated with the particular SEP model region certain additional QC requirements may be required. These steps will be determined by NOAA 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. A thorough validation of the accuracy of a modeled SEP value is achieved by obtaining a GPS height observation at a point wherein the tidal datum is known. Ideally, data from all tidal benchmarks with historical datums are already incorporated into VDatum or ERTDM, and thus QC requirements represent points/areas “far” from those established observations.

    b. Traditional water level observations tied to the ellipsoid, acquired for 30 days or more, present a sufficient point-check on the SEP. Such ellipsoid tidal datum observations may be conducted using an ellipsoid-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 / Tide-Corrected Hydrography Comparisons

    a. A basic test methodology that includes the acquisition and processing of sounding data in the “traditional” manner (i.e., reduction to chart datum using water levels, discrete zoning, and TCARI), and then compared to ellipsoid-referenced data. SEP verification survey lines should be conducted according to the following nominal 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 or mean dynamic ocean topography (TSS, MDOT).

        ii. Spatial sampling is adequate to compute an ERZT separation surface (Section 3.5.2.1).

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 model 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 a final tidal model
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 and 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, 5, 6, and 8 and NOAA contract hydrographers shall be responsible for functional areas 4 and 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 modeling to promote safe navigation applications.

4.1.3 Planning and Preliminary Tidal Modeling

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.

4.1.4 NOS Control Stations and Data Quality Monitoring

4.1.4.1 Monitoring National Water Level Observation Network

CO-OPS manages the NWLON of approximately 290 continuously operating water level observation stations in the U.S. coastal zone, including the Great Lakes. As most of these stations are equipped with a satellite transmitter, near real-time (within about 18 minutes of collection) preliminary data are made available to all users through the CO-OPS website 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 on the CO-OPS website relative to Mean Lower Low Water (MLLW) datum, station datum, or special water level datum as a user option in the interface.

4.1.4.2 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, year-round basis for CO-OPS monitored gauges. CORMS will monitor the status and performance of all in-house hydro gauges equipped with a 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 (HHL) 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 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, available at https://tidesandcurrents.noaa.gov/hydro.shtml. Section 4.1.1 states, 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 0.5 feet below Mean Sea Level (MSL). In the Great Lakes, all soundings will be reduced to the 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. However, the errors associated with water level reducers are generally not depth dependent. 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):

$$95\%\ CI = b + 1.96\ (s)$$

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

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

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:

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

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 0.020 m for each 6 minute observation, relative to datum (Refer to CO-OPS Measurement Specifications). 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 introduction through the collection and processing of raw water level data are within 0.010 m.

   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 period 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 are 0.08 m for the east and west coasts and 0.11 m for the Gulf coast (at the 95% confidence level).

6. The Tidal Reduction Error: The error in application of the tidal model.

   Tidal reduction 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.

4.1.6.1 Estimated Errors

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 models 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 OCS, 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 for new or historical station and bench mark information, and/or updated Project Instructions.

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 3 hours before the beginning of the hydrographic survey operations to 3 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 are 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 Columbia River Datum (CRD), Hudson River Datum (HRD), or Mississippi River Low Water Reference Plane (LWRP). Great Lakes permanent stations will provide water level data referenced to an established Low Water Datum relative to IGLD85.

4.2.2 Data Collection Platform (DCP) and Transmissions

The DCP shall acquire and store water level measurements every six-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.) The standard deviation of the discrete water level samples that comprise the six-minute measurement shall be computed and stored. The six-minute centered average water level data are 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 radio system shall be maintained within one-second to avoid cross-channel interference. Non-satellite radio systems shall maintain a clock accuracy of within 30 seconds per month.

For more information refer to the following references:

- The Portable Tide Gauge Setup, Configuration, and Data Export Procedure:
  https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=Portable+Tide+Gauge+Setup
- The User's Guide for 8200 Bubbler Gauges:
  https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=Bubbler
- The User's Guide for 8210 Water Level Gauge for Hydrographic Surveying Applications:
  https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=Bubbler

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 as per the assigned frequency slot. 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 4.6). 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 4.4.2 for further details on the water level data format specifications.

Close coordination is required between the hydrographer and the 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) at 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 the field can be documented in the eSite Report, Field Tide Note, or Water Level Station Report, as appropriate. (Refer to Section 4.4 Data Submission Requirements).

4.2.3 Water Level Sensors

The primary water level sensor shall be selected from one of CO-OPS approved sensors:
The sensor type to be installed shall be approved by CO-OPS after the site reconnaissance and the preliminary conceptual station design are completed and submitted to CO-OPS for review. CO-OPS' approval of the water level sensor type is mandatory for a NOS project gauges. The reconnaissance for a water level station shall be performed in accordance with references Desktop Reconnaissance Procedure for Observing System Installation Planning and the Field Reconnaissance Procedures for Observing System Installation Planning, both are available in the CO-OPS Field Library here: https://tidesandcurrents.noaa.gov/fieldlibrary/Welcome. A detailed reconnaissance report is required and shall be submitted 90 calendar days prior to the planned installation.

The selected sensors' measurement range shall be greater than the expected range of water level at the measurement site, and the installation shall be designed to measure the full range of extreme water levels, such as the highest observed and lowest observed water level data (100 years, if available). The highest observed may have an additional wave allowance value added as determined by CO-OPS' Engineering Division (ED). Wave allowance information is available to the contractor if requested through the COR.

The sensor resolution is also important and is a function of the range of the water level being observed. For a tidal range less than or equal to 5 m, the required water level sensor resolution shall be 1 mm or less. For a tidal range between 5 m and 10 m, the required water level sensor resolution shall be 3 mm or less; and for a tidal range greater than 10 m, the required water level sensor resolution shall be 5 mm or less.

Calibration of the gauge/sensor systems prior to deployment is required. The calibration standard's accuracy must be traceable to National Institute of Standards and Technology (NIST), the manufacturer, or an independent reputable laboratory. The calibrations records shall be submitted with the station documentation.

The primary water level sensor configured at the majority of CO-OPS water level stations is the Aquatrak® acoustic sensor with a protective well and parallel plate assembly. The MWWL radar sensor, ParoScientific® intelligent pressure sensor, or a well/float with absolute shaft angle encoder are other options for water level stations. For short-term subordinate stations, the MWWL sensor is preferred over the pressure sensor whenever possible.

At stations where freezing of the water surface, or the lack of a suitable support structures prohibits the installation of the acoustic sensor or a MWWL sensor, then the installation of a single or dual ParoScientific® intelligent pressure sensor(s) is suitable.

For further information, please refer to:

- Next Generation Water level Measurement System (NGWLMS) Site Design, Preparation, and Installation Manual, NOAA/NOS, January 1991. Available here:
  https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=NGWLMS

- CO-OPS Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations, Updated December 2017. Available here:
  https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=CO-OPS+Specifications+and+Deliverables+for+Installation

For pressure sensors installations, the orifice shall be mounted on a vertical surface such as a pier or wharf piling so the precise elevation of the orifice below a staff stop can be measured with a steel tape. The elevation of the staff stop will be measured via differential leveling to the nearest bench mark network including the Primary Bench Mark (PBM). If the orifice is mounted vertically and its elevation can be determined precisely with reference to the PBM, then intermittent staff-to-gauge readings may not be necessary. If the orifice cannot be mounted to a vertical surface for direct leveling to the PBM, then staff-to-gauge readings are required to relate the water level data to the bench marks. The requirement for staff-to-gauge readings may also be waived in salt-water environments as described in Sections 4.2.4, if weekly density measurements are taken and submitted to CO-OPS.

When using a vented pressure sensor, a series of staff-to-gauge comparisons through a significant portion of a tidal cycle shall be required at the start of a deployment, at frequent intervals during deployment, and at the end of a deployment. Frequent staff-to-gauge comparisons (Refer to Section 4.2.5) during the deployment shall be completed to assure measurement stability and to help minimize processing errors. The staff-to-gauge observations shall be at least three hours long at the beginning and end of the deployment and periodic observations during the deployment shall be at least one hour long.

If a pressure sensor is planned, then the reconnaissance shall include a Conductivity/Temperature/Depth (CTD) cast performed in accordance with reference to CTD Observation Analysis found here:
https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=CTD+Observation+Analysis

The CTD data must be submitted with the reconnaissance report and station documentation.

Account for known error sources for each sensor 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.

For pressure sensor installations, a parallel plate assembly (with 2" orifice chamber) is attached to the bubbler orifice to minimize systematic measurement errors due to wave and current effects, as shown in Figure 4.1. The bottom assembly on a bubbler orifice is made of red brass, and its chemical properties prevent the growth of marine life by the slow release of the copper oxide on its metal surface. A Swagelok® hose fitting is screwed into the top end cap and is used to discharge air from the Waterlog system. 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 the Venturi effect. A two-inch by eight-inch pipe provides the correct volume of gas for the widest range of surf conditions encountered by most coastal surveys. A bubbler orifice with parallel plates is generally required and shall be used for CO-OPS installations.

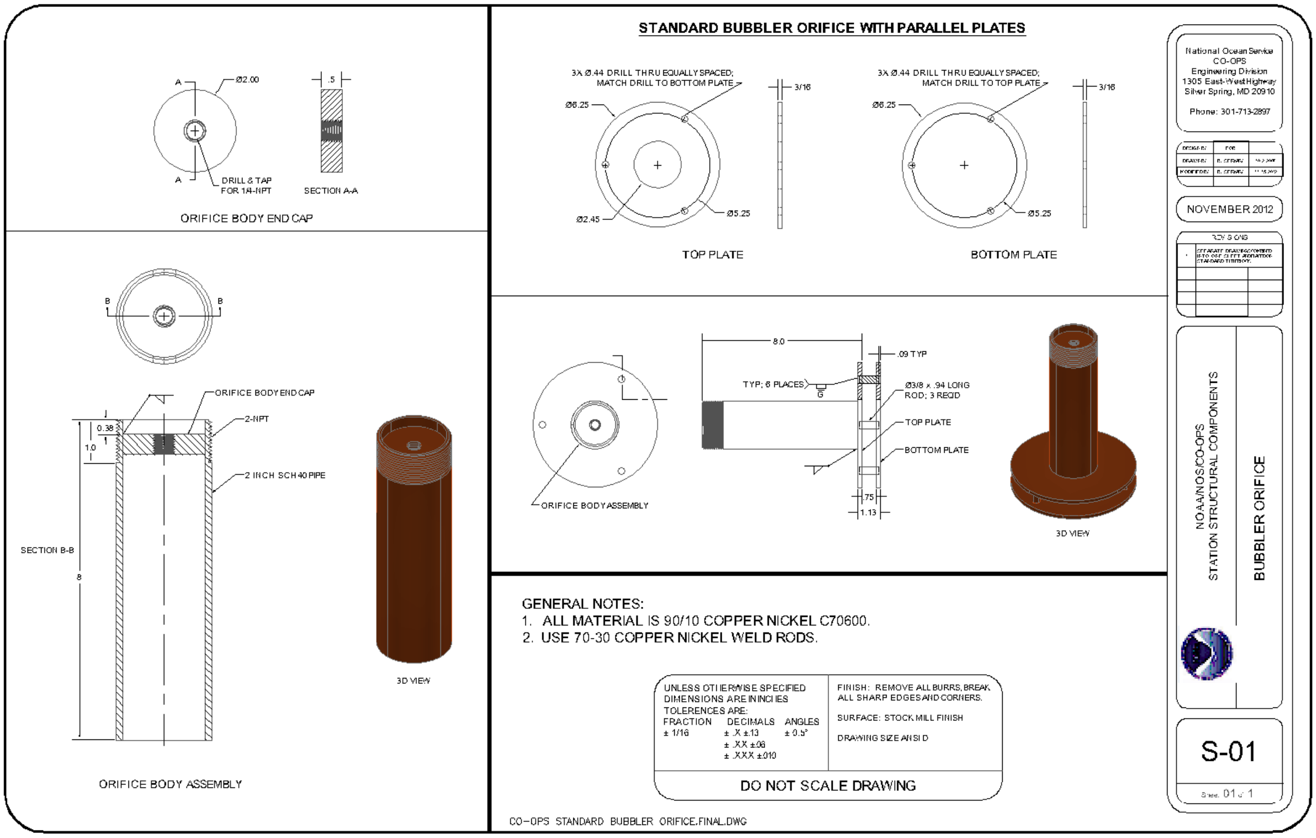


Figure 4.1: Bubbler Orifice with Parallel Plates Bottom Assembly

4.2.3.1 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 Datums Team (DT) about the placement of this station are suggested).

2. To replace a required subordinate installation where traditional shore-based water level stations with water level gauges mounted on nearshore 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 the typical MWWL, acoustic, or bubbler gauges. This most often occurs in Alaska. Communications detailing the reason why standard methodologies for data collection are not viable are required.

4.2.3.1.1 Water Level Specifications

The water level sensor for BMPG shall be a ParoScientific® or equivalent pressure sensor (with respect to accuracy and performance). The sensor shall have a documented calibration and certification by the manufacturer or an independent lab such as NIST. The calibration and certification records shall be submitted with the station documentation.

The field party or instrument lab shall perform a documented acceptance check regarding the sensors' operation prior to the deployment. The sensor shall be calibrated immediately if a drift of 0.5 cm or more is noticed in one month of data; otherwise, the sensor shall be calibrated every 10 years.

The system shall have internal recording capability with a sampling scheme capable of producing an average pressure reading every six-minutes, derived from an average of 36 five-second water level samples, centered on each tenth of an hour (i.e., 00:00, 00:06, 00:12, etc.). A three standard deviation outlier rejection test must be applied and the recalculation of the mean and standard deviation along with the number of outliers is recorded internally in the DCP.

The system shall keep accurate internal time with no noticeable drift over a 3-month deployment period, e.g., less than five seconds drift over a three-month period. The system shall be deployable for a minimum of 30 days without having to retrieve for maintenance or data collection.

Real-time data telemetry is desirable for system performance and data quality monitoring.

4.2.3.1.2 Mooring Specifications

The hydrographic survey contractors shall design their own mooring systems.

Typical installations require self-contained sensors each mounted to a 300-1000 pound anchor with a 45'-120' buoy line (depending on water depth) and an 80'-150' drag line attached to a 150-pound anchor. The objective is to have a mooring that will not drag or move horizontally or vertically during deployment, and be capable of being deployed using relatively small boats and the sensors are deployed offshore far enough (200-1500 m) to ensure measurement of the lowest expected water level.

4.2.3.1.3 Water Density Data Specifications

Water density data shall be obtained at least hourly but preferably, every six-minutes by using a bottom mounted conductivity and temperature (CT) sensor, or daily hydrometer measurements during the deployment period. Surface measurements using a hydrometer may be inaccurate in areas of high freshwater runoff. Conductivity and temperature sensors shall undergo documented manufacturer recommended calibrations and acceptance tests prior to each deployment. The calibration records shall be submitted with the station documentation.

4.2.3.1.4 Barometric Pressure Data Specifications

Barometric pressure data shall be obtained using a nearby reliable existing source (NWS or airport). If these sources are not available, then a separate barometric pressure sensor shall be installed at the water level station location within five miles of the BMPG or on land as close to the BMPG location as practicable for the duration of the survey. The data shall be collected at a minimum sample rate of hourly observations. Barometric pressure sensors shall also have documented manufacturer recommended calibrations and acceptance tests prior to each deployment. This correction is an added correction to those needed for a normal in-house shore-based pressure gauge(s) vented to the atmosphere. This correction should be of suitable accuracy with a standard industry barometric pressure sensor.

4.2.3.2 GNSS Tide Buoys

The National Ocean Service has accepted the use of GNSS-equipped buoys ("tide buoys") to support hydrographic surveys through tidal reconnaissance, water level measurement, and datum computation in the offshore. If the hydrographer determines that tide buoy deployments are necessary and warranted for the support of a project which does not otherwise include buoy requirements, the hydrographer should consult with the OCS Hydrographic Surveys Division and CO-OPS Products and Services Branch prior to use. GNSS positioning requirements for tide buoys are fundamentally the same as those established for ellipsoid referenced survey (ERS) control and the associated use of the real-time and post-processed techniques of carrier-phase based kinematic positioning, see Chapter 3, Hydrographic Positioning. The required assessment of confidence intervals for tide buoy GNSS water levels and datum computations must account for all systematic and random errors associated with the measurement and processing as outlined in Chapter 3, and Section 4.1.6, Error Budget Considerations. In general, buoy water level measurement performance is degraded in strong currents and high waves. The total allowable vertical uncertainty (TVU) for reduced depths (or heights) is detailed in Section 5.1.3, Uncertainty Standards.

4.2.3.2.1 Planning

GNSS Tide Buoys 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 in addition to the required subordinate stations as stipulated in the Project Instructions (communications with CO-OPS and OCS about the placement of this station are highly recommended.
2. Replacing a required subordinate installation where traditional shore-based water level stations with water level gauges mounted on nearshore infrastructure is not possible during the summer months (non-ice deployments). This includes areas where the low tide line is far offshore and the full range of water level cannot be measured with the typical MWWL, acoustic, or bubbler gauges. This most often occurs in Alaska. Communications detailing the reason why standard methodologies for data collection are not viable are required.

Planning for and deploying a GNSS Tide Buoy must consider at a minimum the following environmental parameters and their effect on the uncertainty of buoy observed water levels and derived datums.

a. Significant wave height (tilt error, satellite tracking, mooring integrity)
b. Surface current magnitude and direction (dynamic draft error)
c. Depth (mooring weight)
d. Wind speed and direction (tilt error)

Such planning will include an environmental assessment to decide where best to position the GNSS buoy system for a particular hydrographic survey project area, based upon available knowledge of the desired location and existing sea state. Surface currents and waves appear to have the largest impact on GNSS buoy water level measurement performance. Strong currents cause the buoy to draw-down and ride lower in the water as it pulled taught on its mooring line. High waves result in the broadest range of average buoy tilts.

4.2.3.2.2 GNSS Buoy Sensor Specifications

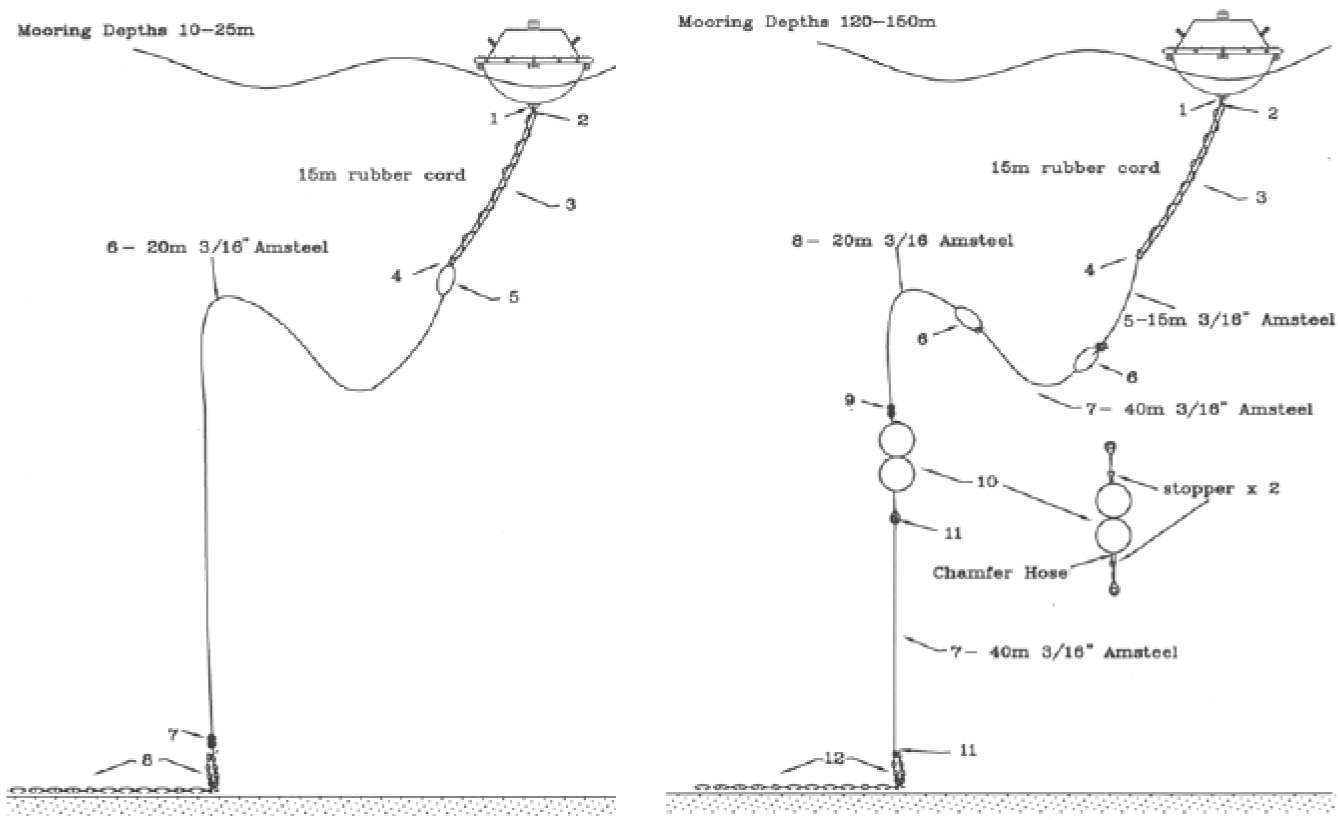
The approved GNSS tide buoy configuration consists of a spherical hull wave-rider design, with a compliant cord section integrated in the mooring. A tide buoy is essentially a floating GNSS receiver to acquire the instantaneous antenna position and ancillary data necessary to precisely compute the dynamic height of the in situ sea surface in an ellipsoidal reference frame. The sensor type currently approved for internal hydrographic surveys is the AXYS Hydrolevel system utilizing the 0.6-meter diameter AXYS Mini hull with 15 meter x 25 mm rubberized compliant cord.

