



United States Department of Commerce
National Oceanic and Atmospheric Administration
Office of Coast Survey
Coast Survey Development Lab
Hydrographic Systems and Technology Programs



Processing Data with TCARI Tide Data

Standard Operating Procedure

11/26/2014

APPROVAL AND RECORD OF CHANGES:

Approval Authorities:

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Assigned Manager: ENS Charles Wisotzkey

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Report of Discrepancies:

Direct any questions about the information or processes described in this document to the Hydrographic Systems and Technology Programs office.

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1. PURPOSE

This document describes in detail how to apply TCARI data to bathymetric data and outlines a standard operating procedure that can be utilized by NOAA Field Units and Hydrographic Branches as a template for their own operating procedures.

2. SCOPE

The document is tailored specifically to assist NOAA Field Units and Hydrographic Branches in processing bathymetric data using TCARI tide data.

The procedures described here utilize the following software versions:

<u>Software</u>	<u>Version</u>
Pydro	14.6
CARIS HIPS	8.1.7
CARIS BASE Editor	4.0

The preferred and simplest method of applying TCARI tide data is with CARIS HIPS in conjunction with Pydro. The FetchTides or the NOAA Tides and Currents website may also be used to obtain appropriate water level data files. Use of FetchTides is described in Section 5 of this SOP.

Post all issues, questions, error messages, or desired enhancements/changes to <http://205.156.4.93/trac/wiki/TracNav/TOCTCARI>. HSTP of Office of Coast Survey is responsible for changes to and maintaining the TCARI program within PYDRO.

In the event an error is discovered, please contact the Hydrographic Planning Team (HPT, NOS.COOPS.HPT@noaa.gov). HPT will correct any problems and send a revised TCARI grid.

The HPT (NOS.COOPS.HPT@noaa.gov) within CO-OPS is responsible for creating and maintaining all TCARI grids to be used for hydrographic and photogrammetric surveys. The Office of Coast Survey and National Geodetic Survey field teams are responsible for proper application, quality control, and submittal of TCARI grids. CO-OPS and OCS are responsible for ongoing training and development of TCARI.

Additional information concerning TCARI tides can be found in Section 4.2.3.4.1 of the Field Procedures Manual (2014 edition).

3. OVERVIEW

Tidal Constituent and Residual Interpolation (TCARI) was designed by the Office of Coast Survey (OCS) for total water levels relative to Mean Lower Low Water (MLLW) at selected hydrographic survey areas along the coast by the spatial interpolation of tidal data. The model spatially interpolates the harmonic constants (used to predict the astronomic tide), tidal datums, and residual water levels (i.e., the non-tidal component or the difference between the astronomically predicted tide and the observed water level) using the values at a combination of operational and historical stations. The method works best in regions where there is an abundance of high quality tidal data surrounding the survey area. TCARI methodology has the potential to yield water level correctors with increased accuracy and reduced uncertainty

NOAA has investigated sophisticated water level interpolation schemes as part of the TCARI program. The objective has been to eliminate or reduce some of the drawbacks and uncertainties in using discrete tidal zoning, including the vertical "stepping" effects typically produced across hydrographic survey project areas, the use of an averaged time difference correction for both high and low waters, and the limitations of tidal zoning corrections in areas of large range and time differences and changes in tide type (i.e changes in the shape of the tide curve).

The use of TCARI, just as in discrete tidal zoning, requires the oceanographer to evaluate and understand the tidal characteristics of the survey areas. Success in either method requires information from historical tide stations and other sources. Gaps in information limit both methodologies. And both methodologies require tide stations to be in operation during survey operations. TCARI first requires the development of a model grid to cover the survey areas and then requires a spatial field of harmonic constants from historical stations for the interpolation instead of just the average time and range of tide required by tidal zoning. Finally, TCARI planning requires an analysis of the non-tidal residual across the survey area to determine the location and number of stations to be in operation during the survey. TCARI grid files, interpolation weighting functions, and harmonic constant files are created during planning and sent to the survey platform. Survey vessels must obtain the observed data from the specified tide stations during the survey so that TCARI can apply the interpolated water level residuals in the process.

