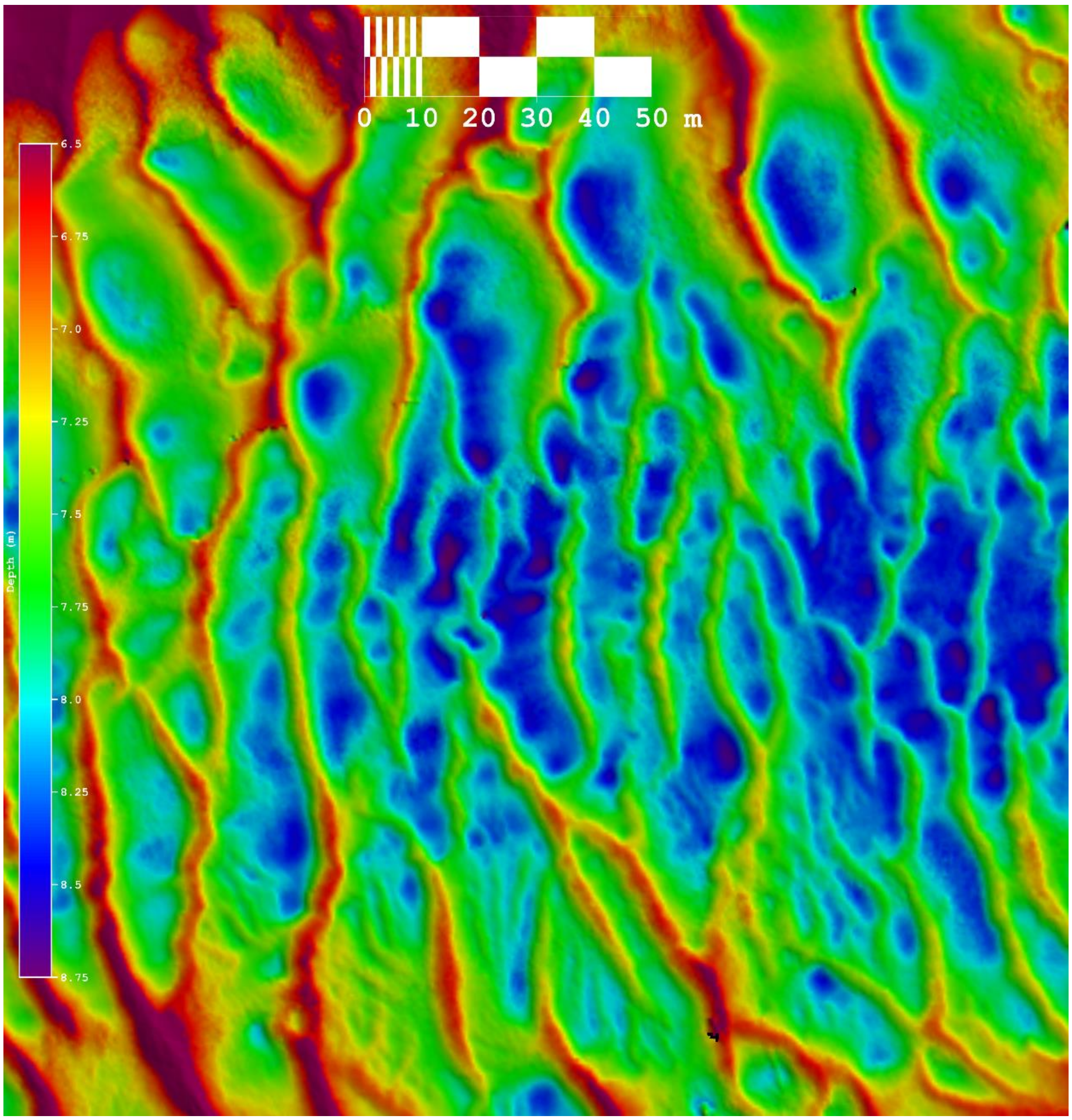
EDGETECH 4600 AND 6205
DATA PROCESSING WITH CARIS HIPS 8.1 AND 9.0
IN SUPPORT OF SANDY SUPPLEMENTAL RESEARCH

Val Schmidt and Kevin Jerram
University of New Hampshire
Center for Coastal and Ocean Mapping



EdgeTech 4600 PMBS bathymetry data collected over bedforms near Fire Island Inlet, New York. Raw soundings in each survey line were binned by acrosstrack range at 40cm resolution; all binned survey data were gridded at 50 cm resolution using the CUBE implementation in CARIS HIPS 8.1. The depth scale is 6.50 m (purple) to 8.75 m (dark blue). No manual inspection or rejection of soundings has been performed in CARIS. Other examples in this document demonstrate considerations for binning raw data and processing echosounder uncertainty data.

PURPOSE

Phase-measuring bathymetric sidescan (PMBS) echosounders, such as the EdgeTech 4600 and 6205, offer potential increases in swath width and sounding density in shallow waters compared to multibeam echosounders. These advantages are balanced by the drawbacks of increased volume and 'noisiness' of PMBS data, which have traditionally presented challenges in post-processing but may now be accommodated using existing multibeam workflows in modern software.

CARIS HIPS is a commercial off-the-shelf software package employing the Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm to effectively handle large PMBS datasets and produce bathymetric surfaces requiring only minor manual editing. This document is intended to supplement the multibeam workflow for CARIS HIPS 8.1 and HIPS 9.0 [Help → User Guides → User Guide (workflow)] by providing additional information specific to the processing of EdgeTech PMBS data.

A fundamental consideration for processing EdgeTech data in CARIS HIPS is the proper handling of echosounder uncertainty data. At the time of writing, EdgeTech 4600 files processed with Discover Bathymetric software version 34.0.1.101 (and possibly earlier) include realtime sonar uncertainty data that are properly applied in CARIS 8.1 and 9.0. EdgeTech 6205 files must be processed with Discover Bathymetry version 34.0.1.110 (or later) and then converted in HIPS 9.0 (or later) to correctly incorporate and apply realtime echosounder uncertainty information. After file conversion in HIPS 9.0, this uncertainty information within a project is also readable in HIPS 8.1.

Though data structure has been significantly modified between HIPS 8.1 and 9.0, the nature and order of the data processing steps remain generally unchanged. While this document describes important differences between HIPS 8.1 and 9.0 where appropriate, the respective CARIS User Guide should be consulted for details of data processing in each version of HIPS.

This guide does not represent an endorsement of any particular echosounder or software package.