External parties may utilize this system or any equivalent sensor system with respect to accuracy of 6-minute water levels: Better than 10cm, 95% confidence. For datum computation purposes, the system shall be deployable for a minimum of 30 days without having to retrieve it for maintenance or interrupt continuous data acquisition. Real-time data telemetry is desirable to monitor system performance and data quality. The buoy sensor suite shall have a documented calibration and certification by the manufacturer or an independent lab to attest for the accuracy of ellipsoidal water level heights, with consideration of degradation effects under a range of typical values for the environmental parameters outlined in 4.2.2.2 GNSS Tide Buoys, Planning. The calibration and certification records shall be submitted with the station documentation. The field party or instrument lab shall perform and document an acceptance check on the GNSS tide buoy sensor suite, operation, data acquisition & logging, and data processing prior to the deployment.

4.2.3.2.3 Hull and Mooring Specifications

The hydrographic survey contractors shall design their own mooring systems.

The spherical hull, wave-following buoy is moored with a compliant cord section, a rubberized shock absorber, braided line, and a network of anchors. The buoy payload plus any ballast required is such that the spherical hull floats about its equator. This configuration ensures maximum upward-buoyant and downward-restorative forces are optimized to help maintain a stable aspect with respect to the water line. The relationship between hull size (volume) and required buoy weight is an important consideration; for example, a 0.6-m diameter hull implies a total on-deck weight of approximately 73 kg (160 lbs). A useful objective is to have a system that is capable of being deployed using relatively small boats with a mooring that minimizes drag on the system given the deployment environment (depth, currents, etc.), as shown in Figure 4.2. Surface currents have the potential to impact GPS buoy water level measurement performance. During periods of high current speed, a buoy is susceptible to draw-down displacement resulting from an increase in mooring tension (Diwan, et al., 1988, Jack L. Riley, et al. 2014).



1 – Shackle (D), ½" SS316
2 – Swivel, 5/8" (16mm) 5:1 3.2 Ton SS316
3 – Rubber shock cord, 15 m x 1", w/ braided line
4 – Shackle (D), ½" SS316
5 – Net float, 4"
6 – Amsteel, 20 m x 3/16", w/ eye thimbles
7 – Shackle (D), 3/8" Galvanized
8 – Chain & anchor

1 – Shackle (D), ½" SS316
2 – Swivel, 5/8" (16mm) 5:1 3.2 Ton SS316
3 – Rubber shock cord, 15 m x 1", w/ braided line
4 – Shackle (D), ½" SS316
5 – Amsteel, 15 m x 3/16", w/ eye thimbles
6 – Net float, 4"
7 – Amsteel, 40 m x 3/16", w/ eye thimbles
8 – Amsteel, 20 m x 3/16", w/ eye thimbles
9 – Swivel, eye-to-eye ½" Galvanized + 3/8" shackle
10 – Subsurface floats, 2 x 14"-diameter spheres
11 – Shackle (D), 3/8" Galvanized
12 – Chain & anchor

Figure 4.2: Tide buoy mooring

4.2.4 Station Installation, Operation, and Removal

The field party shall obtain all required permits and permissions for the installation of the water level sensor(s), DCP(s), bench marks, and utilities, as required. The field party shall be responsible for security and/or protective measures, as required. The field party shall install all components in the manner prescribed by the manufacturer or the installation manuals. The field party shall provide CO-OPS the geographic position of all gauges installed before the coastal shoreline mapping survey begins, including those that were not specified in the Project Instructions, as appropriate. The horizontal geographic positions of bench marks, sensors, and DCPs installed or recovered shall be obtained and reported in latitude and longitude in the format of degrees, minutes, seconds and tenth of a second.

The water level station and its various components (tide house, DCP, 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 the manufacturers, installation manuals, appropriate local building codes, and/or as specified by the COR, where applicable. The water level station and all installed components shall be structurally sound for its intended application, secure, and safe to use for NOS, local partners, contractors, and public, as appropriate.

The following sections provide general information regarding requirements for station installation, operations and maintenance, and station removal.

4.2.4.1 Station Installation

Complete water level measurement station installation shall consist of the following:

A. The installation of the water level measurement system (water level sensor, DCP, and satellite transmitter), its supporting structure, and a tide staff, if required.

B. The recovery and /or installation of a minimum number of bench marks and a level connection between all bench marks and the water level sensor(s), and the tide staff, as appropriate. For all installations, a minimum of five bench marks with stability code A or B are required.

C. The documentation of the horizontal geographic positions of the sensors, station, DCP, and bench marks installed or recovered. The positions shall be obtained using a hand-held GPS receiver in latitude and longitude and reported in degrees, minutes, seconds, and tenth of a second (e.g., bench mark position as latitude 37 degrees 45 minutes 34.1 seconds and longitude as 75 degrees 25 minutes 32.5 seconds).

D. The collection and submission of GPS observations at one or more bench marks in the network.

E. The preparation and submission of the station installation documentation.

4.2.4.2 Operation and Maintenance

The field party shall monitor the near-real time water level data daily for indications of sensor malfunction or failure, and for other causes of degraded or invalid data, such as marine fouling. When GOES telemetry and the NOS satellite message format are used, and when CO-OPS is monitoring the gauges for NOS in-house projects, the data can be viewed by accessing the CO-OPS Diagnostic Tool (DiagTool) at https://access.co-ops.nos.noaa.gov/diagtool/diagtool.html. The raw data are typically available within 18 to 30 minutes after collection for 6-minute data, or between 48 minutes to 1.5 hours depending upon the frequency of the transmissions. For NOS contract projects, contractors are responsible for monitoring the gauges and for taking the proper corrective actions, as necessary.

All repairs, adjustments, replacements, cleaning, or other actions potentially affecting sensor output or collection of data shall be documented in eSite report or the appropriate maintenance forms as identified in contract documents and retained as part of the water level data record. This documentation shall include, but not be limited to, the following information: date/time of start and completion of the maintenance activity, date/time of adjustments in sensor/DCP, datum offset/sensor offset/orifice offset changes and date/time of the change, personnel conducting the work, parts/components replaced, component serial numbers before and after the maintenance, acceptance tests results, purpose of the trip, and recommended actions that could not be completed and the reason for the incompletion, etc.

4.2.4.3 Removal

Complete removal of the water level measurement station shall consist of the following:

A. Closing levels - a level connection between all bench marks and the water level sensor(s) and tide staff as appropriate.

B. Removal of the water level measurement system and restoration of the premises, with reasonable wear and tear accepted.

C. Disposal of expendable or unusable components in an environmentally friendly manner.

D. Termination of any utilities.

E. Close out or termination of license agreement.

F. The preparation and submission of the station removal documentation.

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

4.2.5 Tide Staff

The field party 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 seafloor. Even directly leveled pressure gauge(s) may require staff readings, for assessment of the variations in gauge performance due to density variations in the water column overtime. The tide staff shall be mounted on a separate piling other than the piling on which the water level sensor is installed so independent stability of the staff and sensor is maintained. The staff shall be plumb. When two or more staff scales are joined to form a long staff, the field party 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 appropriate site 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".

4.2.5.1 Staff Observations

When using the vented pressure sensor, a series of gauge/staff comparisons through a significant portion of a tidal cycle (minimum 3 hours) 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 6-minute intervals. Frequent gauge/staff comparisons during the deployment shall be required to assist in assuring measurement stability and minimizing processing errors. The staff-to-gauge observations at the start and end of deployment shall be at least each three (3) hours long and the periodic observations during the deployment shall be at least an hour long. The staff-to-gauge observations shall be performed three times per week, during each week of the project, with at least an hour of observations at six-minute intervals. The observations shall be recorded at the same time the gauge is collecting data at the six-minute interval (starting with 0 minutes, e.g., 0, 6, 12, 18, 24, 30, 36, 42, 48, and 54 minutes after the hour). Where staff-to-gauge observations cannot be performed three times a week as required, then an explanation is required and CO-OPS ED will grant a waiver, or alternate staff-to-gauge observations will be performed:

(a) 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

(b) 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 reference number 32 for an example pressure tide gauge record (see Section 4.6).

If the staff is found destroyed during the deployment, a new staff shall be installed for the remainder of the deployment and a new staff-to-gauge constant shall be derived by staff-to-gauge observations. When a staff or an orifice is replaced or re-established, check levels shall be run to a minimum of three bench marks including the Primary Bench Mark (PBM). Refer to Section 4.2.7 for leveling frequency and other leveling requirements.

When reoccupying historic water level stations, 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 4.3 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 per deployment. 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 elevation 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.

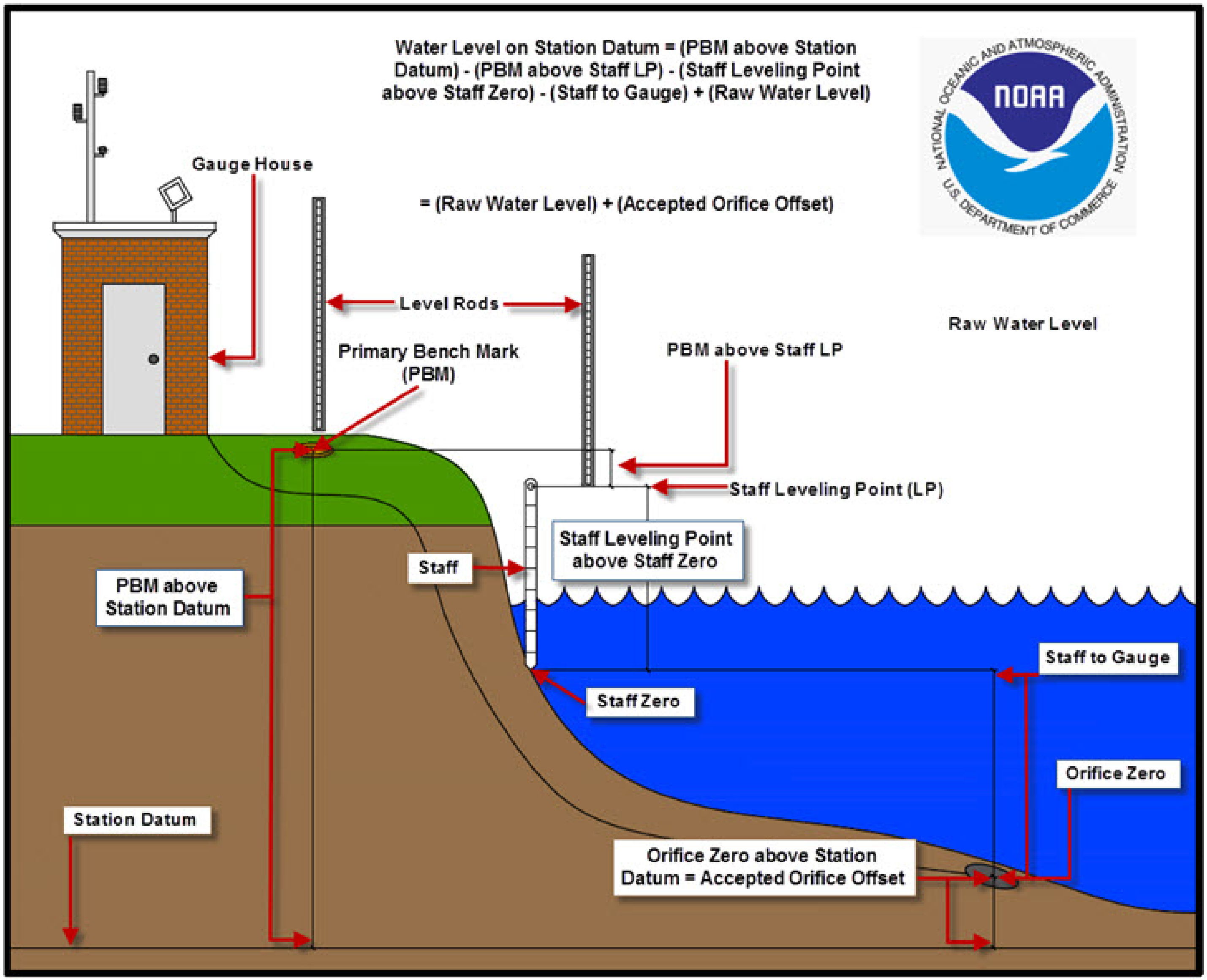


Figure 4.3: Relationship of Station Datum, Orifice, and Staff

4.2.6 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. Please note that if a direct measurement between the water level sensor and the bench marks cannot be made, then staff-to-gauge measurements and comparison as described in Section 4.2.4 Staff Observations above is required.

Before installing a new mark, perform a 1.6 kilometer (1 mile) radial search from the tide station (DCP) location at NGS website, 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.

Bench mark descriptions shall be written according to the 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 bench marks must be identified on the bench mark 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. Submissions of updated bench mark diagrams are required only when necessary to document newly established marks, marks removed from the network, and/ or physical changes in the area. Refer to reference number 32 for the bench mark diagram template (see Section 4.6).

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/or it is not holding its elevation, contact CO-OPS ED for assistance in selecting another PBM and determining its elevation above Station Datum.

4.2.6.1 Type of Bench Marks

The number and type of bench marks required depends on the duration of the water level measurements. The User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems, dated May 2018, specifies the installation and documentation requirements for the bench marks. Generally, for hydrographic surveys, a minimum of five bench marks are required at each station. The required minimum separation between each bench mark is 200 feet (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.
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.

For GPS observations, the most desirable bench mark 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.

4.2.6.2 Digital Photographs of the Station and 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 the Seattle water level station should be named as 9447130-7130E1990-1-20090101.jpg. Sample file names are shown in the table below.

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

4.2.6.3 Obtaining and Recording of Positions of Station, 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.

4.2.7 Leveling

Second Order Class I geodetic levels are preferred but at least Third Order geodetic levels shall be run at short-term stations operated for less than one year. Requirements for higher order levels will be specified in individual Project Instructions, or contract documents, as appropriate. 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 preferred. Specifications and standards for digital levels can be found in Standards and Specifications for Geodetic Control Networks. Additional field requirements and procedures used by NOS for electronic leveling at water level stations are documented in the User's Guide for Electronic Levels with Translev and WinDesc found in the CO-OPS Field Library.

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. 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. For ParoScientific® sensors, leveling is performed to the Orifice LP and a tape down is used to measure between the Orifice LP and the Orifice Zero. The Orifice Zero is the bottom of the top plate of the two parallel plates (if installed) or the apex of the V notch of the orifice where the bubbles are released.

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. ED must approve use of other leveling fixtures and leveling techniques in advance.

For information on leveling to the bubbler orifice, see Section 4.2.4 Tide Staff.

4.2.7.1 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 every 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 five bench marks are required (a) if a gauge is in operation for more than 30 days but less than 12 months (b) if final tides are required, or (c) every 6 months from the start of the station collecting data for long term hydrographic surveying projects.

4.2.7.2 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 field party shall verify the apparent movement by re-running the levels between the sensor zero or tide staff to the PBM. Both the initial and confirmation level runs must be submitted to CO-OPS ED. If the vertical stability cannot be verified, contact CO-OPS ED. The threshold of +0.006 m should not be confused with the closure tolerances used for the order and class of leveling.

4.2.8 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 stability/bracketing levels, c) gauge maintenance and repair, and d) removal of the station. Refer to Section 4.4.1 for Documentation Submission Requirements and Section 4.4.3 for specific documentation submission time frames.

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., site report, level files and abstract for bracketing or removal levels, photos etc.). Refer to Section 4.4.1 for Documentation Submission Requirements and Section 4.4.3 for specific documentation submission time frames.

4.2.8.1 NOAA Electronic Navigational Charts

The link below provides an interactive map to search for NOAA Electronic 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

4.2.8.2 United States Geological Survey (USGS) Quad Names

The United States Geological Survey (USGS) quad name for 7.5 minute x 7.5 minute map is required on both the bench mark diagram and for use on the header of the published bench mark sheet. USGS Quad names within the US can be found by imputing the location and map scale (24,000) within the "USGS topoView", available here: https://ngmdb.usgs.gov/maps/topoview/viewer/#4/40.01/-100.06. A digital image of the quad map showing the station location is not required.

4.2.9 Additional Field Requirements

Generally, upon the completion of the data acquisition for each gauge installed the water level data must be submitted as one package for 30-day minimum stations unless the data are transmitted via satellite. For long-term stations running more than three months, the data shall be submitted periodically (monthly) unless the data are transmitted via satellite. A complete data file shall be submitted as part of the station removal deliverable package.

All water level data from a gauge shall be downloaded and backed up at least weekly on a digital media (e.g., diskettes, CD-ROM, DVD, FTP site) whether the gauge data are sent via satellite or not.

For new stations that do not have station numbers assigned, once the location of the gauge has been finalized then contact CO-OPS COET or the COR and provide the latitude and longitude of the gauge site at least ten business days prior to actual installation of the gauge in field. CO-OPS COET will assign a new station number within three business days and inform the field party. If the location of the station changes by more than 0.5 miles after the station number has been assigned, contact CO-OPS COET for an updated station number.

At each water level station, GPS observations on one tidal or geodetic bench mark shall be performed according to the most recent version of the CO-OPS "Users Guide for GPS Observations at Tide and Water Level Bench Marks".

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.

4.2.10 Geodetic Connections and Datums Relationship

The water level 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 connections involve the following two ties:

(A) NAD 83 GPS Tie
(B) NAVD88 GPS Tie

The required "NAD 83 GPS Tie" and "NAVD GPS Tie" are described in the User's Guide for GPS Observations at Tide and Water Level Station Bench Marks found here: https://tidesandcurrents.noaa.gov/fieldlibrary/ViewLibrary?q=GPS+Observations+Guide

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 the 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.

The contractor is responsible for applying any correctors to the data series that ensures that the 6-minute interval water level data are accurate given the technology used to collect it. Examples include the application of barometric pressure, air temperature and density corrections. Corrections or offsets that account for vertical movement of the water level sensor should not be applied prior to data submission.

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 4.4 Data Submission Requirements for details. 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 datums computation.

4.3.2 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".

4.4 Data Submission Requirements

Data submission requirements for water level measurement stations are comprised of both supporting documents for the installation, maintenance, and the removal of stations, along with the formatted digital water level data.