4. PROCEDURE: DOWNLOAD AND APPLY TCARI TIDES IN PYDRO

4.1 Overview of Procedure

TCARI tide correctors need to be loaded through NOAA’s Pydro program. CARIS is used to convert raw data, Pydro is used to apply TCARI tide correctors, and CARIS is again used for subsequent data processing.

The procedure assumes as a starting point that the user has already converted raw data using CARIS HIPS and has set-up a proper HDCS data structure.

4.2 Obtain the required tide files

A TCARI file (.tc) file will be provided by CO-OPS and disseminated with the **Project Instructions** as project data. The TCARI file will enable Pydro to download water level data from required residual stations automatically. Tide stations to be used when processing TCARI tide data will also be listed as ‘Residual Water Level Stations’ in the **Water Level Instructions Project** document disseminated with the Project Instructions.

For examples:

1.3.6. Residual Water Level Station(s) Data

Tidal Constituent And Residual Interpolation (TCARI) method uses harmonic constituents and residuals from historical and operating water level stations to provide precise water level correction for bathymetric surveys. Download the Preliminary/Verified data at following water level station(s) data for all periods of survey.

The operating stations at Port Townsend, WA (9444900) and Seattle, WA (9447130) will provide residuals for this project and must remain in operation during all periods of hydrography.

<u>Station Number</u>	<u>Station Name</u>	<u>Latitude(N)</u>	<u>Longitude(W)</u>
9444900	Port Townsend, WA	48 ° 06.7'	122° 45.5'
9447130	Seattle, WA	47 ° 36.2'	122° 20.4'

The dates of survey for the example will be from 05/01/2012 to 05/15/2012.

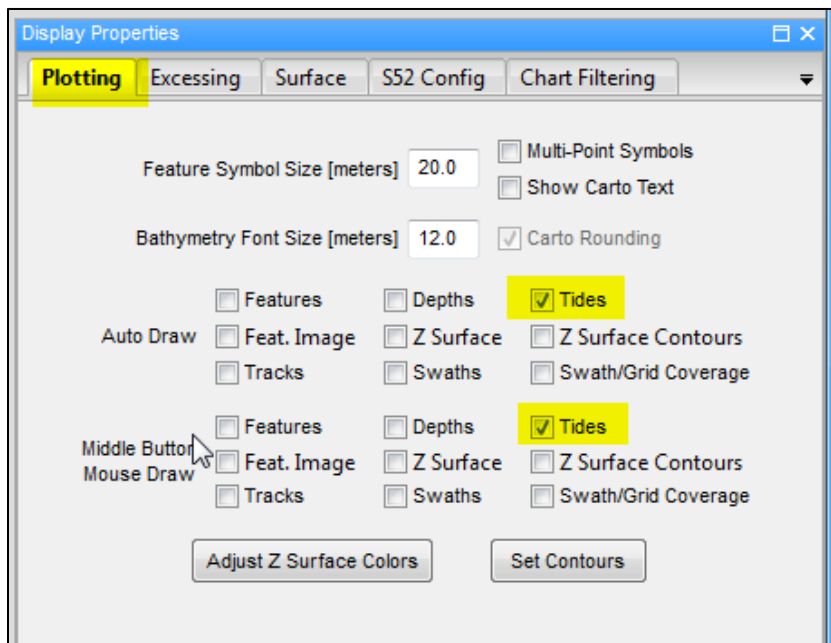
4.3 Ensure proper directory structure

The **Tides** directory in your CARIS directory structure will hold the TCARI data file (.tc file extension) and the water level data files for the required residual water level stations (.tid file extension).