EDGETECH DATA EXAMPLES

This processing guide includes examples of EdgeTech 4600 and 6205 PMBS data collected near Fire Island Inlet, New York, and in Portsmouth Harbor, New Hampshire, respectively. The Fire Island Inlet region was impacted by Super Storm Sandy and is considered relevant to the Sandy Supplemental research proposal submitted by the University of New Hampshire Center for Coastal and Ocean Mapping (UNH CCOM). The EdgeTech 4600 data were collected aboard the R/V *Noot Volmaakt* by Williamson and Associates under NOAA project OPR-C331-KR-13. EdgeTech 6205 data examples were collected by UNH CCOM personnel aboard the R/V *Coastal Surveyor*. Because EdgeTech data may be collected from a variety of platforms and vehicles, parameters specific to each vessel described here may or may not apply to processing of data collected from other vessels. These parameters include, but are not limited to, sensor offsets in the vessel configuration file and sources for navigation, draft, tide, and attitude data.

Binning Raw Data in Discover

Before importing into CARIS, raw echosounder 'stave' data files must be pre-processed with EdgeTech Discover Bathymetric software to apply navigation and sound speed data, estimate soundings, and produce a .JSF file for post-processing. Version 34.0.1.110 or higher must be used to integrate realtime sonar uncertainty for EdgeTech 6205 data. The Discover Bathymetric software offers filtering and binning options to reduce the density and noisiness of processed soundings prior to gridding. The binning process acts as a median filter on raw soundings in user-selectable bins of either acrosstrack distance or angle relative to the echosounder. Both binning techniques are suitable for general mapping purposes, assuming the acrosstrack horizontal resolution of the binned results yields adequate sounding density to support the desired resolution of the final gridded surface. Matching the acrosstrack horizontal resolution of the binned data to the alongtrack sounding (or ping) spacing is one strategy for establishing more uniform data density prior to the gridding process. It is also possible to pre-process raw data without binning.

Comparison of angle- and range-binning strategies applied to the Portsmouth Harbor data has shown negligible differences between least depths reported over mooring blocks in the resulting CUBE surfaces. However, a primary consideration in selecting a binning method is the retention of soundings on steep or vertical surfaces which are coincident in range with other soundings from the seafloor. If binning is desired for data expected to include distinct features detected at the same range (such as approaching a junction between a vertical wall and flat seafloor), then the angle binning option should be applied to support imaging of these surfaces. Range binning may confound or reject soundings on such structures, particularly in the presence of strong seafloor returns. Refer to the Discover Bathymetric User Software Manual for additional information on binning and filtering options (http://www.edgetech.com/underwater-technology-support).

Because PMBS systems are typically employed to achieve broad swath coverage in shallow waters, care must be taken to ensure that the user-selected bin size and maximum number of bins allowed by the Discover Bathymetric software are appropriate for the water depth and do not degrade the acrosstrack coverage of soundings in the processed files. An important feature of Discover Bathymetric version 34.0.1.110 is an increase in the maximum number of bins from 600 to 800. Figure 1 includes examples of one survey file processed with different angle bin sizes in Discover Bathymetric (version 34.0.1.110 with a maximum of 800 bins) and gridded at 10-30 cm using the CUBE algorithm in CARIS. These examples illustrate the effective limitations on acrosstrack coverage that may arise due to maximum bin count when using smaller angle bin sizes (e.g., 0.25° in this example) or low acrosstrack binned data density in the outer swath when using larger angle bin sizes (e.g., 1.00° in this example). The examples also demonstrate the capability to import and grid unbinned EdgeTech data in CARIS after pre-processing with Discover Bathymetric software.

NOTE: The option to process .JSF files in Discover without binning may be hidden under Advanced Bathymetric Controls, depending on software version. Double left-click and double right-click in the window to enable this option.