4.4.1 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 4.4.3 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. eSite Report (eSite report in web based electronic format. The use of eSite must be coordinated with COET prior to station installation) or Tide Station Report

3. Sensor Well Drawing (PDF format) (required for newly installed stations or any modification to sensor well) (only applicable with Aquatrak installations)

4. Sensor elevation drawing (PDF format) showing sea floor, pier (deck) elevation, and each sensors' elevation above the appropriate datum (required for newly installed sensor(s), any sensor elevation change)

5. Bench mark Diagram (PDF format) – Large-scale bench mark location sketch of the station site showing the relative location of the water level gauge, staff (if any), bench marks, and major reference objects found in the bench mark descriptions. The bench mark diagram shall include an arrow indicating north direction, a title block that includes: the station name and number, NOAA chart number, USGS Quad name (from a 15" x 15" map), field unit, date created, drawn by, and latitude and longitude (obtained from hand-held GPS receiver) of the gauge, and label of the body of water

6. Bench mark descriptions with handheld GPS coordinates (dd/mm/ss.x format) (electronic file - WinDesc)

7. "Station to Reach" statement in Microsoft Word format when eSite Report application is not used

8. Digital photographs of each bench mark disk (four views: face, setting, and 2 cardinal directions), station, DCP, equipment, underwater components, and the location to include the body of water being observed (JPEG format)

9. Levels (electronic files) including leveling equipment information and field notes of precise leveling, if applicable

10. Abstract of precise leveling (electronic format)

11. Datum offset computation worksheet or Staff/Gauge difference worksheet as appropriate showing how sensor "zero" measurement point is referenced to the bench marks

12. Staff to gauge observations, if applicable (Microsoft Excel format or printed to PDF)

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

14. Calibration records for sensors, if applicable (PDF format)

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

16. Environmental Compliance documentation (Microsoft Word or PDF format)

17. Water level data download in specified format, if applicable

18. DCP configuration files

19. GPS Deliverables - visibility diagram, GPS solution (email), OPUS published datasheet and four photos of the GPSBM in electronic format for each observation session as described in the User's Guide for GPS Observations at Tide and Water Level Bench Marks

20. Diving Documents (DAMP, Dive Plan, etc.)

21. Confined Space Permit

22. As-Built Engineering Drawings and Design Documents (PDF format)

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

4.4.2 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 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 correctors 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 are 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 a 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 6-minute water level data.

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

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

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 (one 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:
86310441 MAY 01 2017 15:24 Y1 D P 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999 999999

4.4.3 Submission and Deliverables - Documentation and Timelines

All documentation, water level data, OPUS published data sheet, bench mark photos, and other reports (as listed above in Section 4.4) 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. 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. All contractors and NOAA field units shall copy the OCS COR or project manager, as appropriate, on all final water level station 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 4.4.1 and 4.4.2 for details about various data and documentation.

Below is an example of a submission of the electronic folders for a water level station. The abbreviations in parenthesis should be used to name the electronic files and subfolders. Empty folders or folders with no deliverable documents do not need to be included.

Standard station documentation package includes the following:

1. Transmittal letter via email for CO-OPS FOD (Transmittal)
2. Site Report (Site Rprt)
3. Sensor Well Drawing (Sen Well DWG)
4. Sensor elevation drawing (Sen Elev DWG)
5. Bench mark Diagram (BM DWG)
6. Bench mark descriptions (WinDesc) (BM Desc)
7. "Station To Reach" Statement (STR Stmt)
8. Photographs of bench marks, station, DCP, equipment, and vicinity in digital format (Photos)
9. Levels (raw electronic files) and field notes of precise leveling (Levels)
10. Abstract of precise leveling (ABS)
11. Datum offset computation worksheet or Staff/Gauge difference work sheet (elevation of sensor zero measurement point referenced to bench marks) (DAT WKS)
12. Staff to gauge observations, if applicable (STG Obs)
13. Calibration certificates for Invar leveling rods, if applicable (Rod Cal Certs)
14. Calibration records for sensors, if applicable (Sen Cal Certs)
15. Agreements, MOU, contract documents, utilities/pier agreements, etc., if applicable (Docs)
16. Environmental Compliance documentation (Enviro Comp)
17. Water level data (6-minute) (WL Data)
18. DCP configuration files (DCP Config)
19. GPS deliverables (GPS)
20. Scheduled Maintenance Checklist (SM Checklist)
21. Diving Documents (Dive Docs)
22. Confined Space Permit (CS Prmts)

23. As Built Drawing (As Built)

24. Other information as appropriate, or as specified in the contract (Other)

The bench mark diagram, and "To Reach" statement need to be submitted with the installation documentation and resubmitted only if these items have been revised during the station maintenance or removal.

When using the electronic/barcode system, the leveling data files, the abstract, and the bench mark descriptions 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.

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, 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

4.5 CO-OPS Final Deliverables and Timelines

The following timelines are provided for reference:

1. CO-OPS's review and acceptance of all final documentation, as outlined in Section 4.4, will be conducted within 20 business days of submission.

2. For in-house hydrographic surveys that require installation of a subordinate installation(s), water level data and water level data products will be accepted and published within 45 business days of the final documentation acceptance. The publishing of water level data and water level products from reconnaissance installations and non-required installations is up to the discretion of CO-OPS' Management. 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 business days of either the receipt of the request to Final.Tides@noaa.gov or of the final documentation acceptance (as outlined in 1 above), whichever of the two is the later date.

3. For contracted hydrographic surveys that required installation of a subordinate installation(s), water level data and water level data products will be accepted and published within 45 business days of the final documentation acceptance (as outlined in 1 above). The publishing of water level data and water level products from reconnaissance installations and non-required installations is up to the discretion of CO-OPS' Management.

4.6 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
2. Sutron® Xpert Data Logger Operations and Maintenance Manual
3. Sutron® Xpert2 Data Logger Operations and Maintenance Manual
4. Sutron® 9210 XLite Operations and Maintenance Manual
5. Sutron® 9210B XLite Operations and Maintenance Manual
6. Sutron® Satlink 2 Logger & Transmitter Operations and Maintenance Manual
7. Portable Tide Gauge Setup, Configuration, and Data Export Procedure
8. Xpert and Xpert Dark Internal Battery Replacement
9. Procedures for Requesting GOES Platform ID Allocations
10. NWLON GOES MESSAGE FORMAT
11. NGWLMS GOES Message Formatting for Hourly Transmissions
12. Attachment of Conduits to Enclosures
13. Engineering Bulletin 10-002 Standardize Battery Type for CO-OPS Water Level and Meteorological Stations with Photovoltaic Charging Systems
14. Engineering Bulletin 07-007 Downloading (Exporting) Data from the Xpert Log Files using Xterm
15. Engineering Bulletin 07-006 Exporting Data from Xpert Family DCP
16. User's Guide for Model 4100/4110 Series Aquatrak®
17. Aquatrak® Calibration Procedure
18. BEI® Series MT40 Multi-Turn Absolute Position Encoder
19. Waterlog® H-334 Shaft Angle Encoder Manual
20. ParoScientific® Digiquartz Pressure Instrumentation
21. KPSI®` Level and Pressure Transducer User's Manual
22. Water Level Sensor Using the Sutron® Data Collection Platform, Ver 1.0
23. WaterLog® H-3551 Gas Purge Bubbler Owner's Manual
24. WaterLog® H3661 SDI-12 Radar Water Level Sensor
25. Sutron® Accubar Barometric Pressure Multiple Interface Sensor Operations & Maintenance Manual
26. SOP 3.2.3.6.F3 RBR-CTD Setup and Data Retrieval
27. Castaway® CTD User's Manual
28. Sutron® Barometer Calibration Procedure
29. CO-OPS Sensor Specifications and Measurement Algorithms
30. User's Guide to Vertical Control and Geodetic Leveling for CO-OPS Observing Systems
31. User's Guide for Writing Bench Mark Descriptions
32. User's Guide for Electronic Levels with Translev and WinDesc
33. User's Guide for GPS Observations at Tide and Water Level Station Bench Marks
34. CO-OPS GPS Observations Implementation Plan
35. Standards and Specifications for Geodetic Control Networks
36. NGS Attachment R, Requirements for Digital Photographs of Survey Control
37. NGS Attachment T, Setting a Concrete Mark
38. NGS Attachment U, Setting a Survey Disk in Bedrock

39. NGS Attachment V, Setting a NGS 3-D Monument
40. NGS Attachment X, Performing Bench Mark Ties
41. Preliminary Step by Step Leveling Instrument Procedures
42. Leveling Frequency Requirements for Water Level Stations
43. Creating a Bench Mark Diagram in PDF Format
44. Procedure to Establish a Meteorological Sensor Reference Mark and to Measure Meteorological Sensor Heights
45. Level Rod Re-Calibration
46. Desktop Reconnaissance Procedure for Observing System Installation Planning
47. Field Reconnaissance Procedures for Observing System Installation Planning
48. CO-OPS Water Level and Meteorological Site Reconnaissance Procedures
49. Latest Project Instructions for Coastal and Great Lakes Water Level Stations
50. CO-OPS Evaluation Criteria for Water Level Station Documentation
51. SOP 7.0.1 Updating Database Information after Annual Inspection or Emergency Maintenance
52. Inside/Outside Water Level Check for the Great Lakes Gauging Station SOP
53. Field Installation Procedures for Design Analysis WaterLog® H3611i Microwave Radar
54. SOP 5.4.1.4A Barometer Calibration Procedure
55. SOP 6.3.2.1.12 Battery Load Testing Procedures for CO-OPS Water Level Observation Systems CO-OPS Guide to Declaring a Newly Installed Water Level Station Operational
56. SOP 3.1.1.5 Conductivity, Temperature, and Density (CTD) Observations Analysis
57. SOP 3.2.3.9.132 Engineering Bulletin 17-003 Standardize the Number of Digits for Transmitting Conductivity Data
58. Requirements and Guidelines for Equipment Shipping
59. CO-OPS eSite User's Guide
60. CO-OPS Equipment Return Form
61. Engineering Bulletin 09-003 Update to Xpert Log File Sizes

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, 6th 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

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

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), 6th Edition. IHO S-44 specifications are suggested minimum standards that member states may choose to follow. 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
- d is the depth
- (b*d) represents that portion of the uncertainty that varies with 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
- In depths greater than 100 meters, a = 1.0 meter and b = 0.023

The maximum allowable uncertainty in depth includes all inaccuracies due to residual systematic and system specific instrument uncertainties; the speed of sound in water; static vessel draft; dynamic vessel draft; heave, roll, and pitch; and any other sources of uncertainty in the actual measurement process, including those associated with ERS or 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 Echo Sounders

Many Hydrographic Survey Project Instructions require the use of multibeam echo sounders 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 echo sounding 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 echo sounders.

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 has 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 echo sounders, 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 uncertainty 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 Navigation Surface Working Group (ONSWG) was formed to develop the Bathymetric Attributed Grid (BAG) format, an open source exchange format for gridded data. 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 Grid Management

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 echo sounder properties to require bathymetric data at several different resolutions. The CARIS CSAR framework has single-resolution and variable-resolution functionality, which are approved for hydrographic surveys. The BAG library (version 1.6) currently supports both single-resolution and variable-resolution surfaces.

For single-resolution deliverables, 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 echo sounder used, and other 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.

For variable-resolution deliverables, the hydrographer shall create a single surface for the entire hydrographic survey. The hydrographer will adjust the grid resolution thresholds based on the requirements described in Section 5.2.2, Coverage and Resolution.

5.2.1.2.2 Multiple Echo Sounding Sources in a Single or Multiple Grids

In cases where multiple echo sounding 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 echo sounders or multibeam echo sounders). The exception to this is for crossline data; where mainscheme 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 mainscheme soundings with scattered high resolution multibeam feature developments, or a mix of multibeam echo sounders 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.

In general, sounding designation should be very exclusive and soundings selected for designation should be done so with discretion. Instances a hydrographer may deem a sounding designation to be necessary could include:

- Where designation directly effects or benefits the safety of navigation, whether atop dangers to navigation or in an area of critical underkeel clearance

- To facilitate feature management (see Section 7.4) or to portray the least depth on a feature when the hydrographer is guided by additional external information regarding the nature of the submerged feature (e.g., a priori knowledge, evidence that may include a diver investigation, or information from side scan sonar)

If the hydrographer chooses to designate soundings, then the hydrographer shall ensure:

1. 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.

2. 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 meter 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:

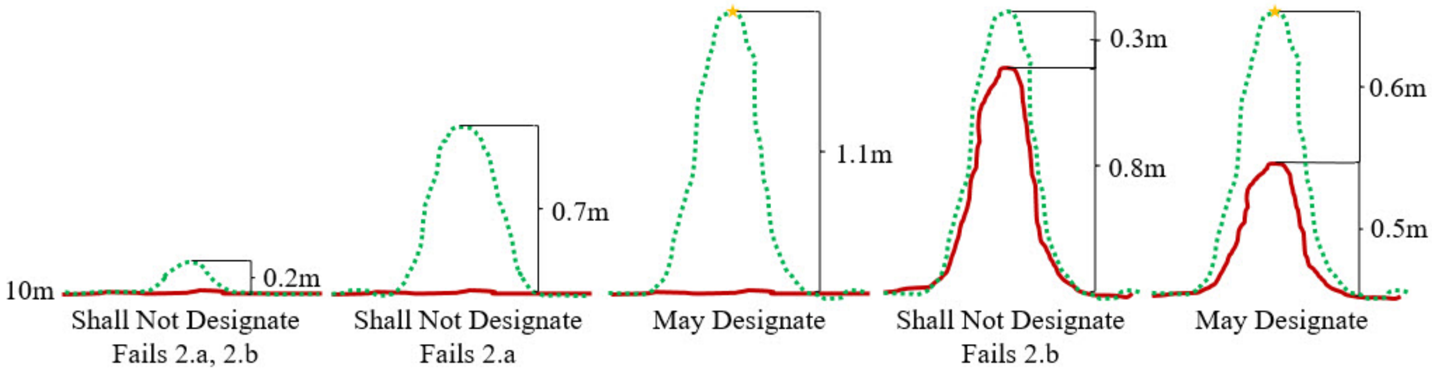


Figure 5.1: The designated sounding guidance above is applied to these example scenarios at depth of 10 m. At this depth, the allowed TVU is 0.52 m (see Section 5.1.3). Following the designated sounding guidance above, in this example, the hydrographer may designate a sounding when the difference between 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.

If the hydrographer finds that a high occurrence of designated soundings is warranted, then 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 either a) the computed uncertainty derived from a mix of a priori and real-time uncertainty estimates, or b) the standard deviation of the soundings contributing to the depth solution. 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. Grid metadata shall include the type of uncertainty computed on the grid. For field units that do not use CARIS software for grid creation, the BAG Uncertainty Type shall be populated with "Product_Uncert" per the BAG Format Specification Document. The hydrographer shall examine the finalized grids and explain in the DR any areas of unusually high or low 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 6.1.3.3) 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 5.2.1.2.2 Multiple Echo Sounding 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 mainscheme 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 mainscheme lines, and to verify currently-charted depths that are shallower than any adjacent echo sounder 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

- Within the grid bathymetry detect and include 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, within the grid bathymetry detect and include 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.

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

Variable Resolution Surfaces	
Depth Range (m)	**Resolution (m)**
0-20	0.5
20-40	1
40-80	4
80-160	8
160-320	16

The grid resolution for water depths greater than 320 m shall be 5% of the water depth, not to exceed 32 m resolution.

For single resolution surfaces, 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.

For variable resolution surfaces, 95% of all surface nodes shall have a resolution equal to or smaller than the coarsest allowable resolution for the node depth.

For both single and variable resolution surfaces:

- 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: a collinear contiguous length equal to three times the coarsest required resolution for that depth. 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.

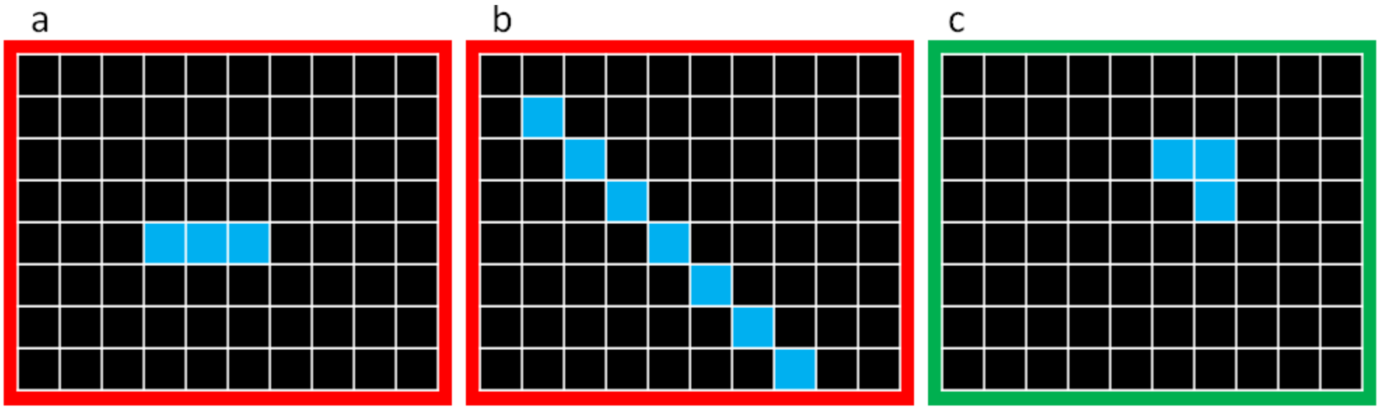


Figure 5.2. Determination of Object Detection holidays for single resolution surfaces. Examples A and B are Object Detection holidays. Example C is not an Object Detection holiday.

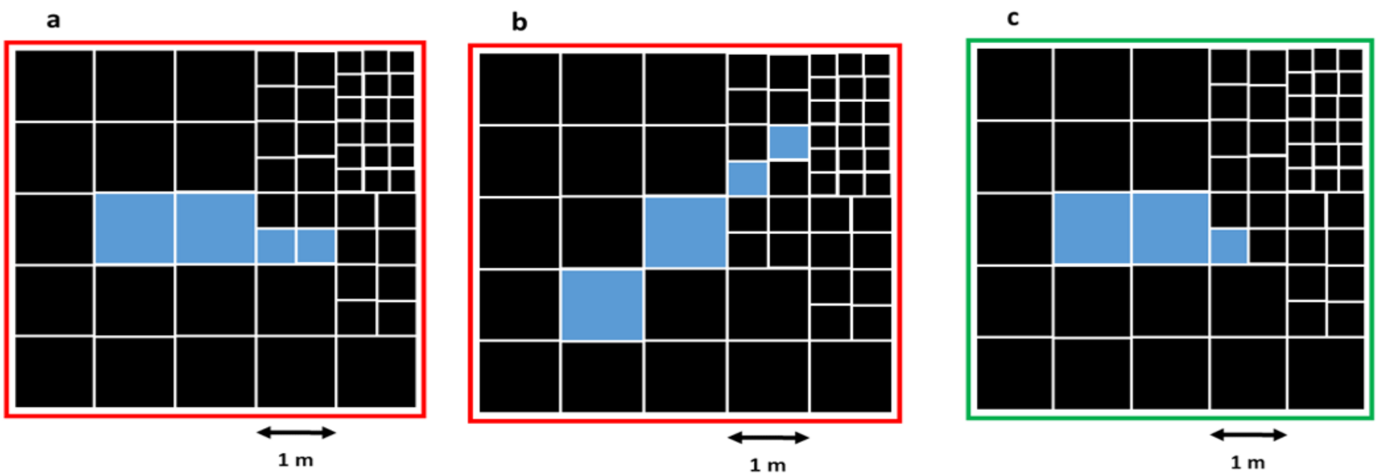


Figure 5.3. Determination of Object Detection holidays for variable resolution surfaces. Water depths for this example surface are 20-40 m, yielding a coarsest allowable grid resolution of 1 m. Examples A and B are Object Detection holidays. Example C is not an Object Detection holiday.

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 (See Section 6.1).

- 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 are 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

- Within the grid bathymetry detect and include 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, within the grid bathymetry detect and include 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:

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

Variable Resolution Surfaces	
Depth Range (m)	**Resolution (m)**
0-20	1
20-40	2
40-80	4
80-160	8
160-320	16

The grid resolution for water depths greater than 320 m shall be 5% of the water depth, not to exceed 32 m resolution.

For single resolution surfaces, 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.

For variable resolution surfaces, 95% of all surface nodes shall have a resolution equal to or smaller than the coarsest allowable resolution for the node depth.

For both single and variable resolution surfaces:

- 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 an area of no coverage equal to or greater than a square with a side length equal to three time the coarsest required resolution for that depth. Figures 5.4 and 5.5 provide examples of Complete Coverage holidays for a single and variable resolution surface respectively. There shall be no holidays in the grid over the tops of potentially significant features.