4.4 Open Pydro

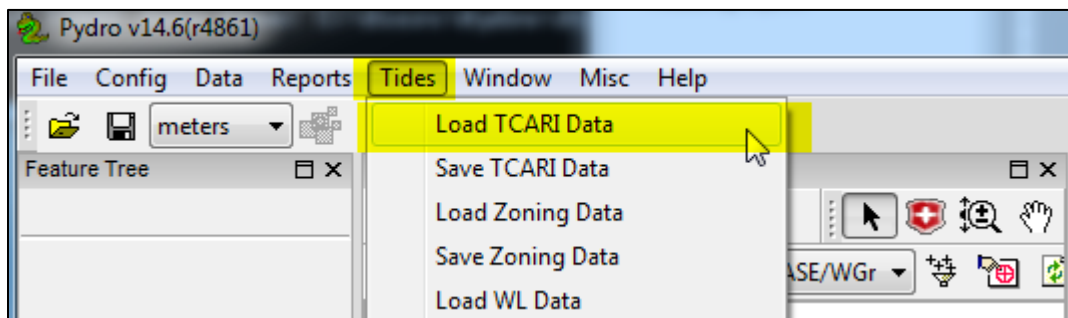
4.5 Set the Display Properties to view the TCARI grid

Right click on the main **Chart Window**, which will still be blank. Click on **Display Properties**. A window will appear in the Pydro GUI window. Check the **Tides** boxes under both the **Auto Draw** and **Middle Button Mouse Draw** groups in the **Plotting** tab.

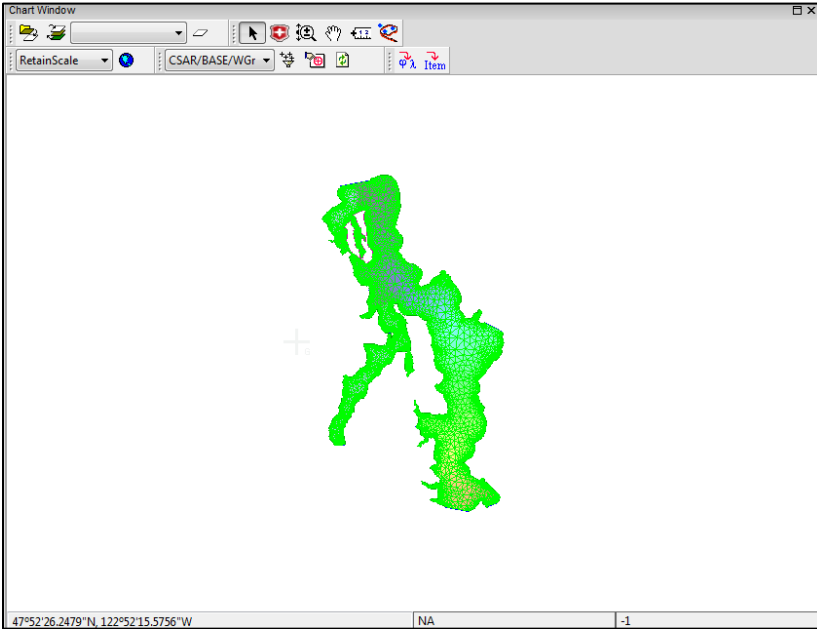


4.6 Load the TCARI data

Navigate from the menu bar to **Tides > Load TCARI Data**. Select and load the project TCARI data file (.tc file extension).