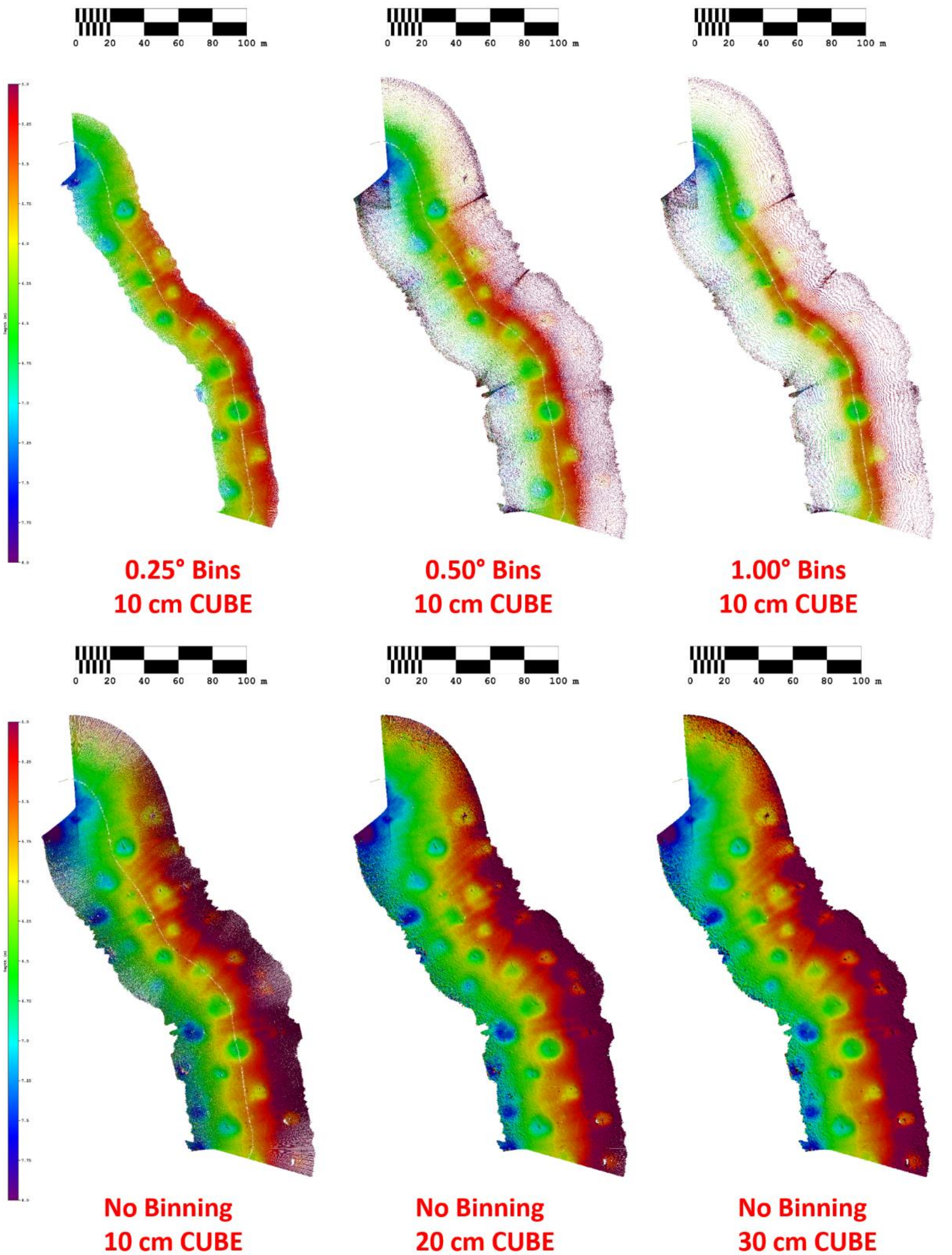


Figure 1. A single EdgeTech 6205 survey line over mooring blocks and associated scour marks in Portsmouth Harbor, New Hampshire, is shown after processing in Discover Bathymetric and CARIS HIPS 8.1 with a variety of angle bin and CUBE grid sizes. The depth scale is 5 m (red) to 8 m (purple) in all images. Of particular interest, the 0.25° angle bin size effectively reduces acrosstrack coverage. Larger angle bin sizes support the full acrosstrack range of the acquired data, though binned data in the outer swath appear to follow angle-dependent trends in density. Binning by range (not shown in this figure) provides more uniform density of processed soundings across each swath but may compromise the imaging of vertical structures. Unbinned data gridded at 10, 20, and 30 cm demonstrate the tradeoff between grid size, data density, and apparent 'noisiness' of the resulting surface.

Vessel Configuration File

General

CARIS requires a HIPS Vessel File (HVF) describing the positions (and angles, as appropriate) of all sensors from which data must be integrated. HVF definition is the first step in any CARIS project, unless an HVF applicable for the survey is already available. Note that the HVF was called a Vessel Configuration File (VCF) in a previous version of HIPS, and 'VCF' is still referenced occasionally in the CARIS documentation.

Correct definition of the HVF is critically important for EdgeTech data because these systems utilize two transducer arrays which are treated independently in CARIS. The CARIS HVF coordinate system is X positive to starboard, Y positive forward, and Z positive downward. Rotation about these axes follows the right-hand rule: pitch (about the X axis) is positive with the bow up, roll (about the Y axis) is positive with the port side up, and yaw or azimuth (about the Z axis) is positive with bow rotation to starboard (compass convention). Note that these sensor installation attitude sign conventions may differ from those applied for attitude of the entire vessel reference frame, such as in vessel attitude data recorded by an onboard motion sensor.

Modifications to these installation angles (e.g., transducer angular offset calibration results) may be applied in the Transducer 1 and Transducer 2 fields of the HVF in a manner that is consistent with this CARIS sign convention.

Changes to the HVF

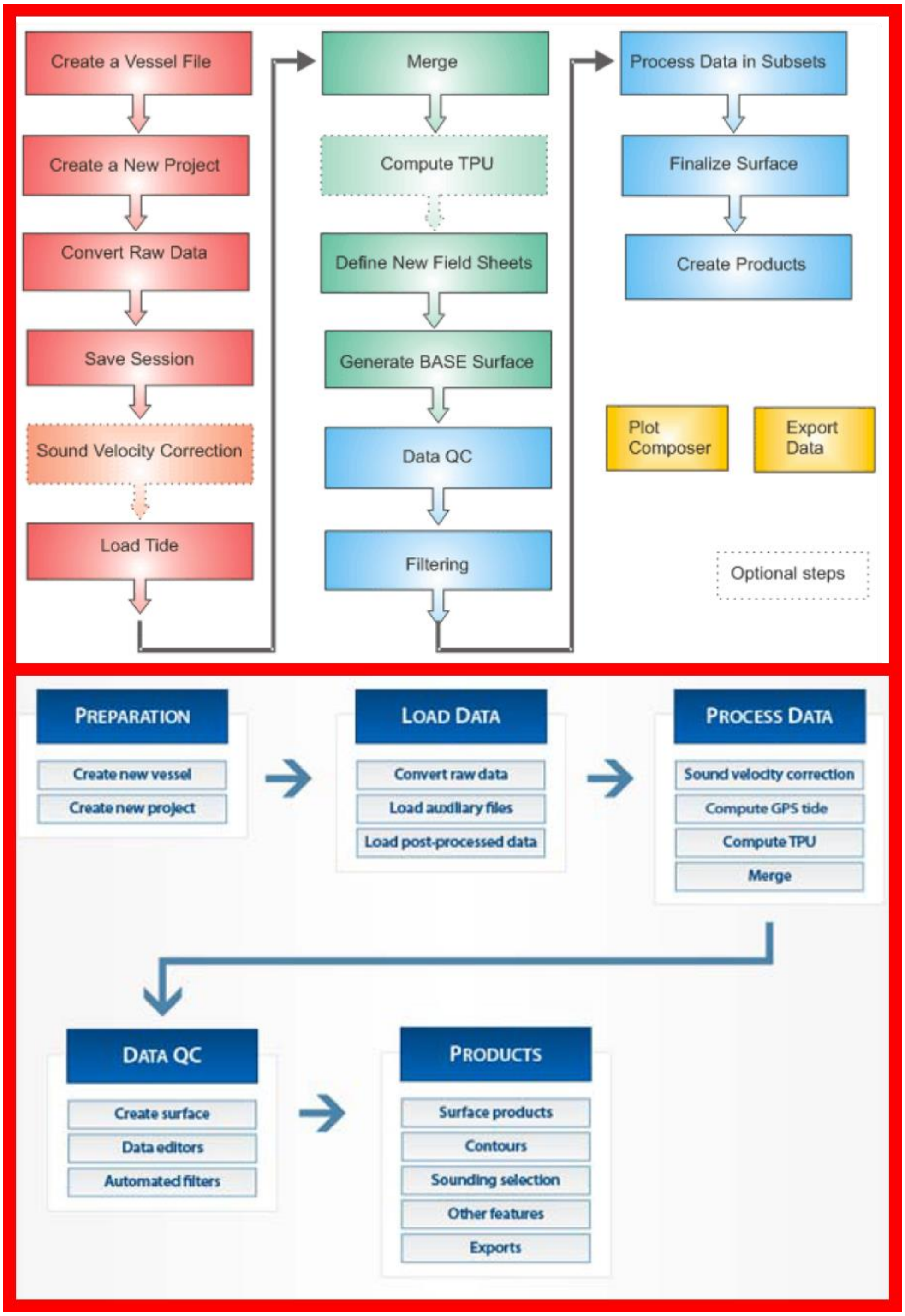
It is important to carefully manage the vessel configuration file. With care paid to the dates for each entry, multiple sets of setting can be specified in a single file to provide a running history of changes. Alternatively, separate vessel configuration files may be used, though this may require separate CARIS projects for each survey.