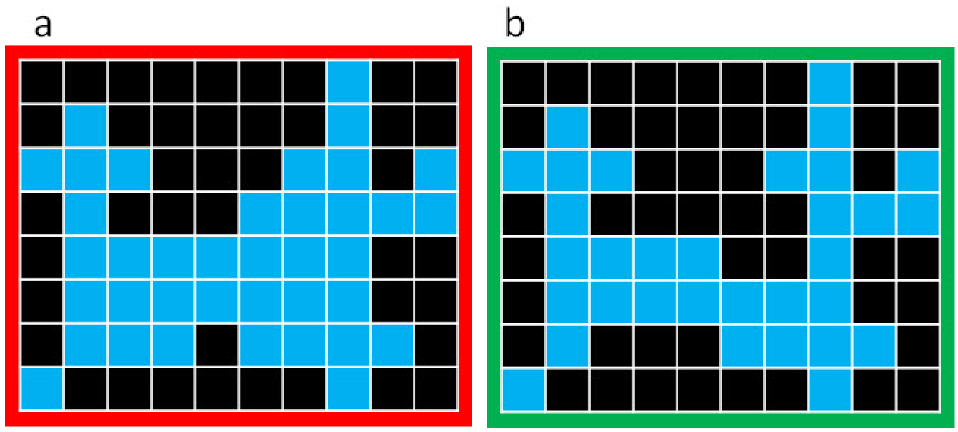


Figure 5.4: Determination of Complete Coverage holidays for single resolution surfaces. Example A is a Complete Coverage holiday. Example B is not a Complete Coverage holiday.

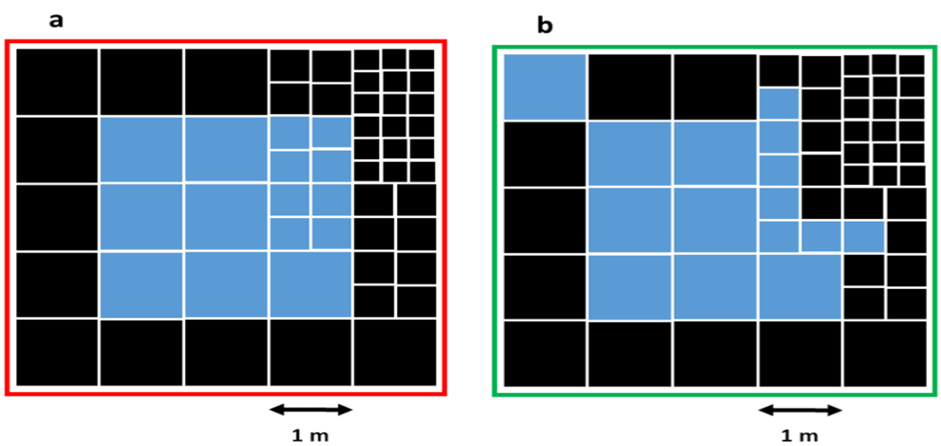


Figure 5.5: Determination of Complete Coverage holidays for variable resolution surfaces. Water depths for this example surface are 0-20 m, yielding a coarsest allowable grid resolution of 1 m. Examples A is a Complete Coverage holiday. Example B is not a Complete Coverage holiday.

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 (See Section 6.1).

- 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 are 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

- These data are 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 echo sounder).

- Due to the potentially sparser sounding sets produced by single beam echo sounders, 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 as the Primary Sounding Technique

- Gridded at 4 m resolution, regardless of depth

- Due to the potentially sparser sounding sets produced by single beam echo sounders, 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: Single Beam Sounding Resolution Scaled with Depth (used rarely)

- 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 echo sounders, 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. 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 are acceptable.

- 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 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 DR Memo 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. 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.

- 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. 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 uncertainty 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. Uncertainty analysis is the study and evaluation of these uncertainties with the purpose of estimating the extent of them, and reducing them when necessary.

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 echo sounder 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 echo sounders 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 echo sounders, "confidence checks" shall be conducted periodically.

For single beam echo sounders, a comparison should be made at least once per project (e.g., per OPR) with depths from bar checks, lead lines, or other single beam echo sounders.

For multibeam echo sounders, comparisons should be made at least once per project between the nadir (vertical) beam of the multibeam and another multibeam system, a single beam system, or lead line. 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 vessel's uncertainty 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 uncertainty budget. However, the accuracy of the uncertainty 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.

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, unless the manufacturer recommends a different calibration frequency. 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, unless the manufacturer recommends a different calibration frequency. In addition, the instrument(s) must be recalibrated when they are removed from operations or at the end of their service life. If values differ, the new values should be post-applied to the data. Surface sound velocity (SSV) sensors shall be sent in for calibration per manufacturers instructions when discrepancies exist when compared to a calibrated sound speed profiler. If no accurate comparison can be obtained, or if the bathymetric data shows signs there may be an issue with beamforming caused by incorrect SSV data, the SSV sensor shall be calibrated per manufacturers instructions.

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. The hydrographer should establish a means of monitoring changes in the water column between subsequent speed casts as well as a means of forecasting changes in oceanographic temporal and spatial variability through the use of tools such as SmartMap (https://www.hydroffice.org/smartmap/). Modeled sound speed (such as from World Ocean Atlas) for the water column deeper than 500 meters may be appended to measured sound speed profiles when deep casts cannot be achieved.

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.

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 echo sounding, 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 or within 500 m range of the 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 uncertainty 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. The required depth accuracy requirements cannot be achieved if the greatest error for each sensor shown below is used.

Maximum allowable errors are specified to ensure that all error 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 m to 0.45 m. 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 3.5.2) 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 to compute 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 8.1.6.1). 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 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 should not exceed 1 km spacing except in the case that it will result in the percentage of mainscheme to crossline mileage exceeding 5% for Object Detection or Complete Coverage surveys. For Set Line Spacing surveys, 9% of mainscheme mileage should not be exceeded. An example of appropriate geographic distribution of crossline spacing is shown in the below Figure 5.4.

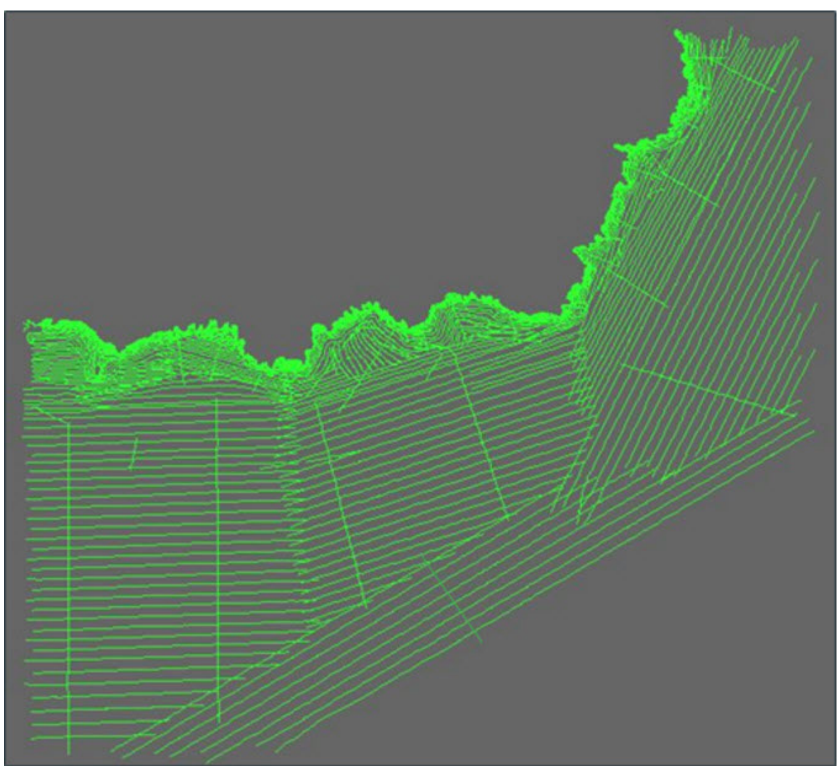


Figure 5.4: An example of appropriate geographic distribution of crosslines

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 mainscheme mileage in areas surveyed to meet object detection or complete coverage requirements.

- Set Line Spacing: Lineal mileage of crosslines shall be approximately 8% of mainscheme mileage in areas surveyed with set line spacing coverage using single beam or multibeam echo sounders. This applies for mixed mainscheme and crossline techniques, i.e., single beam mainscheme 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 echo sounder 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 mainscheme 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 mainscheme and crossline coverage indicate potential systematic errors in offsets, biases, or correctors or the application thereof, faulty positioning or echo sounder 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 data sets 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 uncertainty 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 uncertainty 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 uncertainty 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.
- 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 either a) the computed uncertainty derived from a mix of a priori and real-time uncertainty estimates, or b) the standard deviation of the soundings contributing to the depth solution. 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. Grid metadata shall include the type of uncertainty computed on the grid. For field units that do not use CARIS software for grid creation, the BAG Uncertainty Type shall be populated with "Product_Uncert" per the BAG Format Specification Document. The hydrographer shall examine the finalized grids and explain in the DR any areas of unusually high or low 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 uncertainty 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. Uncertainty 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 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 uncertainty 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 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. 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 8.1.6.1). 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 Lidar Crosslines

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 mileage of crosslines shall be at least 4 % of mainscheme 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 mainscheme 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 mainscheme data shall be conducted. Although any crossline/mainscheme 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 surveying the use of side scan sonar may be required for supplementing echo sounding to meet object detection requirements. For instance, side scan sonar may be used in the region between regular sounding lines for additional indication of dangers and bathymetric irregularities. 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, which limits 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 echo sounders may not be met when using this technique.

Side Scan Coverage Gap:
If the "proof of coverage" (mosaic) includes an imagery gap or "holiday," then complete coverage requirement was not met; there is no minimum data coverage gap size. Any imagery gap existing indicates that complete coverage was not achieved. Coverage gaps can be remedied by acquiring additional side scan coverage, reducing the swath range scale, or acquiring multibeam echo sounder coverage that meets complete coverage requirements common to the imagery gap.

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.

6.1.3.2 Environmental Influences

Environmental influences such as density differences between water masses can influence the imagery. The affected swath area commonly observed is portrayed as refraction in the outer swath regions. Other environmental influences include water mass separation and mixing due to tidal flows, surface mirroring (Lloyd Mirror Effect), passing vessel prop wash, sediment, fish, and other biologic organisms suspended within the water column. These influences can affect the return signal and degrade the quality and interfere with sea floor detection.

Side scan sonar records that include environmental influences affecting any portion of the swath and hinders the selection of contacts in the affected regions does not meet the requirement of 100% complete coverage, and is considered to be a holiday. In such cases, the swath range shall be reduced and the affected areas rejected, and should be reacquired with side scan or multibeam echo sounder coverage such that the acquired bathymetry data meets the complete coverage requirement.

6.1.3.3 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 echo sounder 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 meets the requirements to be included in the Final Feature File, follow the feature development guidance in Section 7.3.3.

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 echo sounder 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.

6.1.3.4 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:

Attribute Legend:	
Mandatory	(salmon)
Conditional	(yellow)

$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.*

6.1.3.5 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) or multibeam data. 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.

6.1.3.6 Identification of Features

The hydrographer shall use the SSS Contact File, in conjunction with an analysis of echo sounder least depths and gridded data layer attributes (standard deviation, uncertainty, etc.), to identify features which may require a development and inclusion in the Final Feature File (Section 7.3).

6.2 Multibeam Echo Sounder Seafloor Backscatter

6.2.1 Coverage

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

A backscatter holiday has the same definition as the multibeam echo sounder holiday. Adequate backscatter coverage is equivalent to bathymetric coverage requirements as defined in Depth Sounding, Object Detection and Complete Coverage sections. As with bathymetric holidays, backscatter holidays shall be documented in the Descriptive Report.

6.2.2 Acquisition Parameters and Requirements

Seafloor backscatter is a measure of the intensity of the seafloor echo, corrected to determine the scattering strength of the seafloor. These corrections are dependent on the environment and measurement system. Depending on the multibeam echosounder, the measurement system may affect the measurement in an unaccountable way. It is incumbent upon the hydrographer to minimize these effects.

6.2.2.1 Accuracy

The accuracy of a seafloor backscatter measurement may be judged relative to a standard, requiring some sort of calibration, or may be judged by internal consistency. Any applied normalization values, technique of calibration, and the methodology used to derive values used for calibration shall be described in the DAPR.

When specified in the Project Instructions, verification may be required to 'ground truth' seafloor backscatter data by acquiring seabed samples. Sampling locations should be judiciously selected to verify areas of obvious or apparent bottom composition change

Any known or suspected inconsistencies between reported settings and resultant settings (i.e., reported transmit power used versus actual transmit power) that may inhibit full calibration between survey platforms shall also be documented.

6.2.2.2 Acquisition Parameters

Backscatter samples shall be collected to allow for contiguous samples across the beam footprint for each seafloor detection, but not exceeding 1.5 times the beam footprint. All real time acquisition parameters used in post-processing shall be included with the digital data. Where the hydrographer does not have full confidence in the ability to fully compensate for any changes in acquisition parameters, the adjustment of multibeam settings should be minimized to limit the likelihood of artifacts in the resulting backscatter products.

6.2.2.3 Requirements

Efforts shall be made to avoid multibeam receiver acoustic saturation of the backscatter data. Raw multibeam backscatter data must contain intensity values and be capable of being successfully imported and processed into a backscatter mosaic.

6.2.3 Backscatter Data Processing

Processing of seafloor backscatter accounts for the contribution of system and environmental factors in the raw measurement, resulting in information concerning only the seafloor scatter strength. This processed backscatter is combined to create a product that represents backscatter over the survey area in a spatially meaningful way.

6.2.3.1 Measurement System Contributions

During processing, all measurement system influences on the recorded backscatter shall be accounted for including at least:

1. Transmit power
2. Receiver gain, both static and time varying
3. Beam footprint (ensonified area) effects, including the pulse length as projected on the seafloor
4. Manufacturer specified backscatter offsets, such as a beam pattern or other corrections

6.2.3.2 Environmental Factors

During processing, all environmental system influences on the recorded backscatter shall be accounted for including at least:

1. Acoustic absorption in the water column
2. Acoustic spreading
3. Seafloor slope

6.2.3.3 Angle Dependence

Seafloor acoustic backscatter is dependent on angle. Backscatter data shall be processed using a method that normalizes the backscatter values if it were collected from 45 degrees incidence angle during mosaic creation.

6.2.3.4 Data Removal

Backscatter associated with poor seafloor detections that have been removed in bathymetric processing should also be removed from backscatter processing. Only data associated with the seafloor and associated features should be included in the seafloor backscatter product.

6.2.3.5 Mosaic Processing

The combined seafloor backscatter is commonly called a backscatter mosaic as it is a combination of the "imagery" for each line. Seafloor backscatter from a survey shall be grouped by acoustic frequency and by survey system, and each group turned into a mosaic. If a relative backscatter calibration has been conducted to bring different survey systems into alignment, data of the same frequency and different survey systems may be mosaicked together.

The hydrographer should refrain from using image processing techniques to remove apparent artifacts and improve the appearance of the resulting product. Changes should occur on the underlying backscatter data using physics-based or statistical approaches rather than touching up the final product.

Backscatter measurement resolution does not directly scale with depth, although there is correlation. Thus a single resolution product for a survey area may be produced, avoiding the need to break the area up into different resolution products. The natural break of mosaics is by frequency. As a result the minimum mosaic resolution is:

$$Resolution = ceiling \left| \frac{600}{nominal\ frequency\ (kHz)} \right|$$

Where ceiling(x) is a function that maps 'x' to the least integer greater than x (i.e. roundup) and nominal frequency shall be rounded to the nearest 100 kHz. For any frequency less than 50 kHz, the default mosaic resolution is 10m.

6.2.4 Deliverables

A mosaic or set of mosaics depicting the backscatter over the survey area with GSF files shall be submitted to document the processed backscatter data.

6.2.4.1 GSF Files

GSF files containing the final bathymetry and backscatter with edits shall be included with the processed data. As a minimum these files shall contain the processing parameters record and swath bathymetry ping records, including the system specific subrecords containing the full time series backscatter.

6.2.4.2 Mosaic

Mosaics shall be submitted in floating point GeoTIFF format with the processing steps and resolution described in Backscatter Data Processing.

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, bottom types).

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, or other 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. The assigned limits of a sheet may junction with adjoining sheets of the current project or with other surveys listed as junctions in the Project Instructions. The PRF file includes sheet limits in the S-57 object TESARE and junction surveys of other projects in the S-57 object TWRTPT. If the junction is not publicly available at the National Center for Environmental Information website, https://www.ncei.noaa.gov/maps/bathymetry/, BAG files with respective DRs will be provided to the field units.

Junction Overlap

The field unit shall ensure overlap is acquired between junction surveys. Junction overlap shall be acquired according the assigned coverage in the Project Instructions, and shall consist of approximately one bathymetric swath width at the nominal depth of the junction area. If the field unit is unsure about junction overlap requirements, contact the HSD/NSD Project Manager or COR.

Junctions shall be evaluated for completeness to ensure sufficient overlap is acquired. The field unit shall evaluate and quantify depth differences between junctions, 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 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 significantly differ from charted depths, 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 MHW 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 MHW 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, seaward of the NALL: address by including in the FFF with appropriate attribution (Section 7.3).

  Note: Assigned submerged rocks within survey coverage, seaward 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. If an unassigned feature is addressed, it shall be included in the FFF. 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 6.1.3.3. Only a subset of SSS contacts will potentially become FFF features (Section 7.3).

7.3.4 Feature Disprovals

7.3.4.1 General Feature Disproval

If a charted feature 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.

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

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

7.3.4.2 Feature Disproval Radii

In certain cases (e.g., 100% side scan sonar with concurrent multibeam or set line spacing surveys), a disproval radius will be assigned based on the status of the charted feature and the chart scale. For features in the CSF which do not have sftype = Unverified Charted Features (UCF) (Section 7.3.5), the disproval radius will be as follows:

Chart Scale	Search Radii
Larger than 1:20,000	100 m
1:20,000 to 1:40,000	150 m
Smaller than 1:40,000	200 m

If the non-UCF charted feature is found and developed (Section 7.3.3) before the entire radius area is ensonified, the hydrographer does not need to continue surveying the radius area. The disproval may include one or more of the following options:

- Object detection multibeam coverage (HSSD Section 5.2.2.2 Option A)
- Object detection side scan coverage with concurrent multibeam (HSSD Section 5.2.2.2 Option B)
- Complete coverage multibeam (HSSD Section 5.2.2.3 Option A)

7.3.5 Unverified Charted Features

Unverified Charted Features (UCF) are features without a verified position and/or depth. These features are inclusive of wrecks, rocks, obstructions, piles, dolphins, and other features labeled as Existence Doubtful (ED), Position Approximate (PA), Position Doubtful (PD), Reported (Rep), or without a least depth or depth unknown. Shoaling reported or depths reported are also considered UCF.

Features in the CSF may have the sftype populated with "Unverified Charted Feature." For all assigned UCF with an unverified position, a corresponding assigned ACHARE feature will be provided in the Project Reference File (PRF). In the case the UCF disproval radius extends beyond the TESARE sheet limit, the feature disproval radii becomes the sheet limit or the limit of safe navigation.

The search radii for these features follows:

Chart Scale	Search Radii
Larger than 1:20,000	125 m
1:20,000 to 1:40,000	250 m
Smaller than 1:40,000	500 m

The radii must be fully ensonified as specified in the Project Instructions and may include one or more of the following options:

- Object detection multibeam coverage (HSSD Section 5.2.2.2 Option A)
- Object detection side scan coverage with concurrent multibeam (HSSD Section 5.2.2.2 Option B)
- Complete coverage multibeam (HSSD Section 5.2.2.3 Option A)

7.3.6 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 that find an ATON off station or uncharted, per definitions below, shall be summarized in the DR (Section 8.1.4 D.2) and all correspondence listed in DR Appendix II. An ATON on station and serving its intended purpose shall not be addressed in the DR or FFF.

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 as outlined in Section 1.6 Dangers to Navigation. Include the ATON in the FFF with correct attribution.

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 promptly report the new ATON as outlined in Section 1.6 Dangers to Navigation. Include geographic position, characteristics, apparent purpose, and by whom the aid is maintained (if known). The uncharted ATON shall be included in the FFF. 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 for Feature Management

The hydrographer may choose the gridded estimate of the depth to represent the feature or choose to create a designated sounding (Section 5.2.1.2.3) to facilitate feature management. If a designated sounding is chosen to aid with feature management, the following criteria shall be used:

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. The position of the designated sounding must match the feature's position to the maximum precision allowed by the feature processing software (typically 0.0000001 degrees for x/y and 0.01 meters for z.)

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.

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 https://www.iho.int.

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:

Attribute Legend:	
Mandatory	
Conditional	

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.