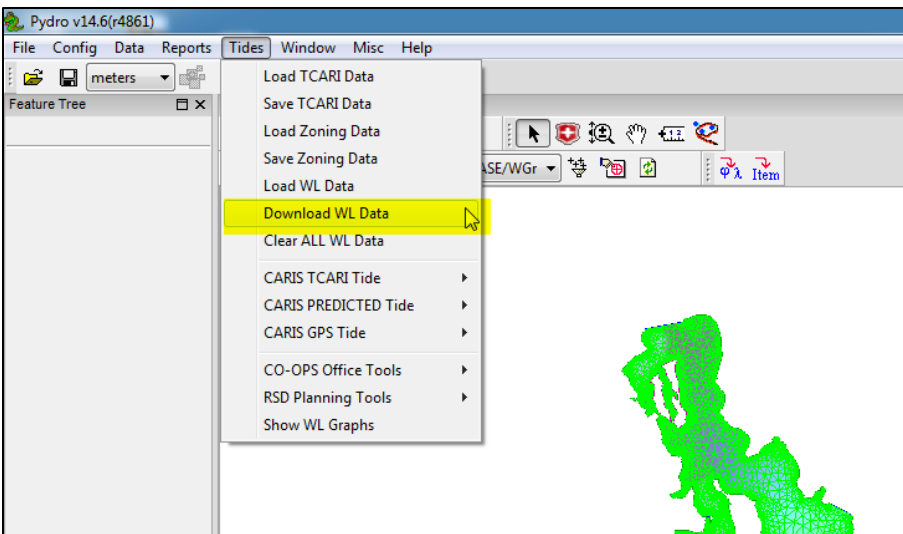
Use your mouse wheel to refresh the **Chart Window**. The TCARI grid should appear.



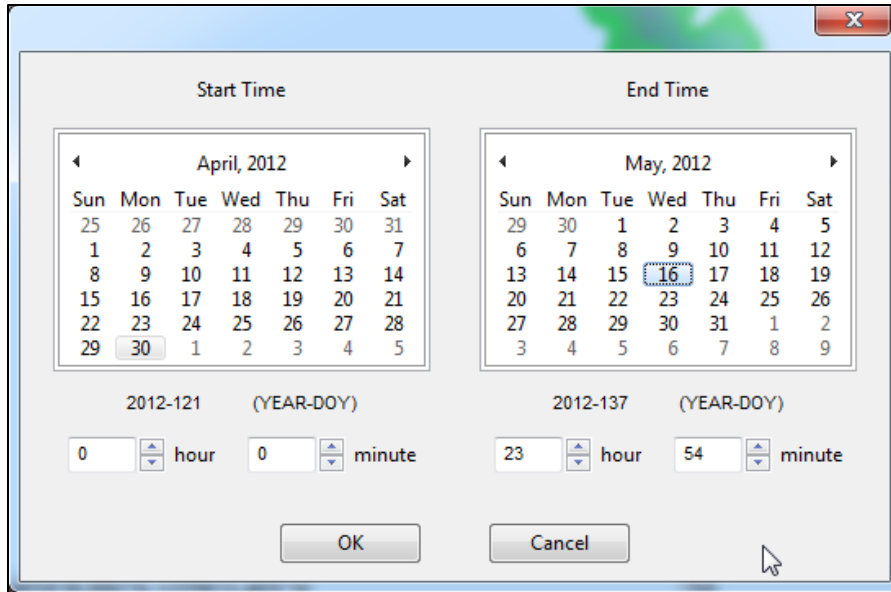
4.7 Download the water level data for the residual stations

Pydro is used to automatically download the required water level data for the residual tide stations in the workflow described in this procedure. The same data may be obtained for individual tide stations through the use of the Pydro FetchTides tools; this process is described in Section 5 of this SOP.

Navigate from the menu bar to **Tides > Download WL Data**.



Select the correct type of water level data in the **Water Levels Choice** window. Select the dates of survey for the survey data.