Some changes to the vessel configuration file require data to be reimported (attitude sensor latency, for example) whereas other changes do not (TPU parameters, for example). When in doubt, it is safest to reimport the data after any vessel file changes.

NOTE: Overlapping sensors (i.e., Transducer 1 and SVP 1 with the same linear offsets) may not be distinguishable in the CARIS Vessel Editor 3D view because the markers are the same size. Activation/deactivation may help distinguish overlapping markers, but may also lead to loss of entries in the vessel file. Be careful to keep at least one sensor active at all times or an error may result which removes all entries. Finally, be sure to activate all sensors required for the particular survey configuration and verify all offsets before saving the HVF and processing survey data.

Data Processing Workflow

The steps outlined in this guide follow the workflows for multibeam data with additional information specific to CARIS HIPS versions 8.1 and 9.0.



Data processing workflows as depicted in the CARIS User Guides for HIPS 8.1 (top) and 9.0 (bottom).

1. Create or Copy an HIPS Vessel File (HVF)

a. If an HVF exists for the data collected, it must be copied to *HDCS_Data/VesselConfig/* before it will be selectable during project creation. In some installations of CARIS, the *HDCS_Data/VesselConfig/* directory is not created by default; the user must navigate to the CARIS root directory and create it.

b. If no HVF exists, the user should consult the CARIS User Guide 'Create a New HVF' section and *Vessel Configuration File* above.

c. WARNING: Dates in the HVF must precede the data to be processed. Otherwise, the data import process will fail.

2. Create a New Project

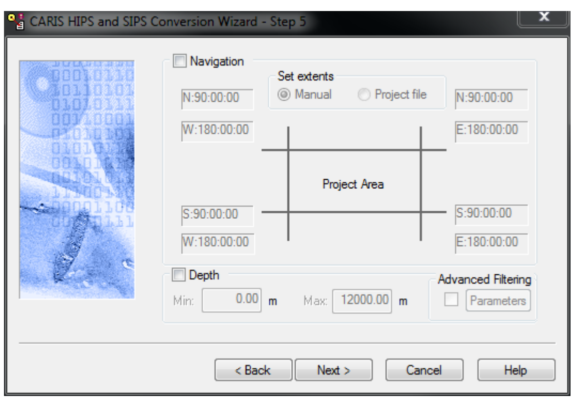
a. Establish the project-vessel-day directory structure.

3. Convert Raw Data

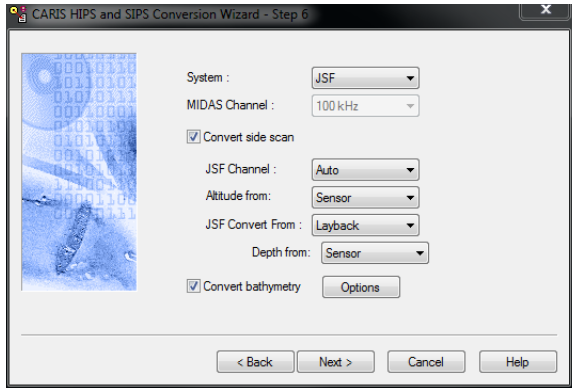
a. Using the Conversion Wizard, select *EdgeTech* for the data format

b. Filtering during import is an effective option for reducing outliers in PMBS data if the ranges of depths is known. Note that depth filters applied during data conversion are relative to the transducer and not relative to total water depth.

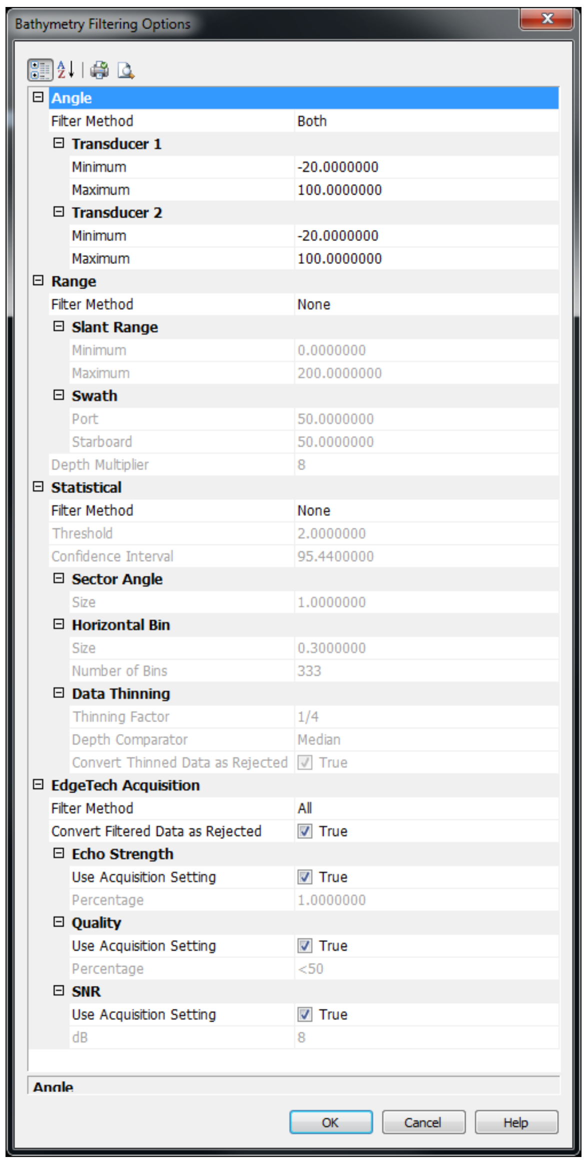
c. Select Navigation and/or Depth filters, if desired. The Advanced Filtering option is not available in Step 5 during data import, but other options exist for filtering data in JSF format in Step 6.



d. Ensure that 'Convert bathymetry' is checked in Step 6. Additional bathymetry filtering options are available under the Options button.



e. Bathymetry filtering options are broken into subcategories of Angle, Range, Statistical, and EdgeTech Acquisition.