<table>
<tr><th>Attribute</th><th colspan="2">Description</th></tr>
<tr><td>All Feature Objects</td><td colspan="2">All surveyed objects will have the following attributes populated.</td></tr>
<tr><td>SORIND</td><td>Source Indication</td><td>Information about the source of the object</td></tr>
<tr><td colspan="3">• Country Code - US
• US Authority code - US for OSC
• Source - graph
• ID code - registry number
• E.g., US,US,graph,H12345</td></tr>
<tr><td>SORDAT</td><td>Source Date</td><td>The last day of survey acquisition formatted as YYYYMMDD</td></tr>
<tr><td colspan="3">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</td></tr>
<tr><td colspan="3">Note:
• There shall not be any spaces after comma separated values in SORIND</td></tr>
</table>

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 features with a VALSOU should have a TECSOU and QUASOU. Features above chart datum with heights should not have TECSOU and QUASOU populated.
- 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 structure from motion	'10' found by photogrammetry
Heights on rocks or islets using range finder or visual estimation	'12' found by leveling

TECSOU: If a VALSOU was not obtained on a sounding feature, attribute TECSOU as "Unknown"

***QUASOU: All soundings derived using a multibeam echo sounder, single beam echo sounder, structure from motion, or lidar to NOAA/IHO standards are assumed to be QUASOU Depth Known. If a sounding 'feature' is created for a DTON or other purpose the 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 Echo Sounder (MBES)*
    - *Diver investigation using Diver Least Depth Gauge (DLDG)*
    - *Manual Depth Measurement Equipment using lead line or sounding poles*
    - *Sounding "designated" from the grid*
    - *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: • If a feature has a height above MHW, it can be encoded with a WATLEV of "Always Dry". If a feature is submerged (no HEIGHT) and has no VALSOU then the WATLEV should be "Unknown". • 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)
UWTROC (Underwater/Awash/Covers & Un-covers Rock)	VALSOU*	(Value of sounding)
	WATLEV	(Water level effect)
	QUASOU	(Quality of Sounding Measurement)
	TECSOU	(Technique of sounding measurement)
** If water level of a rock is observed at time of survey and the hydrographer is unable (unsafe conditions to approach) to acquire the exact height of the rock, WATLEV may be populated and VALSOU left blank.* ***Note:*** *If several assigned rocks are found to be part of an 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)
** For line or area objects - 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 shall be left blank if depth not available or if OBSTRN CATOBS = foul area. VALSOU, TECSOU, and QUASOU shall be left blank if OBSTRN CATOBS = foul ground.* *** For OBSTRN CATOBS = foul ground, WATLEV shall be populated relative to the shallowest surveyed depth within the area.* *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 (1.6), 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 charted wellhead is not found, in cases where 100% SSS with concurrent multibeam is 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 E 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 E 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. See Appendix G for 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 attributed as follows:

NATSUR: sand, shells, pebbles
NATQUA: fine, broken, -
COLOUR: black, - ,-

Sediments are typed according to the size of the particles, see Table 1, Appendix G. A measurement or 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.

Object	Attribute	Description
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.*

Object	Attribute	Description
COALNE (Coastline)	CATCOA	(Category of Coastline)

Note:

descrp = new or descrp = update COALNE features require CATCOA attribute populated

Object	Attribute	Description
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.

Object	Description
LNDARE (Land area) *Point, Line, or Area*	Used to characterize islets. 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

LNDARE objects 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. See Appendix E: WATLEV Attribution for vertical height requirements.

Object	Attribute	Description
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 additional information 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. Note that any free text (string) field is limited to a maximum of 255 characters.
The following Attribute Legend shall be used for the subsequent tables in Section 7.5.2:

Attribute Legend:	
Mandatory	
Conditional	

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 in the CSF which were not addressed. Include re-mark 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 at 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
5. Charted feature has an acronym change:
   - descrp = Delete for charted feature (delivered from CSF)
   - 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 MHW 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**:*
- *Optional for all features.*
- *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
		Unverified Charted Feature	Unverified Charted Feature

***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) or foul ground (OBSTRN = foul ground). Additionally images are not required for features such as UWTROC (individual rocks) or SBDARE area features (ledges) unless there is something unique or significant about the feature.*
- *The required format for all images is JPEG, PNG, GIF, or TIFF.*
- *Images shall have a unique identifier name. However, it is permissible to reuse the same image for different cartographic features, when applicable. See Section 7.5.4 Bottom Sample Images for more information.*
- *Multiple images for one feature shall be semicolon 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.

<table>
<tr><th>Attribute</th><th colspan="3">Description</th></tr>
<tr><td>acqsts</td><td>Acquisition Status</td><td colspan="2">A tracking tool used during data processing that ensures features are fully investigated as necessary</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td>Investigate</td><td>Indicates that further field examination and analysis are required</td></tr>
<tr><td>Resolved</td><td>Indicates that field examination and analysis is completed</td></tr>
<tr><td>asgnmt</td><td>Assignment Flag</td><td colspan="2">Indicates assignment status of items delivered to the field by the HSD/NSD Project Manager or COR.</td></tr>
<tr><td colspan="2" rowspan="3"></td><td>Unassigned</td><td>Not assigned</td></tr>
<tr><td>Assigned</td><td>Assigned</td></tr>
<tr><td>For Info Only</td><td>For Information Only</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>cnthgt</td><td>Contact Height</td><td colspan="2">Contact height of side scan sonar contacts.</td></tr>
<tr><td>invreq</td><td>Investigation Requirements</td><td colspan="2">Specific investigation requirements defined by the HSD/NSD Project Manager or COR</td></tr>
<tr><td colspan="4">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.</td></tr>
<tr><td>keywrd</td><td>Keyword</td><td colspan="2">Customized word used for processing or querying data</td></tr>
<tr><td>prkyid</td><td>Primary Key ID</td><td colspan="2">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</td></tr>
<tr><td>prmsec</td><td>Primary/Secondary Status</td><td colspan="2">Indicates the status of the feature during feature or contact correlation.</td></tr>
<tr><td colspan="2" rowspan="3"></td><td>Primary</td><td>Principal feature that can be associated with one or more secondary features</td></tr>
<tr><td>Secondary</td><td>Indicates that the feature is correlated to the primary.</td></tr>
<tr><td>Pending</td><td>Indicates that further analysis or examination is required</td></tr>
<tr><td>userid</td><td>User ID</td><td colspan="2">Provides a unique identifier</td></tr>
</table>

7.5.4 Bottom Sample Images

If digital images were collected in conjunction with bottom samples, the following naming convention shall be used for image files entered into the NOAA Extended Attribute “images” in the Final Feature File:
<Survey registry number><Feature Acronym><unique numeric identifier><JPEG, PNG, GIF, or TIFF>.

Example: H12345_SBDARE_1.jpg

If drop camera imagery or Image Grab Sampler is used for bottom sampling, then the following images should be delivered with each bottom sample:

- Substrate – An image of the substrate collected while the ponar/frame is on the seafloor
- Overview of Habitat – an overview image while the drop camera is in the water column that is representative of the surrounding habitat
- Oblique (optional) - an oblique image of the habitat (e.g., while the Image Grab Sampler is on its side)
- Grab Sample – An image of the recovered sample. If no grab sample is obtained (e.g., hard substrate) no image is required

8 Deliverables

Contents

8.1 Field Reports

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 PDF:
  Each appendix shall be combined and submitted as a separate, single concatenated file. Individual report naming is provided for the rare instance a report would need to be submitted separately.

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

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

  - Format: <Survey Registry Number>_Vertical_Control_Memo.pdf
  - Example: "H12345_Vertical_Control_Memo.pdf"

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

  II. Supplemental Records:
  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"

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

Descriptive Report Supplemental Reports:

- Data Acquisition and Processing Reports in PDF:
  - Format: <Project Number>_DAPR.pdf
  - Example: "OPR-A123-KR-10_DAPR.pdf"

- Data Acquisition and Processing Report Appendices in PDF:
  - Format: <Project Number>_DAPR_Appendices.pdf
  - Example: "OPR-A123-KR-10_DAPR_Appendices.pdf"

- Horizontal and Vertical Control Reports in 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 of a hydrographic survey report. This occurs most often when the DAPR submitted with the first survey of a long project (as required in Section 8.1.6.1) 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 progress reports is to keep the project managers and Coast Survey staff apprised of ongoing field and data processing work. The field unit shall submit a weekly progress report during field operations, no later than Monday (close-of-business), each week of data acquisition, and then monthly once data acquisition has been completed for the project. If there is a planned extended break in operations, the field unit shall communicate to the HSD/NSD Project Manager or COR via email when field operations cease and then recommence. Once field operations recommence, weekly progress reports shall be submitted.

The publicly available Pydro Explorer tool "Scribble" facilitates semi-automated report compilation to an Excel spreadsheet. NOAA field units shall use Scribble for weekly progress submission. Contractors may use Scribble or use the Weekly Report Excel Template provided by the Project Manager. The Excel reports shall be submitted to the Google Drive folder specified in the Project Instructions.

Weekly Progress Report Contents:

a. Survey Miles Report
   The Survey Miles Report tracks weekly statistics by survey and includes survey metadata (e.g., survey start/end dates), survey metrics (e.g., linear nautical miles, square nautical miles and features), survey processing progress (cumulative percentage complete), and brief narratives. The statistics shall be reported on a weekly basis during data acquisition and then on a monthly basis until the data is submitted to the processing branch.

   The brief narrative shall summarize the activities of the past week (Sunday to Saturday) 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, or anything which could potentially cause the project not to meet requirements, etc.) that may affect data acquisition milestones shall be discussed.

b. Vessel Utilization
   Vessel Utilization will track planned and actual operational hours and the reason for down time on a daily basis. The unit is quarter days where a "day" is user defined (i.e., 8 hours, 10 hours, 24 hours, etc.) for small and large platforms.

c. Coverage Grid or GeoTIFF
Submit an up to date coverage map with the following specifications, 32-bit depth floating point raster, at 8 m or 16 meter grid resolution projected to the project's NAD83 UTM zone. Z-values shall be positive down, in meters, and areas of no data shall have value of -9999. The single band, gray scale raster shall depict the cumulative data acquisition coverage. Acceptable raster file formats include BAG, CSAR, and TIFF. Side scan sonar coverage maps may be submitted in TIFF format. Naming convention shall follow: OPR_X###_XX_## _<year><month><day>.<bag/csar/tiff> (e.g., OPR_A123_KR_10_20210720). If the project coverage is split up into disparate regions or spatial constraints hinder a single whole project level coverage submission, use 'xofx' designations as appropriate (e.g., OPR_A123_KR_10_20210720_1of2_.tif).

Georeferenced images shall be submitted to the Google Drive location specified by the HSD/NSD Project Manager or COR. Contact the Project Manager or COR if there are any file transfer issues.

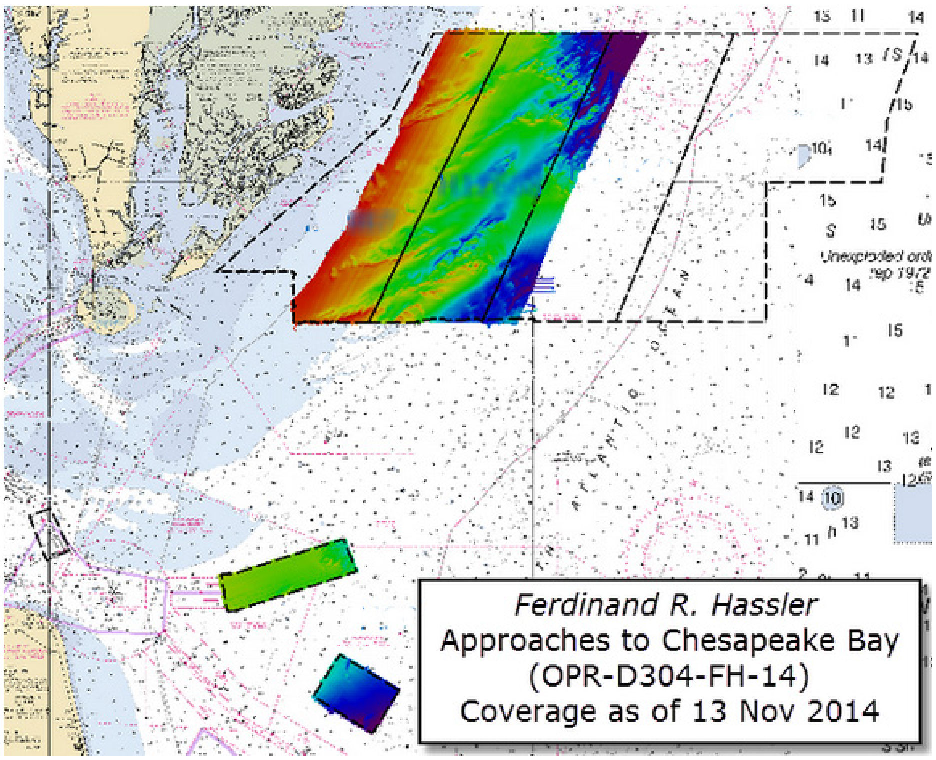


Figure 8.1: Example of a weekly progress report graphic per 8.1.1.1.c.

8.1.1.2 Final Progress Report

The purpose of the final progress report is to provide a graphic and a one-page summary of the project accomplishments. At HSD's discretion, the report or portions of the report may be shared internally or externally. The field unit shall submit the final progress report within 30 days of completion of field work to the assigned HSD/NSD Project Manager or COR with a CC to progress.sketches@noaa.gov. The final progress report shall be submitted to the Google Drive location specified by the HSD/NSD Project Manager or COR.

The Final Progress Report Contents:

a. Project graphic - Graphic showing final data coverage, the project sheet limits, and appropriate chart.

b. Project Metadata and Statistics - For each survey of the project list the Survey Start Date, Survey End Date, Total SNM, Total LNM, and Total Number of Addressed Unverified Charted Features.

c. Recommendations and Notes - This may include recommendations for future surveys in the area, interesting findings or acquisitions strategies, and/or unique challenges.

The final progress report shall be submitted as a PDF following the naming convention: OPR-X###-XX-##_Final_Progress_Report_<month>_<day>.pdf. A template may be provided by the HSD/NSD Project Manager or COR.

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 (e.g., 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 shall be submitted as either a S-57 feature in .000 format or as a shapefile. For S-57 submission, the outline shall be attributed with Feature Object Class M_COVR in a .000 format in the WGS84 datum, unprojected. The outline shall not be included in the FFF. The M_COVR feature shall be attributed as depicted in the table below:

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 (i.e., 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.*

To submit the outline in shapefile format, the submission must be in the Latitude/Longitude NAD83 (EPSG:4269) coordinate system and include the following file formats:

- .shp - containing feature geometry
- .shx - containing positional index of the feature geometry
- .dbf - containing feature attributes
- .prj - containing coordinate system and projection information

The shapefile Attribute Table shall be populated with the Platform, State, Scale, and category of coverage.

Final survey outlines shall be submitted via email survey.outlines@noaa.gov with a CC to the HSD/NSD Project Manager or COR. All relevant correspondence shall be listed in DR Appendix II. The final survey outline shall also be included in the final data submission to the Branch under Supplemental Records.

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 nautical miles reported in the Final Progress Report and the area defined by the survey outline should be explained in the cover email. 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, https://nauticalcharts.noaa.gov/publications/coast-pilot/index.html. 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 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). All relevant correspondence shall be listed in DR Appendix II.

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 Summary or DR Memo is acceptable instead of the standard DR. (See Section 8.1.5 for more information on the DR Summary and DR Memo.) 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 (or Descriptive Report Summary or Memo, if specified in the Project Instructions) shall be submitted electronically in both XML and PDF. The XML file shall be validated against the latest version of the XML DR schema available at https://nauticalcharts.noaa.gov/publications/standards-and-requirements.html. 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.

The XML file shall be named according to the Registry Number of the Survey (e.g., 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 (e.g., H12345_DR.zip).

Submit the entire Report (Cover Sheet, Title Sheet, Sections A through E) in a single 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 Instructions: Project Number, Project Name, General Locality, Field Unit, Registry Number, Sheet ID, Sublocality, State, Country, and Scale.

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 succinctly. Avoid using geographic names in the text of the Descriptive Report that do not appear on the nautical chart.

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 survey should be clearly shown and highlighted in a 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 the survey location.
- When appropriate, simple statements indicating adherence to the Project Instructions, Statement of Work, or HSSD are acceptable (e.g., "Survey Limits were acquired 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 survey only, not the total project.

B. DATA ACQUISITION AND PROCESSING

B.1. 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 8.1.6.1).

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.

B.2. 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 5.2.4.2 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 allowed as described in Section 5.2.2.

- Junctions - Junctions and overlap requirements are defined in Section 7.2.2. This section of the DR shall include an evaluation of overlap for each junction and a summary of each junction's relative agreement of depths with respect to maximum allowable TVU (Section 5.1.3). The hydrographer shall document junction areas with depth differences that exceed maximum allowable TVU. Junctions with adjoining sheets of the current project only need to be described in one of the two DRs.

- 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.")

B.3. 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.")

B.4. Backscatter

If applicable, discuss multibeam acoustic backscatter data acquisition and processing methods. Document the acquisition parameters and the raw and processed file formats. Discuss the methods and software used to produce multibeam acoustic backscatter mosaics. 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.")

If backscatter data were not required and not acquired, a simple negative statement is acceptable (e.g., "Backscatter was not acquired for this survey.")

B.5. 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). If separate grids are submitted for different coverage requirements within a survey, provide an explanation of which surface meets a coverage type (e.g., H12345_MB_VR_MLLW_1of2 meets object detection requirements and H12345_MB_VR_MLLW_2of2 meets complete coverage requirements.

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 8.1.6.2 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.

When utilizing vertical transformations from ERS to chart datum, the associated geometric datum and mapping-frame epoch shall be reported in the Descriptive Report (DR). "Associated geometric datum" implies the indicated reference frame matches that of the vertical datum separation (SEP) model as utilized by the field and also reported in the DR. Examples: NAD83 (2011) 2010.0, NAD83 (PA11) 2010.0, NAD83 (MA11) 2010.0, NATRF2022 2021.0, PATRF2022 2021.0, CATRF2022 2021.0, MATRF2022 2021.0, etc. If a variable "mission date" was utilized for the mapping-frame epoch, indicate the average date per survey; e.g., 2019.67 (i.e., 9/2/2019)."

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 to the largest scale Electronic Navigational Charts (ENCs) that are covered by the survey data, with attention to any changes that are navigational significant. For each category below, 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 assigned or existing features, provide a brief explanation of why the investigation was not conducted.

- Charts- List the largest scale Electronic Navigational Charts (ENCs) that are covered by the survey data and were reviewed during chart comparison. Identify the charts by ENC cell name, scale, edition number, update application date, and issue date.

- Shoals and Hazardous Features - Conduct a detailed review of any potentially hazardous shoals or features. State whether any Danger to Navigation Reports were submitted for this survey.

- Charted Features - As needed, provide additional information regarding charted features that is not already documented in the Final Feature File.

- Uncharted Features - As needed, provide additional information regarding uncharted features that is not already documented in the Final Feature File.

- Channels - List and discuss comparisons of survey depths with controlling depths, tabulated depths, and reported depths of all maintained channels. If survey depths are shallower than controlling, tabulated, or reported depths in maintained channels, see Section 1.6.2.1, Federal USACE Channels for guidance and notification procedures. All relevant correspondence shall be listed in Appendix II.

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 Final Feature File. For each category below, 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 assigned or existing features, provide a brief explanation of why the investigation was not conducted.

- ATON (Section 7.3.5) - As needed, provide additional information regarding aids to navigation that is not already documented in the Final Feature File. If applicable, discuss uncharted aids to navigation that are not included in the FFF because they were deemed to be temporary in nature or repositioned frequently. State whether any aids to navigation were reported to the U.S. Coast Guard according to Section 1.6 and all relevant correspondence shall be listed in Appendix II.

- Maritime Boundary Points - As needed, provide additional information regarding assigned Maritime Boundary features that is not already documented in the Final Feature File.

- Bottom Samples - As needed, provide additional information regarding bottom samples that is not already documented in the Final Feature File.

- Overhead Features - Invalid, incorrectly positioned, or uncharted overhead clearance information, or ongoing construction of bridges or overhead cables and pipelines, constituting a potential danger to navigation, shall be reported to the Project Manager and the authoritative sources (U.S. Coast Guard and U.S. Army Corps of Engineers). State whether any overhead clearance reports were submitted for this survey and list all relevant correspondence in Appendix II. Determining overhead clearances of bridges, overhead cables, or overhead pipelines may be assigned in the Project Instructions. As needed, provide additional information regarding overhead features that is not already documented in the Final Feature File.