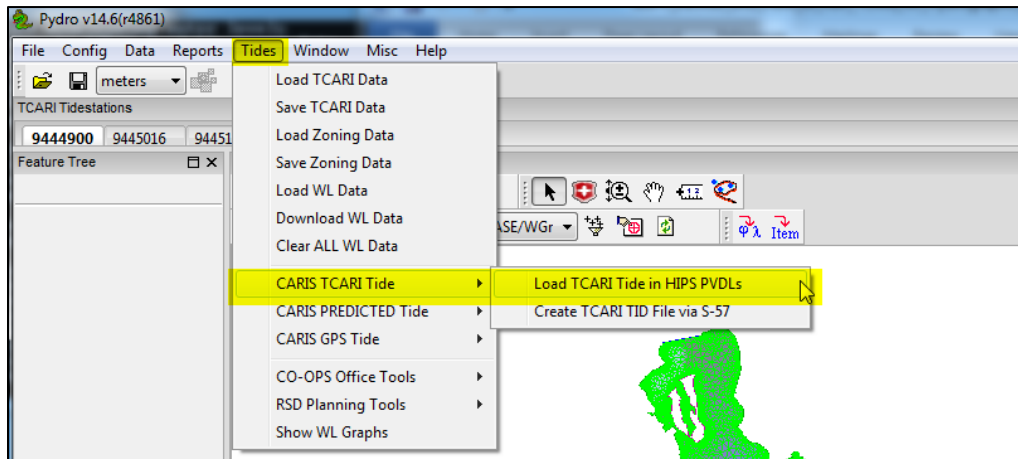


The water level data for the required residual water level data will automatically be downloaded and loaded.

Water level graph data may be viewed for QC purposes. Navigate from the menu bar to **Tides > Show WL Graphs**.

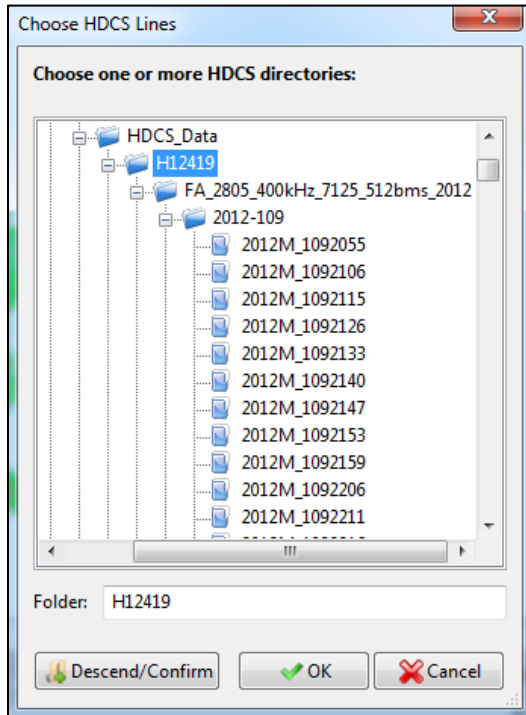
4.8 Load the TCARI water level data to the CARIS HIPS project HDCS data

Navigate from the menu bar to **Tides > CARIS TCARI Tide > Load TCARI Tide in HIPS PVDLs**.



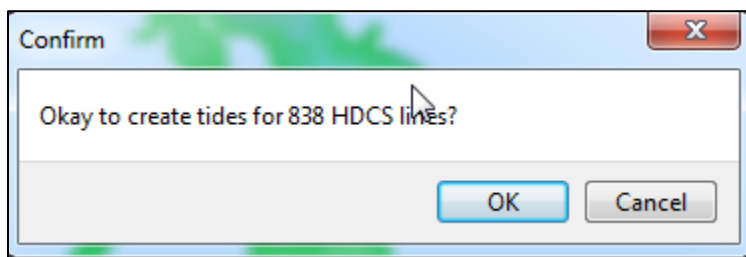
The **Choose HDCS Lines** will appear. Note the 'check box' selection method is no longer utilized in recent version of Pydro. Choose the data to apply the TCARI tide data to by selecting the highest level directory of the appropriate directory and then clicking on the **Descend/Confirm** button. Once the confirmation process has completed, click **OK**.

In the example below, the TCARI tide data will be loaded to all vessels and all days.



Individual vessels or individual days may also be selected by the same process using the appropriate directories.