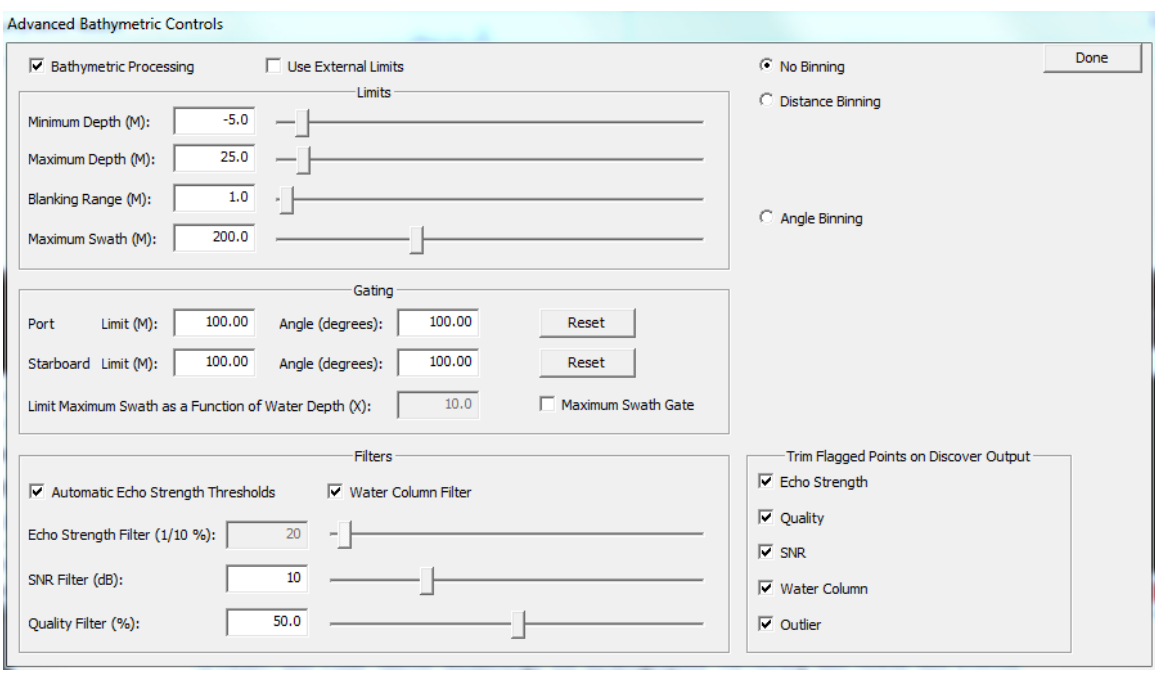


i. **Angle** filters should normally reflect the 200° nominal field of view of the EdgeTech sonar and be applied to both transducers using the 'Both' option under Filter Method. These ranges may be adjusted to eliminate arrival angles associated with multipath artifacts, for example.

ii. **Range** filters are applied by default according to a multiple of the nadir depth entered in the 'Depth Multiplier' field. Unless range-based artifacts exist in the JSF file (e.g., tracking the transmitter ring-down at close range or recording blunders at excessive ranges), the Range Filter Method should be set to 'None' to ensure maximum swath width in the converted data.

iii. **Statistical** filters may be applied to bin soundings in angle or acrosstrack range sectors, much like the binning options available in Discover Bathymetric during data pre-processing. Data thinning is applicable only when a binning method is selected.

iv. **EdgeTech Acquisition** filters remove data points based on any combination of SNR, quality value assigned by the sonar, or echo strength. The filters may be applied independently or in combination using custom settings or the settings used by Discover Bathymetric to flag suspect data during acquisition. In this example, all three filters in CARIS (above) are applied using the acquisition settings shown under the Advanced Bathymetric Controls in the Discover Bathymetric software (below).



f. See **Help → Help Topics → HIPS and SIPS Workflow → Convert Data → Options for Specific Formats → EdgeTech** and **… → Bathymetry Filtering Options** for more information.

g. NOTE: Screenshots in the CARIS Help documents do not always match windows.

4. Open Converted Files (Open Project)

5. Save Session

6. Load Delayed Heave (Optional)

a. Load post-processed heave data, if available, to reduce heave uncertainty.

b. This step is optional and no delayed heave is loaded in this example.

7. Load Delta Draft (Optional)

a. Load delta draft to provide additional correction for the vertical position of the vessel reference frame relative to the water surface.

b. This step is optional and may not be necessary for all data collection methods, such as from a surface vessel with reliable vertical position data. No delta draft is loaded in this example.

8. Load Tides

a. Loading tide data is a necessary step in the CARIS HIPS workflow.

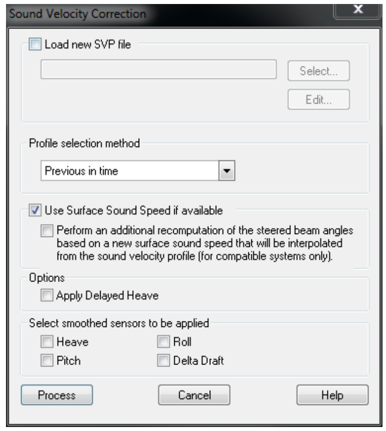
b. Select either a tide file (.tid) or a tide zone definition file (.zdf).

c. A zero-tide file (zerotide.tid) is available under HDCS_Data\Tide and may be applied when tidal amplitudes are negligible. Note that the dates in the tide file must cover the data time range. The default zerotide.tid file may be modified with any text editor to accommodate the data time range.

9. Sound Velocity Correction

a. Sound Velocity Correction (SVC) is typically performed to address refraction artifacts in multibeam or PMBS data. This step is not explicitly required if EdgeTech data are collected and processed in Discover Bathymetric with reliable sound speed information. For instance, the standard EdgeTech 6205 configuration includes a sound speed sensor at the transducer face. Sound speed at the transducer depth may suffice for the sound speed profile value in shallow, well-mixed environments. If the water column is not well-mixed in the survey area, additional sound speed profile information may be necessary to reduce refraction artifacts.

b. If performing SVC, the option 'Use Surface Sound Speed if available' should be checked. The option 'Perform an additional recomputation of the steered beam angles…' should be checked if the selected sound speed profiles are believed to be more reliable than the transducer-mounted sensor data for sound speed at the transducer depth.