- Submarine Features - As needed, provide additional information regarding submarine features (e.g., cables, pipelines, or tunnels) that is not already documented in the Final Feature File.

- Platforms - As needed, provide additional information regarding drilling structure, production platform, and well head within the survey that is not already documented in the Final Feature File.

- Ferry Routes and Terminals - Discuss any ferry routes and ferry terminals if not shown on the chart.

- 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.

- ENC Scale Recommendations- Describe whether larger scale ENCs are requested by chart users or deemed necessary by the hydrographer.

E. APPROVAL SHEET

The approval sheet with a digital signature shall be included in the PDF file. This digital signature (not a digital scan of an ink signature) must append 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

Each appendix shall be combined and submitted as a separate, single concatenated PDF file. If an Appendix is intentionally left empty or is not relevant (e.g., VDatum was used for vertical control instead of zoned tides), place a Readme.txt file in the folder stating as such.

I. WATER LEVELS Include the following (if applicable):

- Field Tide Note (Section 4.2.8)
- Final Tide Note to include the final tidal zoning and final tide reducers used to reduce the data to chart datum.
- 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

II. SUPPLEMENTAL RECORDS

Include any additional survey records not previously addressed in the Descriptive Report, DR Summary, and DR Memo, such as email and phone calls which discuss the requirements of the project (e.g., modified Project Instructions, change memos, waivers). No duplicate material or communication related to Business Identifiable Information (BII) shall be included in the project files. If email correspondence is submitted, when practicable, organize it by subject matter.

In lieu of PDF printed email correspondence, a list of the description of the correspondence, recipient, submittal date(s), and receipt date or acknowledgment date (if known) shall be included for:

- Environmental Compliance
- Dangers to Navigation and Anti - Dangers to Navigation
- Aids to Navigation
- Bridge Heights
- Seep and Pipeline reporting
- Coast Pilot reports
- Sound speed data submissions to NCEI
- Survey outlines

8.1.5 Descriptive Report Summary and Descriptive Report Memo

Descriptive Report Summary

The Descriptive Report Summary is for surveys that have a high likelihood of being used for charting, but are non-standard such as field examinations, track lines, or reconnaissance surveys. The reporting requirements parallel the general section of the DR, but allow more flexibility in reporting details.

Metadata Table
Include the project name, survey number, locality, scale, sonars used, horizontal datum, vertical datum, projection, field unit, survey dates, and the Chief of Party/Lead Hydrographer.

A. Area Surveyed
Provide general information about the area surveyed. See Section 8.1.4, A. Area Surveyed.

B. Survey Purpose
Describe the purpose of the survey including a graphic of the survey overview. Discuss the event, response effort, and the requestor, if outside OCS.

C. Intended Use of Survey
State whether or not the survey is recommended for charting. If the data are not suitable for charting, Sections D and F are not applicable.

D. Data Acquisition and Processing
State whether or not a DAPR was submitted. If no DAPR was submitted, provide similar details on vessel and systems used to acquire bathymetry, SSS, VBES, SVP, positioning equipment and software, acquisition and processing software, etc. A DAPR is preferred over this section.

E. Uncertainty
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 grids and/or BAG(s). Explain and/or justify any areas that have an uncertainty greater than allowable in Section 5.1.3, Uncertainty Standards.

F. Results and Recommendations
Detail chart comparisons, new features for charting, shoals or potentially hazardous features, DTONs, or other relevant information for charting. If the data are not intended for charting, reiterate Section C.

Provide a list of submitted grids/mosaics including the name, TPU, resolution, and depth range. Describe the quality of the grids including whether sounding density per node requirement was met, uncertainty, and any systematic issue evident in the grids (e.g., tide artifact).

G. Vertical and Horizontal Control
Provide a summary of the methods used to determine, evaluate, and apply water level corrections to echo soundings.

H. Additional Results
Provide any other details on the survey that are relevant and not discussed elsewhere, such as sound speed issues, systematic survey problems, and shoreline investigations conducted.

I. Approval Sheet
The Chief of Party/Lead Hydrographer shall furnish a digitally signed statement of approval for all information contained within the DR Summary using the procedures prescribed in Section E under the Descriptive Report Approval Sheet.

Descriptive Report Memo

The Descriptive Report Memo is intended for surveys not planned for charting, which may include hurricane response, special requests, or for homeland security. In some cases, an item may be discovered and data are of sufficient quality that it can be charted. Using the DR Memo does not imply that the data can never be charted, only that the initial intent of the survey was not for chart updates. If during planning there is indication that charting updates will be made, then the DR summary or full DR should be required in the Project Instructions.

The DR Memo shall discuss the area surveyed, the survey purpose, and the requestor or customer, especially if they are outside OCS. Discuss what data products were made and to whom they were provided. Discuss if the purpose was achieved, e.g., surveying and reopening a port.

Describe how soundings were reduced to datum. Discuss any deviation from the DAPR or make a positive statement that DAPR procedures were followed.

Discuss any DTONs that were submitted, or specifically state that all data were reviewed for DTONs and none were found.

State whether the survey meets charting specifications and whether it is adequate to supersede prior data. If the data quality in the entire survey or portions of meet charting standards, specifically state which parts of the survey meet charting specifications and/or should supersede prior data.

The digital version of all products provided to local constituents including water level correction files used and other relevant files, such as a DAPR, shall be included in the data package submitted to HSD.

8.1.6 Descriptive Report Supplemental Reports

8.1.6.1 Data Acquisition and Processing Report

The Data Acquisition and Processing Report (DAPR) details all equipment, systems, and processes used in the acquisition and processing of the hydrographic data. For NOAA field units, the DAPR is an annual report that shall be submitted before or with the first survey submission of the field season. The DAPR shall be sent to the Chief of the 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 with the first survey submission of the project. The DAPR shall be sent to the appropriate Hydrographic Branch specified in the Hydrographic Survey Project Instructions with each survey. Field units and contractors shall not encrypt, secure, or lock the DAPR or HVCR reports.

The DAPR shall be submitted electronically in both XML and PDF format. The XML file shall be validated against the latest version of the XML DAPR schema available. The PDF file shall be generated using the latest version of the XML DAPR stylesheet. The schema will define the required structure, order, and information to be included in the DAPR.

The DAPR files shall be named according to the Project Number (e.g., OPR-A123-KR-10_DAPR.pdf/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. Submit the report (Cover Sheet, Sections A through E) in a single PDF file. The Appendices, described below, shall be submitted as a separate single PDF file.

The following information is required in the DAPR in the order listed below:

Cover Sheet

The Cover Sheet shall include the survey year, field unit, Chief of Party/Lead Hydrographer, date, and version number.

A. System Equipment and Software

Describe the major operational systems and software used to acquire survey data or control survey operations and how the equipment was used. Include images or figures of the installed equipment.

A.1. Survey Vessels
Describe all vessels used for hydrographic survey operations. Include the vessel name and the hull number and describe how the vessel was used while conducting survey operations. Indicate the most recent static offset surveys and offset verifications.

A.2. Echo Sounding Equipment
Describe the echo sounding systems used to acquire survey data. Indicate the manufacturer and model number with a description of the equipment, including the system specifications (e.g., range scales, number of beams, resolution, and along-track coverage). Indicate on which vessel(s) the equipment is installed. If applicable, note the most recent system calibrations and/or accuracy checks and describe whether any nonstandard procedures were used.

A.3. Manual Sounding Equipment
If applicable, describe the manual sounding systems used to acquire survey data and most recent system calibrations

and/or accuracy checks. Describe any nonstandard procedures.

A.4. Horizontal and Vertical Control Equipment
Report the systems used to acquire horizontal and vertical control data. Indicate manufacturer, model number, and serial numbers of all component parts. Where applicable, explain any system calibrations and state whether data quality assurance tests were performed.

A.5. Positioning and Attitude Equipment
Discuss the positioning and attitude systems used to acquire survey data including manufacturer, model number, firmware, and/or software versions. Indicate which vessel(s) use the systems and the serial numbers of all component parts. Where applicable, describe any calibrations performed on the equipment. Include any attitude sensor calibration reports (e.g., GAMS calibration report) and system configuration reports (e.g., POS/MV configuration report) in the DAPR Appendices.

A.6. Sound Speed Equipment
Describe the sound speed systems used to acquire survey data, including sound speed profiling equipment as well as surface sound speed equipment. Include the manufacturer, model number, serial numbers, and most recent calibration dates. Manufacturer calibration reports shall be included in the DAPR Appendices.

A.7. Computer Software
Document the computer software used for all data acquisition and processing, including the manufacturer, software, and the version number(s) used.

A.8. Bottom Sampling Equipment
Describe the bottom sampling equipment used to acquire bottom samples.

A.9. Photogrammetry
Describe the primary photographic imagery sensors used to acquire survey data. Indicate the manufacturer, model number, and the serial number of the sensors as available. If applicable, note the most recent system calibration and/or accuracy checks.

B. System Alignment and Accuracy

Describe the methods used for the determination of all corrections to echo soundings.

B.1. Vessel Offsets and Layback
Describe all vessel offsets and layback correctors applied to echo soundings. Specify the reference point location for each vessel and discuss how vessel offset correctors are accounted for during data acquisition. Describe when and how all vessel offsets were measured on each vessel. Include vessel offset, vessel layback, and dynamic draft reports and diagrams in the DAPR Appendices.

Explain how the position of the towfish is calculated during acquisition (e.g., cable-out, fish depth). Note whether or not a catenary algorithm was applied. Discuss the methods and procedures associated with determining layback error.

B.2. Static and Dynamic Draft
Report all static and dynamic draft correctors applied to bathymetry. For each vessel, describe the method for achieving a waterline height measurement and how this measurement is referenced to the reference point. Include factors such as fuel usage influence waterline height for each vessel.

Describe the procedure for measuring dynamic draft for each vessel. If an ellipsoid referenced dynamic draft measurement was performed, explain why the selected test site was chosen (i.e., minimal geoid slope). Include supplemental reports and diagrams, as necessary, in the DAPR Appendices.

B.3. System Alignment
Document accuracy and alignment test procedures and results. System alignment, accuracy, and calibration reports shall be included in the DAPR Appendices.

C. Data Acquisition and Processing

Describe all data acquisition and processing methods, procedures, and parameters used.

C.1. Bathymetry
Discuss the bathymetric data acquisition methods and procedures. Include the software settings used during acquisition.

Describe the bathymetric data processing methods and procedures with a high-level overview of the processing workflow. Discuss procedures for converting raw sounding data to the final bathymetric grid deliverables. If applicable, describe equipment-specific acquisition workflows.

Describe grid generation methods and procedures, reporting gridding parameters and gridding computation algorithms. Include a discussion of how the surface computation methodology (e.g., radius of propagation, uncertainty weighting, etc.) is consistent with any given coverage requirement.

C.2. Imagery
Discuss multibeam backscatter imagery data acquisition and processing methods and procedures. Document the acquisition parameters and the raw and processed file formats. If applicable, discuss the methods and software used to produce multibeam acoustic backscatter mosaics.

Discuss side scan sonar imagery data acquisition and processing methods and procedures, including the standards used to examine side scan sonar data. Discuss the methods used for establishing proof of swath coverage and the criteria used for selecting contacts.

If applicable, discuss any phase measuring bathymetric sonar imagery data.

C.3. Horizontal and Vertical Control
Specify if GNSS base station data or DGPS data were acquired. If applicable, describe base station establishment methods and procedures, including whether the GNSS base station site was established on an existing control mark and whether the base station coordinates were determined via OPUS. Discuss sampling intervals, masking, weekly uncertainty checks, etc. If applicable, discuss DGPS correctors including which USCG DGPS stations were used as which DGPS services were used.

Describe all tide and water level correctors and the methods and procedures used to apply correctors to echo soundings. Indicate the source of water level correctors as well as all sounding datums used during the survey project. Describe water level gauge installation methods in this section. Discuss calibration and/or accuracy testing of water level gauges and data quality assurance of water level gauge data.

C.4. Vessel Positioning
Document all positioning and attitude correctors and indicate methods and procedures used to apply correctors to echo soundings. Indicate whether the correctors were applied in real time or during post processing. Document

acquisition of positioning and attitude data, including delayed heave data. Explain methods and procedures used to post-process inertially-aided positioning data. Include a discussion of PPK and/or PPP methods. Discuss methods and procedures used to QA/QC positioning and attitude data. Include methods used to review navigation data, methods used to review post-processed SBETs, etc.

C.5. Sound Speed Data

Discuss all sound speed profile sampling methods and procedures including how the sampling frequency was determined. Describe methods and procedures used to apply correctors to echo soundings. List the software used to process sound speed profiles. Indicate the sound speed correction application method (e.g., nearest in distance within time).

Describe all surface sound speed correctors and indicate methods and procedures used to apply correctors to echo soundings. Discuss surface sound speed acquisition, inputs, and uses (e.g., beam steering). Include a discussion of sound speed data quality assurance methods and procedures.

C.6. Uncertainty

Discuss the methods used to minimize the errors and uncertainties associate with depth determination. Provide details regarding uncertainty modeling and indicate how TPU is computed for each sounding. Any deviation from this requirement must be documented. Include verbiage on how the uncertainty was computed on individual soundings and how the uncertainty was computed on the grid, with a justification for the chosen methodology. Provide source(s) of a-priori (HVF) and real-time uncertainty values.

C.7. Shoreline and Feature Data

Discuss all shoreline and feature data acquisition, processing methods, and procedures.

C.8. Bottom Sample Data

Discuss all bottom sampling methods including how the bottom sample site locations were determined.

C.9 Other Data

If applicable, provide an overview of other data acquisition and processing methods and procedures.

D. Data Quality Management

D.1. Bathymetric Data Integrity and Quality Management

Describe methodology used to maintain data integrity, from raw sounding data to final soundings. Describe all quality assurance methods and procedures. Discuss the methods used to complete crossline comparisons, statistical analysis, directed editing, designated sounding selection, holiday identification, uncertainty assessment, and grid difference review.

D.2. Imagery Data Integrity and Quality Management

Document methods and standards used to examine side scan sonar data. Include the methods used for establishing proof of swath coverage and the criteria used for selecting contacts. If applicable, include a brief description of how the review of side scan sonar data meet object detection and accuracy requirements per section 6.1.2. Any compression methods used in the review of the sides can display must be documented (e.g., whether an average or maximum pixel intensity within a regularly-spaced across track interval X meters is used).

E. 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 the Section 8.1.4.

E., 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 following reports shall be included in the DAPR appendices:

1. Vessel Wiring Diagram(s)
2. Sound Speed Sensor Calibration Report(s)
3. Vessel Offset Reports
4. Position Attitude Sensor Calibration Reports
5. Echo Sounder Confidence Check Reports
6. Echo Sounder Acceptance Trial Results, if applicable

Appendices 1 through 6 and any other optional additional reports shall be submitted together as a single PDF file.

8.1.6.2 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. If no horizontal or vertical control stations were established, a text file shall be included in the HVCR folder stating that horizontal and vertical control stations were not established during the project.

A digital copy of the main text of the Horizontal and Vertical Control Report shall be provided in 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 shall follow:

<Survey registry number>_<Sounding Type>_<Units of resolution>_<frequency>_<xofx>
Sounding types are 'SSSAB' for side scan sonar acoustic backscatter.

Examples:
HXXXXX_SSSAB_Xm_XXXkHz_xofx (H11000_SSSAB_1m_455kHz_1of2)
HXXXXX_SSSAB_Xm_XXXkHz_xofx (H11000_SSSAB_1m_455kHz_2of2)

For a complete coverage survey with a 100% side scan sonar requirement, the naming convention shall follow:

HXXXXX_SSSAB_Xm_XXXkHz_1of1. If side scan sonar is used for the specified radius of a feature disproval, the second 100 percent disproval radius lines shall be submitted as a separate mosaic, HXXXXX_SSSAB_Xm_XXXkHz_2of2.

All object detection and complete coverage side scan sonar mosaics shall be generated into a single georeferenced raster file for each 100 percent coverage in floating point GeoTIFF format (Section 8.3.3). Pixel resolution of the side scan mosaics shall be 1 m by 1 m. Areas of no data shall have a value of -9999.

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 I). The naming convention shall follow: HXXXXX_SSS_Contacts.000.

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.

8.3 Digital Data Files

The survey data will be supplied in a digital format. Hard copy plots or printouts of reports are not required.

This section summarizes 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 I. 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 data should be uncorrected or with exception of online corrections. Processed data should include the CARIS HDCS format. Non-CARIS users shall submit processed data as 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 a USB 3.0 compatible hard drive following the data directory structure in Appendix I. Survey data shall be accompanied by NOAA Form 61-29 Letter Transmitting Data in digital and hard copy format, see Appendix H. 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. The field unit remains responsible for ensuring that all files are present and have not become corrupt during transfer. It is up to the discretion of the field unit to choose how this is done.

Data shall be submitted to the Hydrographic Branch listed in the Project Instructions. All data submittals shall be send attention to the Chief and Data Manager of that Hydrographic Branch.

Chief, Pacific Hydrographic Branch Data Manager, Pacific Hydrographic Branch NOAA Room 1001A, Routing N/CS34 Building 3 7600 Sand Point Way NE Seattle, WA 98115-6349	Chief, Atlantic Hydrographic Branch Data Manager, 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.

Full Resolution Echo Sounding Data

The hydrographer shall submit full resolution echo sounding data in a format readable by CARIS HIPS and SIPS version 10 or above. Full resolution echo sounding data shall be delivered fully corrected for water levels, 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 I). Alternately, non-CARIS users may submit fully corrected, echo sounding data 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 I).

CARIS BASE Surface and/or BAG

The final depth information from the survey will be composed as a collection of single-resolution surfaces or a variable-resolution surface deliverable. The grid(s) 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 Hydrographic Survey Project Instructions. The hydrographer must take steps to ensure that all data has been correctly processed, and if applicable, appropriate designated soundings have been selected (Section 5.2.1.2.3 and Section 7.4).

The grid(s) representing the final reviewed results of the hydrographic survey shall be submitted as CARIS BASE or BAG surfaces. NOAA field units typically process hydrographic data using CARIS HIPS software. The CARIS format for the Navigation Surface is a Bathymetry Associated with Statistical Error (BASE) surface, either an Uncertainty or CUBE Surface. CARIS users shall include the version number used during the creation of the surface in the Lineage section. 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/.csar. Sounding types are 'MB' for multibeam echo sounder, 'VB' for single beam echo sounder, and 'LI' for lidar.

- All users 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 (for single resolution surface)
  H11000_MB_VR_MLLW_Final.bag/.csar (for variable resolution surface)
  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.

Examples:
H11000_MB_50cm_MLLW.csar (for single resolution surface)
H11000_MB_VR_MLLW.csar (for variable resolution surface)

- In cases where non-continuous data such as developments and feature disprovals are distributed throughout extensive single survey area with multiple surfaces of the same resolution, or if multiple surfaces of the same resolution are created to delineate different requirements within a single survey area, a description of why the surfaces were split shall be included in the DR and the following naming convention shall be used: <Survey registry number>_<Sounding Type>_<units of resolution>_<Vertical Datum_xofx>.bag/.csar.

  Examples:
  H11000_MB_1m_MLLW_1of2
  H11000_MB_1m_MLLW_2of2

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. If the submitted calibration data represents the most recent values for other surveys of the same project, a text document stating calibration data were previously submitted with a specific dataset is sufficient. The data format shall be such that CARIS HIPS version 10 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 10 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 10 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 single georeferenced raster file for each 100 percent coverage in floating point GeoTIFF format (Section 8.2.1). Areas of no data shall have a value of -9999. Field units shall deliver all mosaics in the Surfaces_Mosaics folder (Appendix I).

8.3.4 Backscatter Deliverables

The hydrographer shall submit raw multibeam backscatter data in a format readable by QPS Fledermaus Geocoder Toolbox. The raw multibeam backscatter data shall be delivered in the Raw MBES folder (Appendix I).

All users submitting multibeam backscatter mosaics must submit them in a floating point GeoTIFF format. These mosaics shall use the following naming convention:

<Survey registry number>_<Sounding Type>_<Units of resolution>_<vessel>_<frequency>_<xofx>
Sounding type is 'MBAB' for multibeam echo sounder acoustic backscatter. The numbering reflects the total number of mosaics for the entire survey.