Click **OK** when the **Confirm** window appears.



A text log file will appear when the data has been applied. CARIS HIPS should be used to examine the HDCS Project data to ensure that tide data has been properly applied.

5. PROCEDURE: DOWNLOAD TIDE DATA WITH PYDRO FETCHTIDES

5.1 Obtain the required tide files

A TCARI file (.tc) file will be provided by CO-OPS and disseminated with the **Project Instructions** as project data. Tide stations to be used when processing TCARI tide data will be listed as ‘Residual Water Level Stations’ in the **Water Level Instructions Project** document disseminated with the Project Instructions.

In this document the following tide stations will be used for examples:

1.3.6. Residual Water Level Station(s) Data

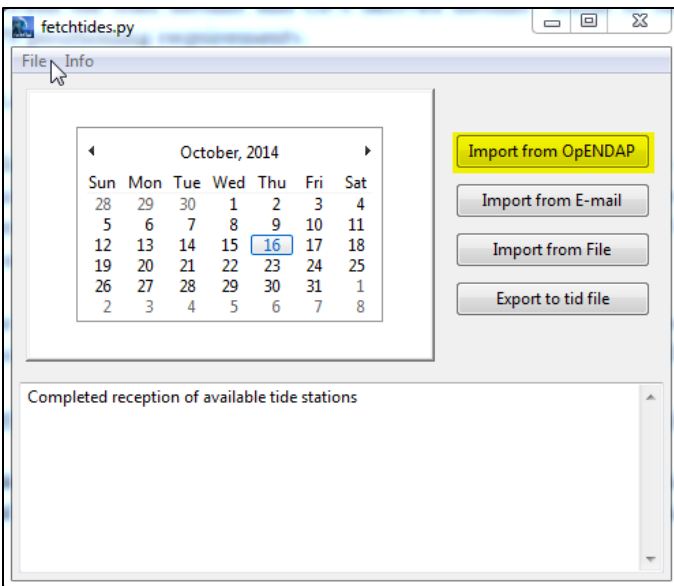
Tidal Constituent And Residual Interpolation (TCARI) method uses harmonic constituents and residuals from historical and operating water level stations to provide precise water level correction for bathymetric surveys. Download the Preliminary/Verified data at following water level station(s) data for all periods of survey.

The operating stations at Port Townsend, WA (9444900) and Seattle, WA (9447130) will provide residuals for this project and must remain in operation during all periods of hydrography.

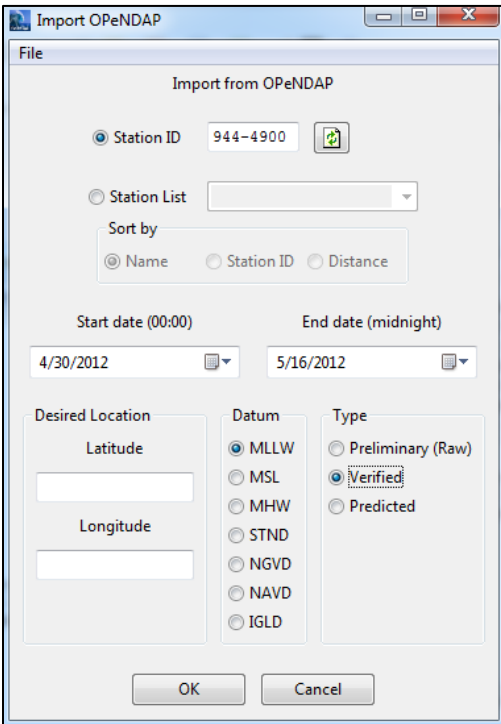
<u>Station Number</u>	<u>Station Name</u>	<u>Latitude(N)</u>	<u>Longitude(W)</u>
9444900	Port Townsend, WA	48 ° 06.7'	122 ° 45.5'
9447130	Seattle, WA	47 ° 36.2'	122 ° 20.4'

The dates of survey for the example will be from 05/01/2012 to 05/15/2012.