10. Merge

a. The Merge process is required.

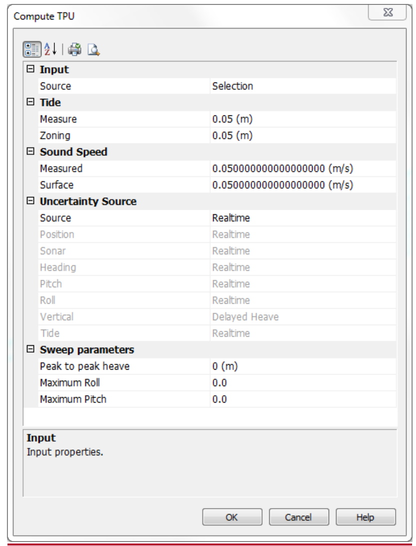
b. After merging, the raw data have been converted to HIPS format with corrections for vessel draft, attitude, tides, and refraction (including transducer installation angles) and are now ready for calculation of total propagated uncertainty and incorporation into a gridded surface.

11. Compute Total Propagated Uncertainty (TPU)

a. This step is required for creating a BASE surface using the Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm in CARIS HIPS 8.1.

b. NOTE: Echosounder uncertainty data are incorporated in EdgeTech 4600 files processed with Discover version 34.0.1.101. Echosounder uncertainty data in 6205 files are supported in Discover Bathymetric version 34.0.1.110 and higher.

c. Enter uncertainty values as appropriate for the data sources and ensure that the Uncertainty Source is set to 'Realtime' to incorporate echosounder uncertainty.



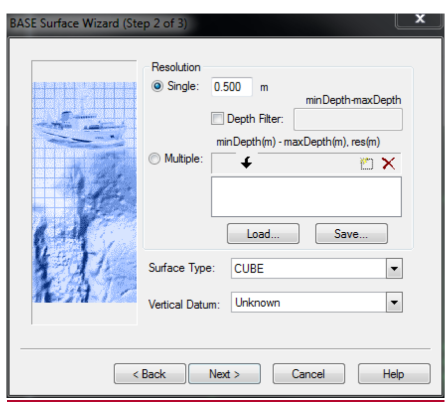
12. Create a Field Sheet

a. This step is required for creating a BASE surface in CARIS HIPS 8.1 but has been eliminated in HIPS 9.0.

13. Create a CUBE surface

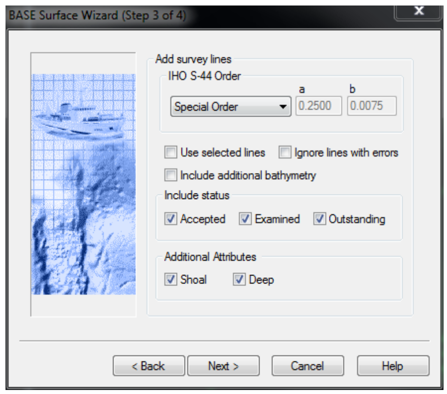
a. The CUBE algorithm is readily applied to PMBS data following the CARIS workflow. In CCOM experience, CUBE processing has handled large PMBS datasets and effectively rejected outliers to develop reasonable hypotheses for the majority of bathymetric surfaces, assuming the desired grid cell size is supported by the data density. As with multibeam datasets, manual inspection and additional sounding rejection or hypothesis selection may be necessary.

b. Depth filters may be selected during surface creation. Note that depth filter values are water depth rather than relative to the transducer (such as filters applied during data conversion).



a. Select the desired IHO specification. CUBE determines the range inside which soundings will contribute to a grid node by the criteria specified in the IHO specifications. For this example, data density is assumed to be sufficient to support Special Order.

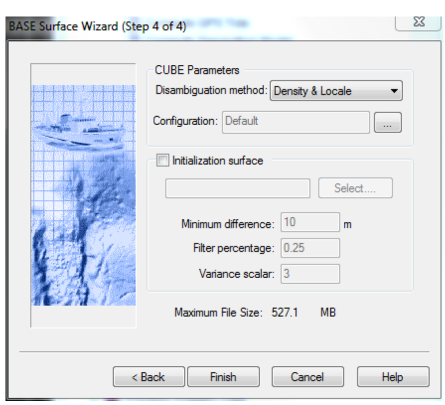
b. Select the 'Shoal' and 'Deep' options to create additional layers showing the shoal and deep hypotheses, which may assist in data cleaning.



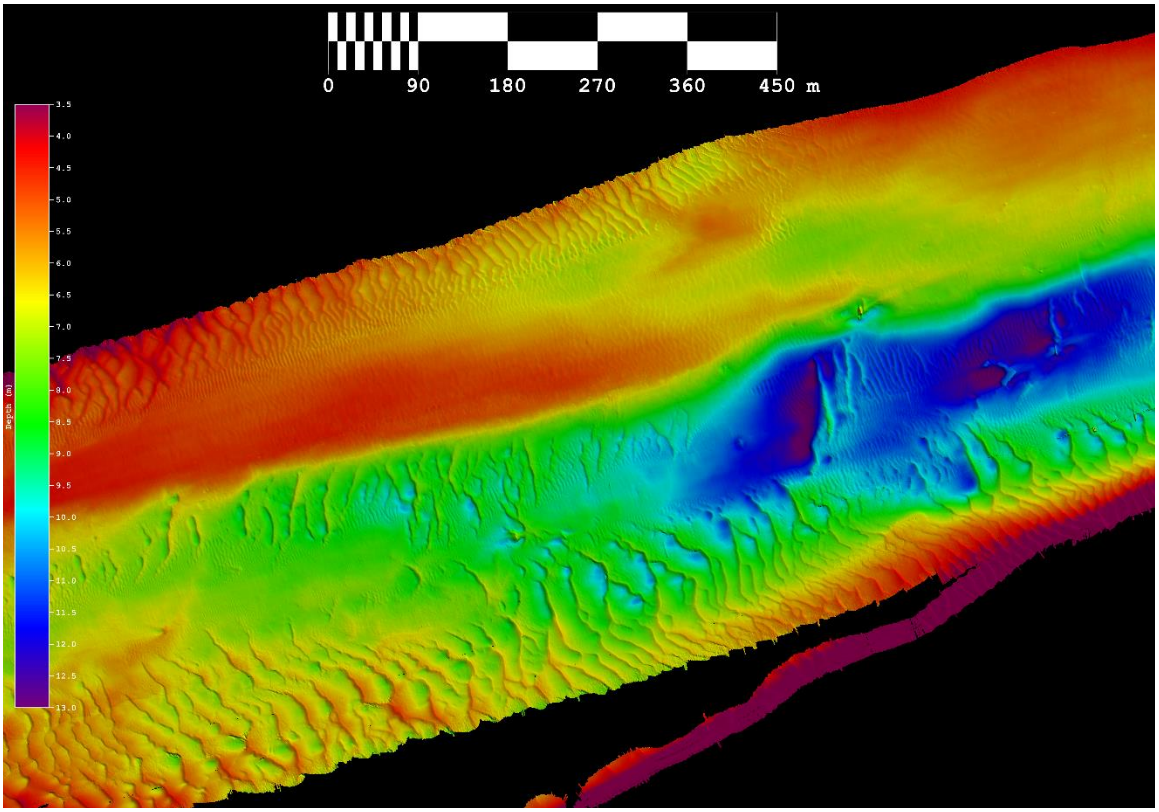
c. CUBE generates hypotheses depending on agreement among soundings contributing to a grid node, then applies a disambiguation algorithm to determine which hypothesis is the most likely to be acceptable for each node. CUBE makes this determination based on the number of soundings contributing to the hypotheses (density), the nearness of the hypotheses to those in adjacent grid nodes (locale), or a blending of the two methods. The blended option 'Density and Locale' is typically selected for most CUBE surfaces.