- Multibeam Acoustic Backscatter Images:
  HXXXXX_MBAB_Xm_vessel_XXXkHz_xofx
  (e.g., H12345_MBAB_2m_3101_400kHz_1of1, H12345_MBAB_6m_S222_70kHz_1of2)

- If multiple vessels have conducted relative calibrations, a single mosaic for a given frequency may be submitted for each frequency. Each mosaic must include all data for utilized and calibrated vessels at a given frequency.
  HXXXXX_MBAB_Xm_XXXkHz_xofx
  (e.g., H12345_MBAB_2m_400kHz_1of2, H12345_MBAB_6m_70kHz_2of2)

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.

The hydrographer shall submit the following ERS positioning data as applicable to the techniques utilized during the course of the project:

- For all non-NOAA CORS base station file data utilized, preferably in Receiver Independent Exchange Format (RINEX); otherwise, non-proprietary receiver "binary" format suffices
- Post-processed position and uncertainty file (e.g., SBET and SBET RMS)
- Datum separation model file used to correct the survey data to chart datum, 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 I) and accompanying log or text file describing the uncertainty of the separation model
  - Comma separated values: decimal latitude, decimal longitude, separation in meters
  - NGS GEOID BIN format
  - Corrector Surface layer in the Bathymetric Attributed Grid (BAG)
  - Separation model should be named by: <Project>_<Datum>_<Sep model>_<Tidal or Reference Datum> Example: OPR-XXXX-XX-XX_NAD83_VDatum_MLLW

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 4.5 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. Project, survey, field 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. In cases of projects spanning multiple years, submissions shall be made yearly. 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. All relevant correspondence shall be listed in DR Appendix II.

- 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. All relevant correspondence shall be listed in DR Appendix II.

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 I.) If the hydrographer has populated any static or dynamic correctors, offsets and uncertainties which have been applied to the "Full Resolution Multibeam Data" in CARIS HIPS and SIPS, the HVF shall be submitted as referenced in Section 8.3.2.

If the hydrographer has captured static and dynamic correctors, offsets and uncertainties in the data acquisition software and CARIS HIPS and SIPS has not applied those correctors, offsets, and uncertainties directly, the submission of a HVF is not required. In a case of a zero HVF or use of non-CARIS software, 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. All submitted data are fully corrected.

Metadata

The following reports shall be included on the submitted data drive in a clearly labeled directory:

- The Appendices to the DR in PDF.
- The Data Acquisition and Processing Report in PDF.
- The Horizontal and Vertical Control Report in PDF.

Final Feature File

The S-57 Final Feature File shall be included on the submitted drive in the Final Feature File folder (Appendix I). The naming convention shall follow: HXXXXX_FFF.000.

Supporting Data

Supporting data include:

- 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 ☐ TERTIARY ☐ SECONDARY | 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
NAME
TELEPHONE NUMBER *(Include Area Code.)* | HOME ( ) | BUSINESS ( )
NEW ☐ YES ☐ NO | 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 RODSTOP/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 GAGE(S) *(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 *(Top 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.*

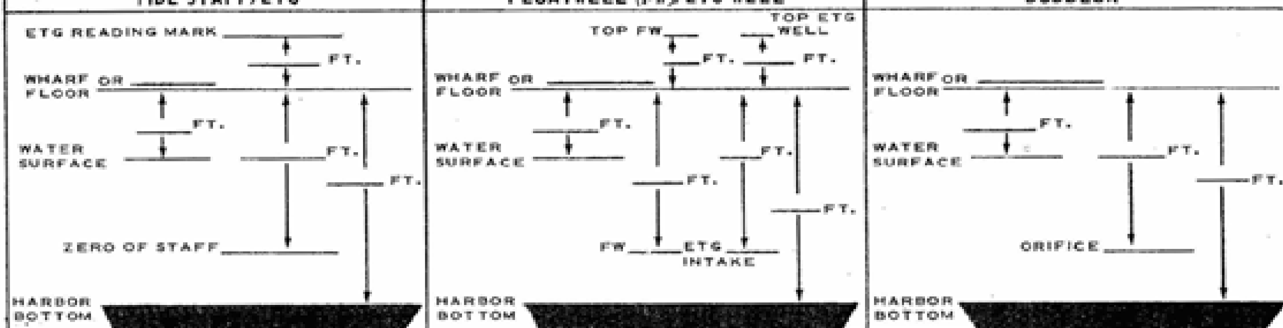
SUPERSEDES PREVIOUS EDITION. EXISTING STOCK MAY BE DESTROYED UPON RECEIPT OF REVISION.

Figure A.1: NOAA Form 77-12 Tide Station Report

ETG WELL	MATERIAL			INTAKE ☐ FIXED/MOLDED ☐ REMOVABLE	WELL CHANGED ☐ YES ☐ NO	DATE OF INSTALLATION
	LENGTH *(Overall)* FT.	LENGTH *(Top 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
TELEMETRY EQUIPMENT	BRISTOL METAMETER TYPE	SERIAL NUMBER	DEDICATED TELEPHONE	GAGE TO METAMETER DIFFERENCE		
	LOCATION OF RECEIVER			PERSON TO CONTACT *(MIC/NWS)*	TELEPHONE	
	DARDC/WLTS TERMINAL UNIT NO.	DARDC/WLTS POWER SUPPLY NO.	WLTS MODULE ☐ A ☐ B	MODULE NUMBER	DARDC/WLTS TELEPHONE	

MEASUREMENTS

TIDE STAFF/ETG	FLOATWELL *(FW)*/ETG WELL	BUBBLER



STAFF/ETG OBSERVATION FOR MEASUREMENT			STAFF/ETG OBSERVATION FOR MEASUREMENT			STAFF/ETG OBSERVATION FOR MEASUREMENT		
FT.	TIME	DATE	FT.	TIME	DATE	FT.	TIME	DATE

LATEST LEVELS	DATE OF LEVELS TO TIDE STAFF	NO. OF MARKS CONNECTED	PBM CONNECTED ☐ YES ☐ NO	NO. OF MARKS ESTABLISHED	NO. OF MARKS RECOVERED
	REMARKS *(Recommendations for new marks, etc.)*				

ADDITIONAL INFORMATION, SKETCH, AND/OR RECOMMENDATIONS *(For continuation, please indicate item. Use additional sheet, if necessary.)*

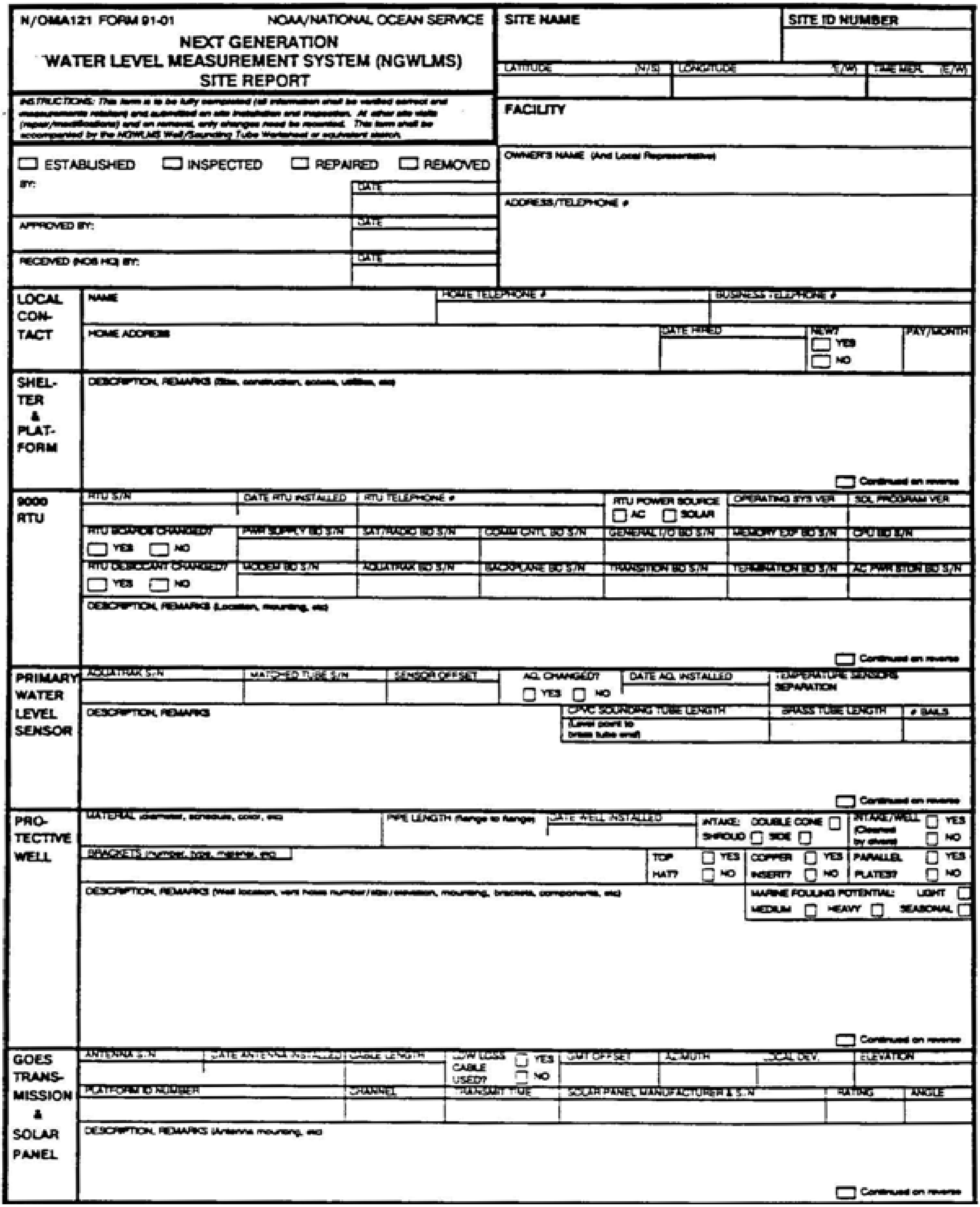
*U.S. GPO: 1988-554-006/81003

Figure A.2: Tide Station Report (cont.)

8200 DATA RECORDER	8200 S/N	DATE 8200 INSTALLED	PROGRAM VERSION	POWER SOURCE ☐ DC ☐ SOLAR	DESICCANT CHANGED? ☐ YES ☐ NO	CPU S/N	INTERCONNECT S/N
	DESCRIPTION, REMARKS (Mounting, location, etc)					AMP GAIN	SENSOR SLOPE
	☐ Continued below						
BACKUP WATER LEVEL SENSOR	SENSOR MANUFACTURER ☐ DRUCK ☐ IMO ☐ PAROSCIENTIFIC ☐ OTHER ______	SENSOR S/N	DATE SENSOR INSTALLED	SENSOR CONFIGURATION ☐ WATER ☐ BUBBLER	PARALLEL PLATES? ☐ YES ☐ NO		
	DESCRIPTION, REMARKS (Sensor location, installation details, etc)						
	☐ Continued below						
OTHER SENSORS	AIR TEMPERATURE ☐ YES ☐ NO	DATE INSTALLED	BAROMETER S/N	DATE INSTALLED	CONDUCTIVITY S/N	DATE INSTALLED	
	WATER TEMPERATURE ☐ YES ☐ NO	DATE INSTALLED	WIND SENSOR S/N	DATE INSTALLED	MET TOWER TYPE: STEEL ☐ FIBERGLASS ☐	DATE INSTALLED	
	DESCRIPTION, REMARKS (Sensor/tower location, installation details, etc)						
	☐ Continued below						
LATEST LEVELS	DATE OF LEVELS	NUMBER OF BENCH MARKS CONNECTED	NUMBER OF BENCH MARKS ESTABLISHED	NUMBER OF BENCH MARKS RECOVERED	PBM CONNECTED? ☐ YES ☐ NO, EXPLAIN	DOWNSHOT LEVELING FIXTURE REQUIRED? ☐ YES ☐ NO	
	REMARKS			☐ Continued below	AQUATRAK COEFFICIENT 2A (PBM above site datum; from HQ)		
					AQUATRAK COEFFICIENT 2B (Leveling point above PBM; from levels) +		
					AQUATRAK COEFFICIENT 2 (2A + 2B = 2) =		

REMARKS (Continuations, recommendations, etc)

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

INSTRUCTIONS: This form is to be fully completed (all information shall be verified correct and measurements rechecked) and submitted on site installation and inspection. At other site visits (repair/modifications) and on removal, only changes need be recorded. This form shall be accompanied by the NGWLMS Well/Sounding Tube Worksheet or equivalent sketch.

SITE NAME | SITE ID NUMBER

LATITUDE (N/S) | LONGITUDE (E/W) | TIME MER. (E/W)

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 BOARDS 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 DESICCANT CHANGED? ☐ YES ☐ NO | MODEM BD S/N | AQUATRAK BD S/N | BACKPLANE BD S/N | TRANSITION BD S/N | TERMINATION BD S/N | AC PWR STDN BD S/N

DESCRIPTION, REMARKS (Location, mounting, etc)

☐ Continued on reverse

PRIMARY WATER LEVEL SENSOR

AQUATRAK S/N | MATCHED TUBE S/N | SENSOR OFFSET | AQ. CHANGED? ☐ YES ☐ NO | DATE AQ. INSTALLED | TEMPERATURE SENSORS SEPARATION

DESCRIPTION, REMARKS | CPVC SOUNDING TUBE LENGTH (Level point to brass tube end) | BRASS TUBE LENGTH | # BAILS

☐ Continued on reverse

PROTECTIVE WELL

MATERIAL (diameter, schedule, color, etc) | PIPE LENGTH (flange to flange) | DATE WELL INSTALLED | INTAKE: DOUBLE CONE ☐ SHROUD ☐ SIDE ☐ | INTAKE/WELL (Cleaned by divers) ☐ YES ☐ NO

BRACKETS (number, type, spacing, etc) | TOP HAT? ☐ YES ☐ NO | COPPER INSERT? ☐ YES ☐ NO | PARALLEL PLATES? ☐ YES ☐ NO

DESCRIPTION, REMARKS (Well location, vent holes number/size/elevation, 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 | GMT OFFSET | AZIMUTH | LOCAL DEV. | ELEVATION

PLATFORM ID NUMBER | CHANNEL | TRANSMIT TIME | 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

8200 DATA RECORDER	8200 S/N	DATE 8200 INSTALLED	PROGRAM VERSION	POWER SOURCE ☐ DC ☐ SOLAR	DESICCANT CHANGED? ☐ YES ☐ NO	CPU S/N	INTERCONNECT S/N
	DESCRIPTION, REMARKS (Mounting, location, etc)					AMP GAIN	SENSOR SLOPE
							☐ Continued below

BACKUP WATER LEVEL SENSOR	SENSOR MANUFACTURER ☐ DRUCK ☐ IMO ☐ PAROSCIENTIFIC ☐ OTHER ______	SENSOR S/N	DATE SENSOR INSTALLED	SENSOR CONFIGURATION ☐ WATER ☐ BUBBLER	PARALLEL PLATES? ☐ YES ☐ NO
	DESCRIPTION, REMARKS (Sensor location, installation details, etc)				
					☐ Continued below

OTHER SENSORS	AIR TEMPERATURE ☐ YES ☐ NO	DATE INSTALLED	BAROMETER S/N	DATE INSTALLED	CONDUCTIVITY S/N	DATE INSTALLED
	WATER TEMPERATURE ☐ YES ☐ NO	DATE INSTALLED	WIND SENSOR S/N	DATE INSTALLED	MET TOWER TYPE: STEEL ☐ FIBERGLASS ☐	DATE INSTALLED
	DESCRIPTION, REMARKS (Sensor/tower location, installation details, etc)					
						☐ Continued below

LATEST LEVELS	DATE OF LEVELS	NUMBER OF BENCH MARKS CONNECTED	NUMBER OF BENCH MARKS ESTABLISHED	NUMBER OF BENCH MARKS RECOVERED	PBM CONNECTED? ☐ YES ☐ NO, EXPLAIN	DOWNSHOT LEVELING FIXTURE REQUIRED? ☐ YES ☐ NO
	REMARKS			☐ Continued below	AQUATRAK COEFFICIENT 2A (PBM above site datum: from HQ) AQUATRAK COEFFICIENT 2B (Leveling point above PBM: from levels) + AQUATRAK COEFFICIENT 2 (2A + 2B = 2) =	

REMARKS (Continuations, recommendations, etc)

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: xxxxxxxxxxxxxxx

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

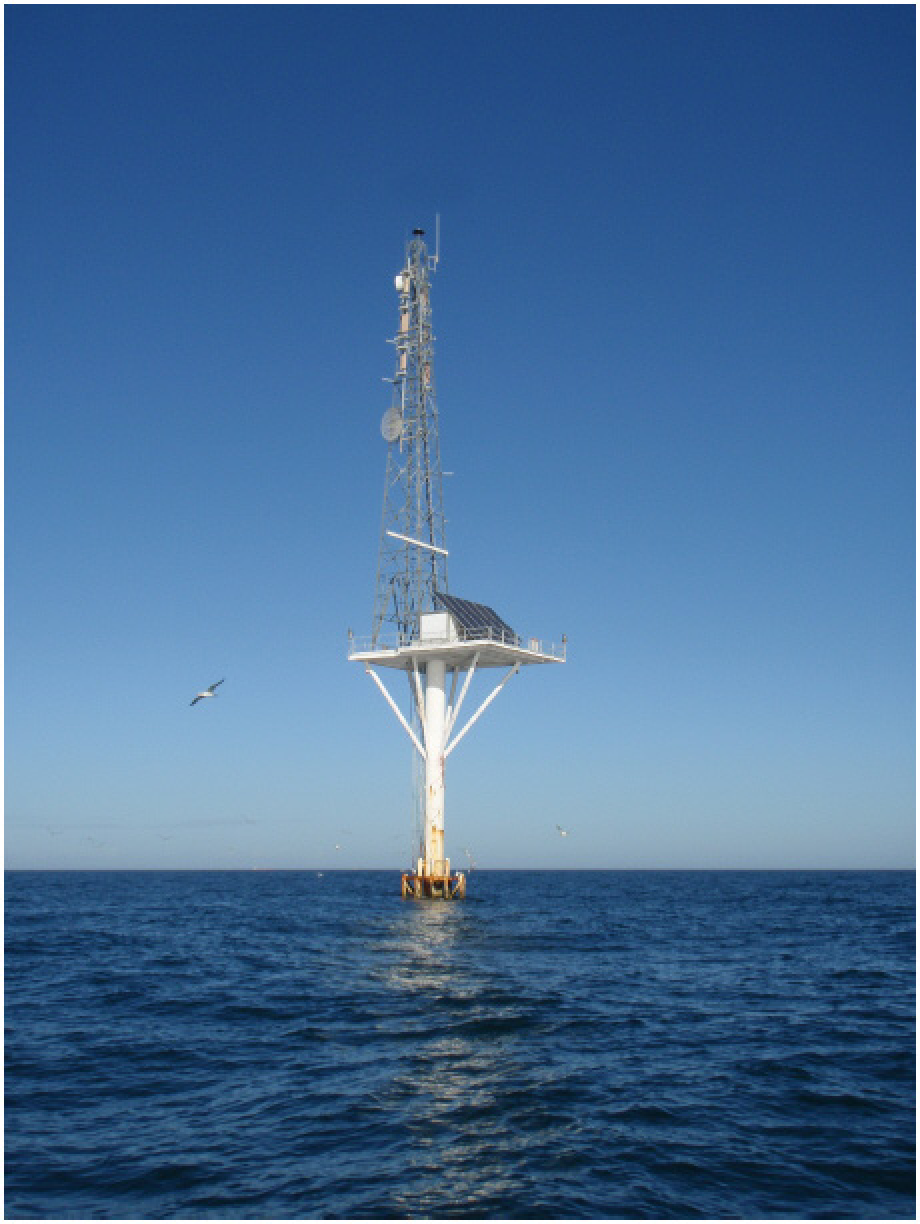


Figure 1.1.1

Figure D.3: Example of Danger to Navigation Report

Appendix E: WATLEV Attribution

Rocks, obstructions, and wrecks may be classified as always underwater, awash, or covers and uncovers. Obstructions and wrecks may also be classified as always dry.

A bare rock extends more than 0.1 meter above the shoreline plane of reference (SPOR), typically Mean High Water (MHW).
A rock, which covers and uncovers is exposed at some stage of tide from 0.1 meter above MHW to 0.1 meter above chart datum.
An awash rock lies less than 0.1 meter above chart datum to 0.1 meter below the chart datum.
A submerged (always underwater) rock is deeper than 0.1 meter from the chart datum.