5.2 Click on Import from OpENDAP:



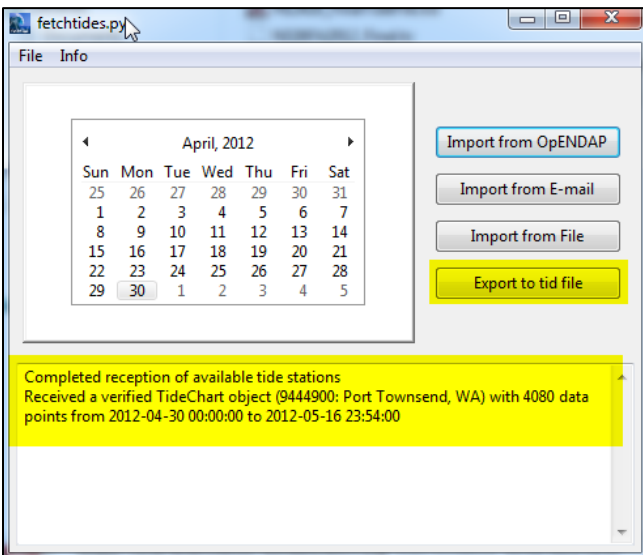
5.3 Fill in the Station ID, Start date, End date, Datum, and Type



Note here that we ‘padded’ the period of survey with one day before and one day after the actual period of survey.

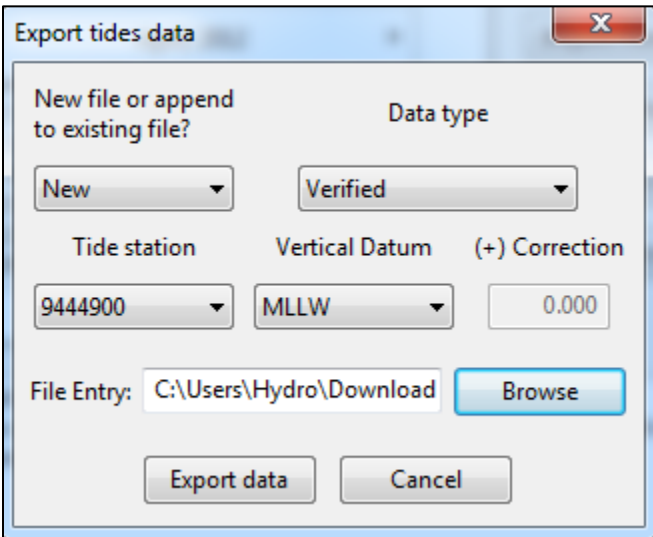
Click **OK**.

A confirmation message should populate the FetchTides message window:



5.4 If successful, click **Export to tid file**

The **Export tides data** window will appear. Here you may export set the export options. In the example below we are creating a new verified tides (.tid) file for station 9444900 and exporting as **9444900_verified.tid**.



5.5 Repeat the process for all residual stations

6. CO-OPS - TCARI FREQUENTLY ASKED QUESTIONS:

6.1 What do we do when a gauge contributing residuals goes out?

Answer:

Email NOS.COOPS.HPT@noaa.gov for suggestions. Part of CO-OPS job during our analysis, is to determine which gauges must be operating during the time of the survey. This is similar to what we do for discrete zoning. Solutions are created for each gauge combination that we deem suitable. If, for example we have 2 gauges contributing residuals in the central part of Chesapeake Bay, CO-OPS decides if one of these goes out, is the remaining gauge suitable for residuals for the entire survey. If the answer is yes, then we set up TCARI to re-compute solutions on the fly if data for the dropped gauge is not loaded. If we decide that both gauges must be running, TCARI will give error messages if data from the one gauge is not loaded.