d. Uncheck 'Initialization surface' unless using an existing CUBE surface for disambiguation and/or additional filtering.

e. CUBE offers Advanced Options to optimize its operation or meet additional criteria. These options can be found under the **Configuration** ellipsis [...]. These parameters are typically left unchanged for routine CUBE processing.



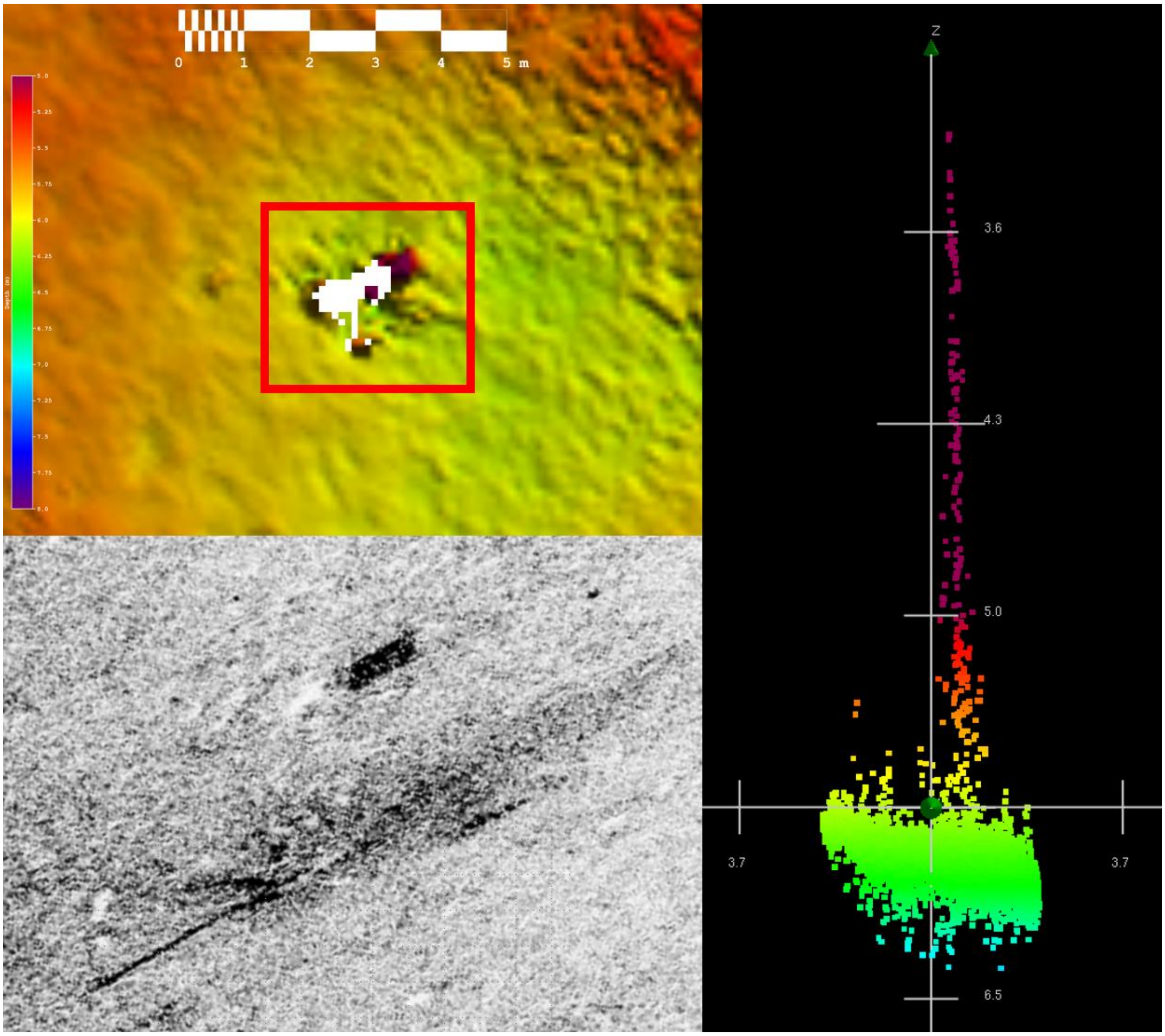
f. Click **Finish** to begin computing the CUBE surface.