Classification	**Always Underwater**	**Awash**	**Covers & Uncovers**	**Always Dry**
Elevation (VALSOU or HEIGHT)	> 0.1 m below chart datum (e.g., MLLW or LWD[+])	< 0.1 m above chart datum (e.g., MLLW) to 0.1 m below chart datum (e.g., MLLW)	0.1 m ≥ chart datum (e.g., MLLW) to 0.1 m SPOR (e.g., MHW)	> 0.1 m SPOR (e.g., MHW)
S-57 Object	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	UWTROC OBSTRN WRECKS	LNDARE & LNDELV* OBSTRN** WRECKS**
WATLEV Value	3	5	4	none
Vertical coordinate system is positive up for elevations and positive down for depths				

[+]In the Great Lakes, rocks, obstructions, and wrecks are defined in relation to Low Water Datum.

*A rock becomes an islet at 0.1 meters above SPOR (e.g. 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 SPOR.

**When the depth of an obstruction or wreck is greater than 0.1 meters above MHW, HEIGHT attribution is required rather than VALSOU. As with ELEVAT, heights are shown relative to SPOR (e.g., MHW). In this situation, WATLEV and VALSOU are left null.

Figure E.1: WATLEV Attribution

Appendix F: 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-57 attribute standards. The following extended attributes are global to all S-57 object classes.

Acronym	Name	Description	IEC/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)oat
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 semicolon-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 semicolon-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	Field unit 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
hsdrec	HSD recommendations	HSD charting recommendations	2011	Free text (S)tring

Figure F.1: NOAA extended attributes parameters

Acronym	IEC/ISO8211 ID	Ennumeration 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
		6	UNVERIFIED CHARTED FEATURE
acqsts	2007	1	Investigate
		2	Resolved

Figure F.2: Expected input values for NOAA enumeration attributes

Appendix G: Bottom Classification

Sediment Size Classification		
Type	**Term**	**Grain Size (mm)**
Clay		< 0.002
Silt		0.002-0.0625
Sand	fine	0.0625-0.25
	medium	0.25 -0.5
	coarse	0.5 - 2.0
Gravel		2.0-4.0
Pebbles		4.0-64.0
Cobble		64.0-256.0
Boulder		> 256.0
Stone		4.0-256.0+

Figure G.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 G.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 G.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 G.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 G.5: NATQUA/NATSUR Allowable Attribute Combination

Appendix H: Survey Data Submission

NOAA FORM 61-29 (12-71) U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION **LETTER TRANSMITTING DATA**	REFERENCE NO.
TO:	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

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 H.1: Survey Data Submission

Appendix I: Data Directory Structure

OPR-X###-XX-##

- **HXXXXX**
    - **Raw**
        - **Features**
        - **MBES**
        - **Positioning**
        - **SBES**
        - **SSS**
        - **SVP**
        - **WC**
    - **Processed**
        - **GNSS_Data**
        - **SBET**
        - **Multimedia ***
        - **Reports**
            - **Project**
                - **DAPR**
                    - **Report**
                    - **Appendices**
                - **HVCR**
                    - **Digital_A-Vertical_Control_Report**
                    - **Digital_B-Horizontal_Control_Data**
                        - **ATON_Data**
                        - **Base_Station_Data**
                - **Project_Correspondence**
            - **Survey**
                - **Descriptive_Report**
                    - **Appendices**
                        - **I_Water_Levels**
                        - **II_Supplemental_Records**
                    - **Report**
                - **Public_Relations_Constituent_Products**
        - **S-57_Files**
            - **Final_Feature_File**
            - **Side_Scan_Sonar_Contacts**
        - **Sonar_Data ****
            - **HXXXXX_GSF *****
            - **HXXXXX_MB**
            - **HXXXXX_SB**
            - **HXXXXX_SSS**
            - **HXXXXX_WC**
            - **VesselConfig**
        - **Surfaces_Mosaics**
        - **SVP**
        - **Water_Levels**

* Multimedia shall not contain subdirectories
** CARIS users:
Processed/Sonar_Data/HDCS_Data/HXXXXX_MB
Processed/Sonar_Data/HDCS_Data/HXXXXX_SB
Processed/Sonar_Data/HDCS_Data/HXXXXX_SSS
Processed/Sonar_Data/HDCS_Data/HXXXXX_WC
Processed/Sonar_Data/HDCS_Data/VesselConfig
*** NOAA Only

Figure I.1: Data Directory Structure

Appendix J: 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

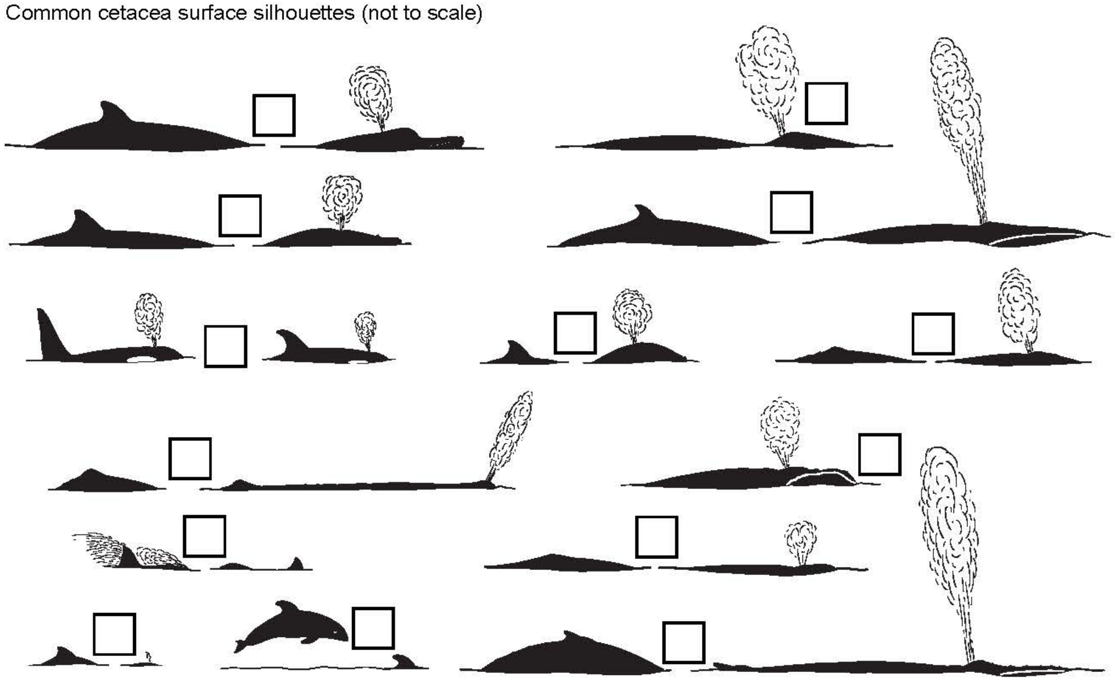
Fishing Interactions
Please fill out the Marine Mammal Interaction and Specimen Form for all fishing interactions

❑ Contact with gear
❑ Contact with vessel
❑ Entangled in gear
❑ Feeding on discards
❑ Feeding from gear
❑ Following vessel while fishing
❑ Swimming near gear

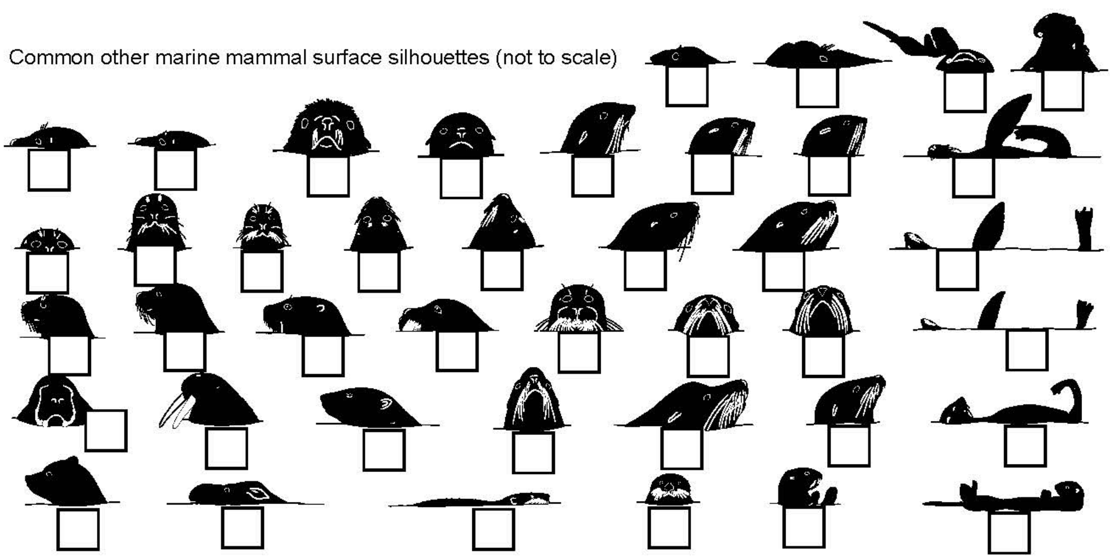
Form 11US : version 1 : 19 June 2013

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

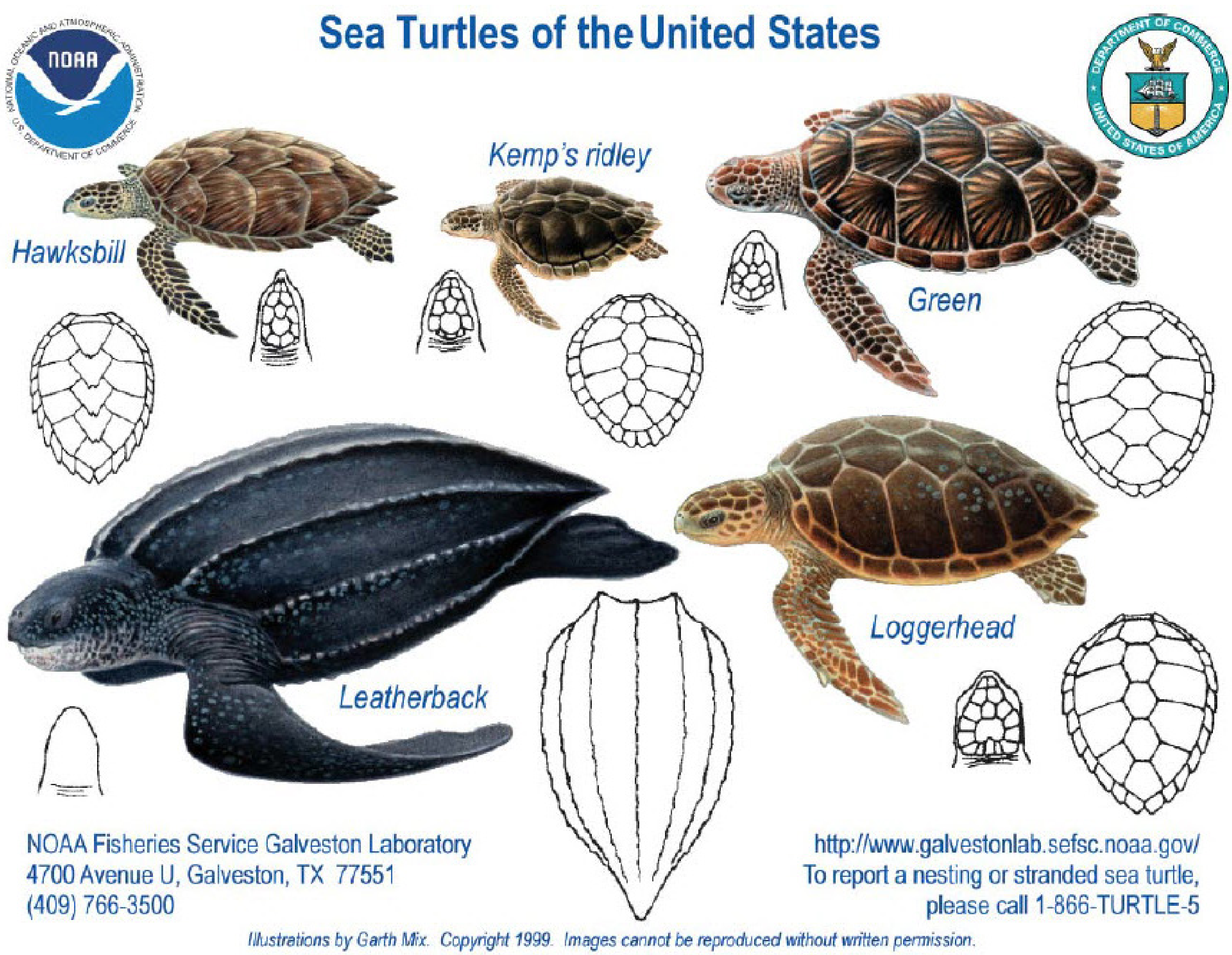
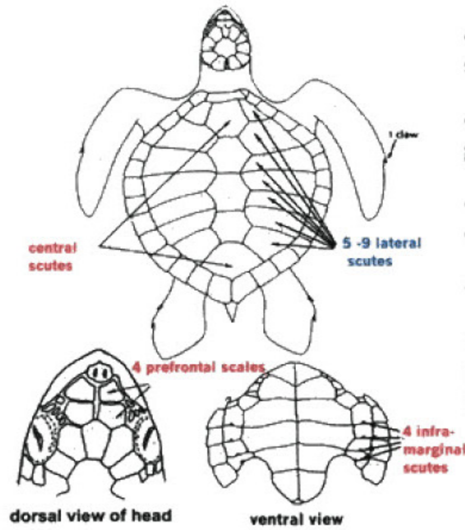

Sea Turtles of the United States
Hawksbill
Kemp's ridley
Green
Leatherback
Loggerhead
NOAA Fisheries Service Galveston Laboratory
4700 Avenue U, Galveston, TX 77551
(409) 766-3500
http://www.galvestonlab.sefsc.noaa.gov/
To report a nesting or stranded sea turtle,
please call 1-866-TURTLE-5
Illustrations by Garth Mix. Copyright 1999. Images cannot be reproduced without written permission.

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

Appendix K: Non-Dangerous Pipeline Reports

H12345 Non-Dangerous Pipeline Report

Registry Number:	H12345
State:	Louisiana
Locality:	Louisiana Sound
Sub-locality:	Vicinity of Lookout Point
Project Number:	OPR-A123-TJ-20
Survey Date:	04/10/2020

Charts Affected

Number	Edition	Date	Scale (RNC)	RNC Correction(s)*
11370	27th	11/01/2008	1:40,000 (11370_3)	[L]NTM: ?
11354	27th	08/01/2008	1:80,000 (11354_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.	Feature Type	Survey Depth	Survey Latitude	Survey Longitude	AWOIS Item
1.1	Obstruction	30.50 m	30° 21' 08.6" N	091° 14' 47.3" W	---
1.2	Obstruction	30.50 m	30° 21' 08.6" N	091° 14' 47.3" W	---

Figure K. 1 Example of Non-Dangerous Pipeline Report

1.2) US 0000028155 00001 / Pipeline.000

Survey Summary

Survey Position:	30° 21' 08.6" N, 091° 14' 47.3" W
Least Depth:	30.50 m (= 100.07 ft = 16.678 fm = 16 fm 4.07 ft)
TPU (±1.96σ):	**THU (TPEh)** [None] ; **TVU (TPEv)** [None]
Timestamp:	2020-101.00:00:00.000 (04/10/2020)
Dataset:	Pipeline.000
FOID:	US 0000028155 00001(022600006DFB0001)
Charts Affected:	11370_3, 11354_1, 411_1

Remarks:

OBSTRN/remrks: Non-dangerous unburied pipeline rises 1.5 m above surrounding seafloor.

Hydrographer Recommendations

Chart new pipeline

S-57 Data

Geo object 1:	Obstruction (OBSTRN)
Attributes:	QUASOU - 6:least depth known
	SORDAT - 20200410
	SORIND - US,US,graph,H12345
	TECSOU - 3:found by multi-beam
	VALSOU - 30.500 m
	WATLEV - 3:always under water/submerged

Figure K. 2 Example of Non-Dangerous Pipeline Report

Feature Images

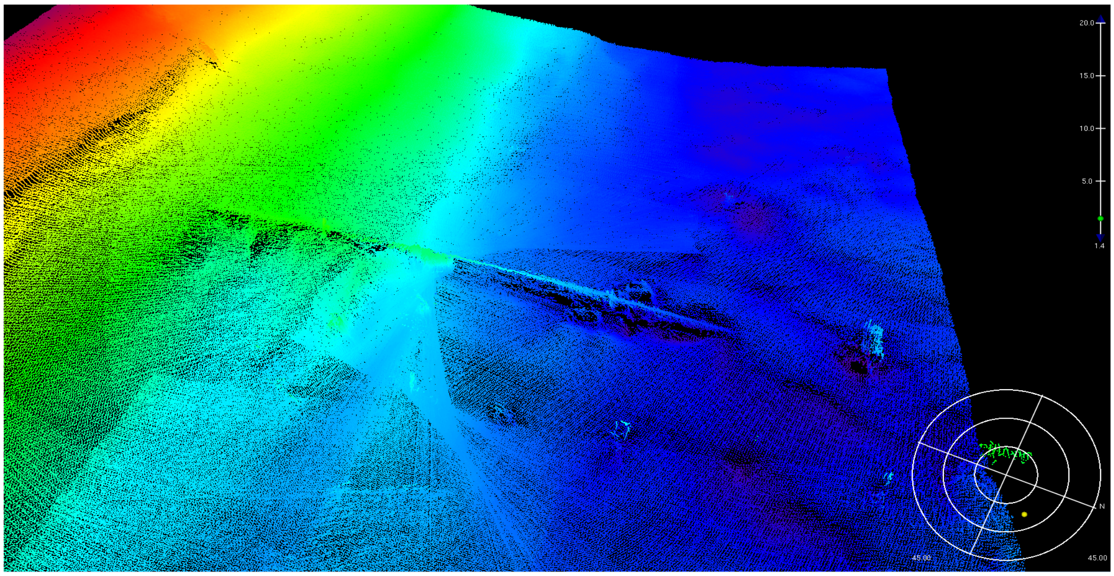


Figure 1.1.1

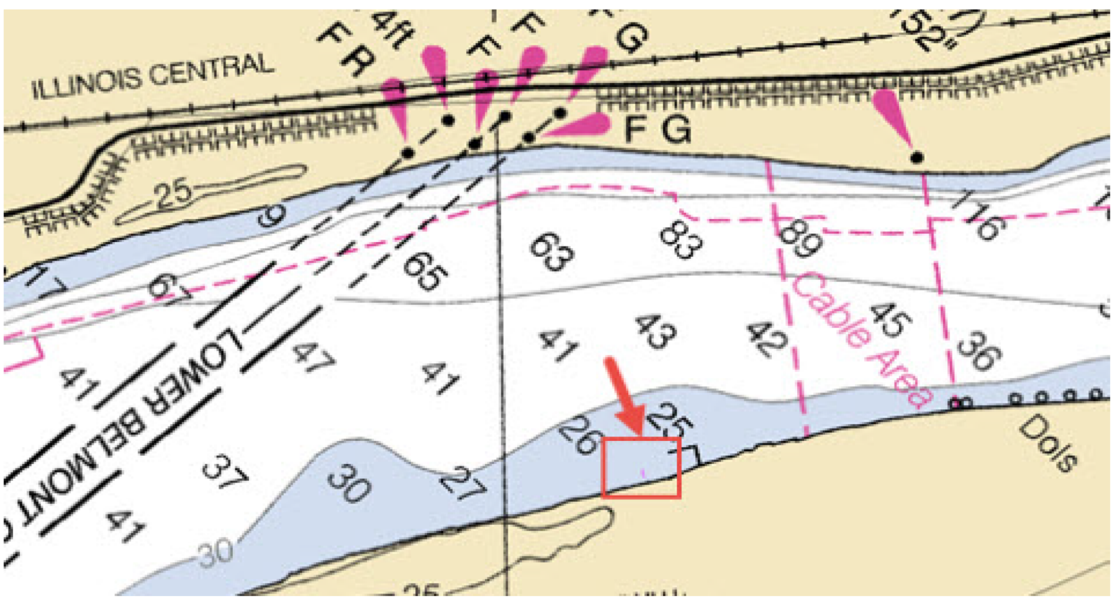


Figure 1.1.2

Figure K.3 Example of Non-Dangerous Pipeline Report