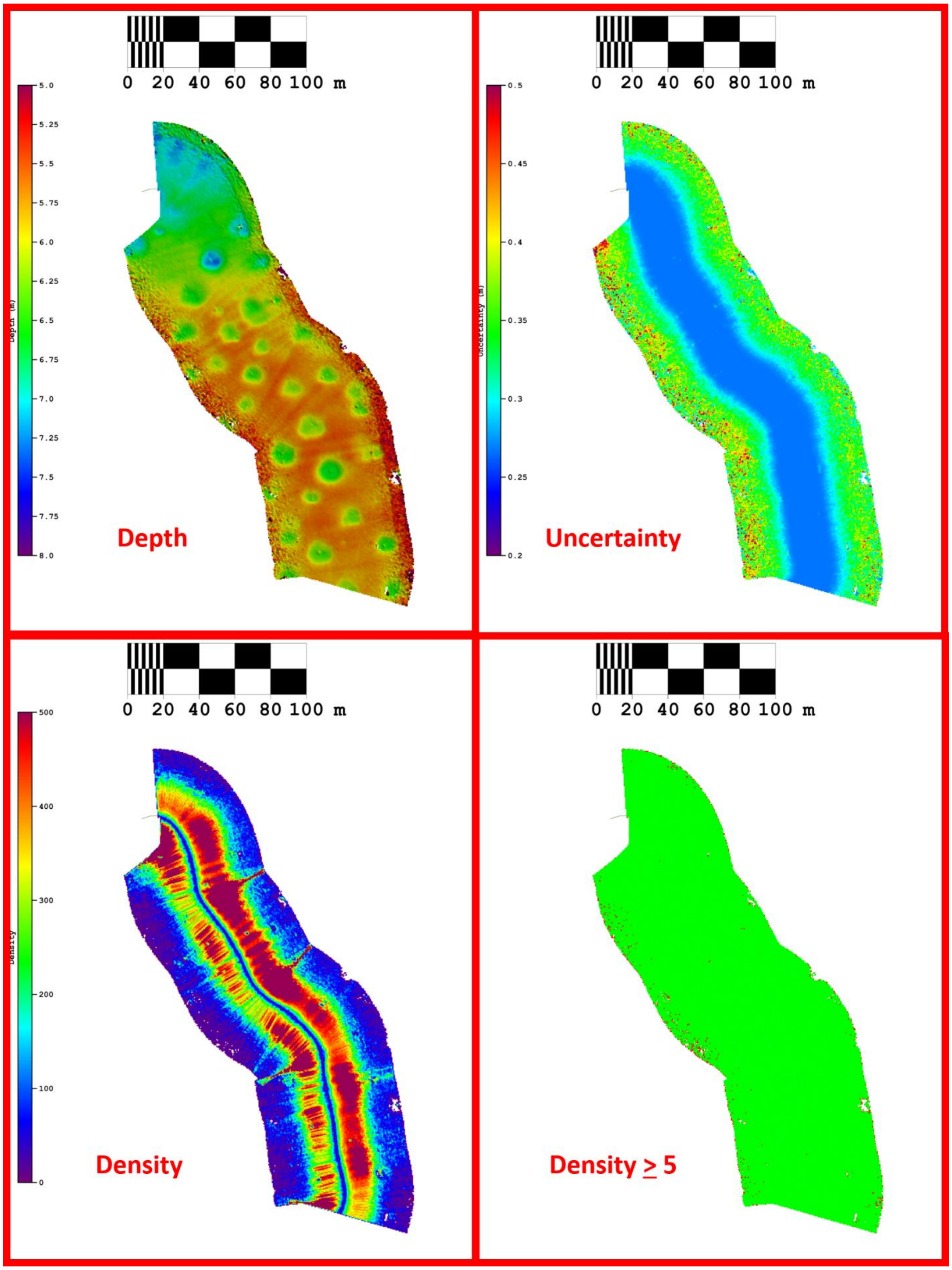
An example of EdgeTech 4600 PMBS bathymetry data collected near Fire Island Inlet, New York, and gridded at 50 cm resolution using the CUBE implementation in CARIS HIPS 8.1, as outlined in the workflow in this document. Extensive bedforms with amplitudes of 20-250 cm and wideranging wavelengths are readily apparent throughout the survey area. The color scale is 3.5 m (purple) to 13.0 m (dark blue). No manual inspection or rejection of soundings has been performed in CARIS. Acrosstrack swath coverage was typically eight to nine times the water depth and line spacing was three to five times water depth, resulting in half-swath overlap between adjacent survey lines over most of the survey area.

14. Data inspection and product creation

a. While raw PMBS data are likely to appear both higher in density and 'noisier' than multibeam data, inspection of the resulting surface and removal of outliers may be accomplished using the same tools. Swath Editor and Subset Editor are typically used for inspecting and editing the surface prior to final product creation. In tandem with these editors, the Side Scan Editor may prove useful in identifying features or hazards. The examples below include perspectives from the CUBE surface, Subset Editor, and Side Scan Editor over a mooring block on the seafloor and associated mooring chain leading to a surface buoy.



Examples of EdgeTech 6205 PMBS bathymetry and sidescan data collected on a SE-heading survey pass over a mooring block and chain in Portsmouth Harbor, New Hampshire. Data were pre-processed without binning in Discover Bathymetric and gridded at 10 cm using the CUBE algorithm in CARIS HIPS 8.1 (upper left image). The depth scale is 5 m (purple) to 8 m (dark blue). A subset of soundings on the mooring block and chain (upper left image, red box) are shown in a north-looking view (right image) using the same depth scale and 5X vertical exaggeration. This subset clearly depicts soundings on the mooring chain from the block to within approximately 3 m of the surface. Though not to scale or rigorously georeferenced, the 'waterfall' sidescan imagery (lower left image) has been rotated for vessel heading and aids in the identification of this feature. No manual inspection or rejection of soundings has been performed in CARIS.



An example EdgeTech 6205 survey line over a mooring field in Portsmouth Harbor meets NOAA requirements for sounding density and uncertainty across a large portion of the swath. The raw data were processed without binning in Discover Bathymetric version 34.0.1.110 and gridded at 50 cm, the finest resolution required by NOAA in this depth range, using the CUBE algorithm in CARIS HIPS 9.0. No manual editing has been performed. Bathymetry (upper left, color scale of 5 m to 8 m) appears generally free of artifacts out to 9-10 times water depth, beyond which a shoal bias is evident. Additional overlapping survey data would likely resolve these outer swath artifacts. Grid cells with uncertainty exceeding the 50 cm maximum allowable TVU in this depth range appear as purple in the uncertainty plot (upper right). Sounding density below the minimum of five soundings per grid cell appear as red in the density criterion plot (lower right). These results suggest suitability of a processing path with Discover Bathymetric and CARIS HIPS 9.0 to address NOAA reporting requirements for EdgeTech PMBS data.