6.2 How do I know if TCARI is correct? How can I QC my results?

Answer:

It is CO-OPS' responsibility to ensure that a TCARI grid sent to OCS will generate tide correctors within the tide error tolerance of Hydrographic Survey Specifications and Deliverable (HSSD) in the survey area. If the field believes there is a problem with the results they are seeing in TCARI, please alert CO-OPS HPT team. Below is a basic description of our QC process.

Once we have computed solutions, we find a historical 6-minute station or pick a spot in the survey area, and plot the TCARI generated tide curve at that location. We then plot this against the observed water levels or what the discrete zoning is at that same location. See example in Chesapeake Bay (Figure 13).

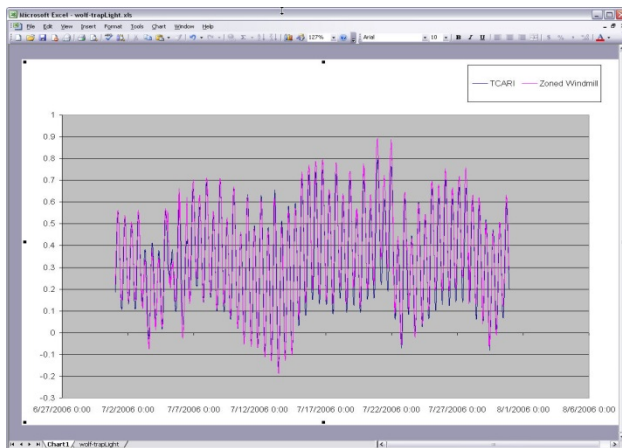


Figure 13. The TCARI results at Wolf Trap Light versus zoning off Windmill Point at Wolf Trap Light.

The plot shows the TCARI results at Wolf Trap Light versus zoning off Windmill Point at Wolf Trap Light. The average difference between these 2 curves is .029m (.09ft). The largest discrepancies (~.1m) exist during weather events, where our zoning has a difficult time.

CO-OPS performs this analysis or spot checks in several locations inside the survey area. The field units can also compare bathymetric surfaces using both TCARI and discrete tidal zoning for a QC check.

6.3 Do I have to make a request for Final Tide Zoning if I am using TCARI?

Answer:

Yes, the field needs to submit a request for Final Tides (“Smooth Tides”), just as you do for discrete zoning. Create a Request for Smooth Tides using Pydro. Send us the times of hydrography and the project information. PLEASE MAKE SURE THAT SOMEWHERE IN THE BODY

OF THE EMAIL OR THE SUBJECT HEADER, THAT YOU STATE A TCARI GRID WAS USED. This will help CO-OPS keep track of who is using what method.

Once CO-OPS receives the request, we will retrieve the grid we sent you. We load the verified water Level data during the times of hydrography for that survey, and perform spot checks again. If there are no discrepancies, then CO-OPS will send the ship a tide note stating that the preliminary TCARI grid can be used as the final grid.

If we find any problems, or if the ships has surveyed completely outside the grid sent, or has surveyed in an area where a gauge should have been installed, or if there were multiple gauge outages during the survey, then CO-OPS will re-evaluate, and either send a revised grid, or if the problems are extreme enough, other options may need to be explored.

6.4 Can we survey anywhere in a grid even if it is outside our proposed survey area?

Answer:

No. Sometimes TCARI grids cover larger areas than discrete zoning. But each grid is tailored to the specific area you are working in. Depending on where you are surveying, subordinate gauge installations may be required. Unless CO-OPS is aware of the changed survey area, the survey vessel runs the risk of surveying without the appropriate tide control. Please please submit a revised project request through tri-office sharepoint site (<http://business.nos.noaa/NavSvs/Shared%20Documents/Forms/AllItems.aspx>). if survey areas have been changed.

7. OBTAIN WATER LEVEL DATA ON THE TIDES AND CURRENTS WEBSITE

The following information is provided by CO-OPS on how to obtain water level data:

All of these may be accessed from the (<http://tidesandcurrents.noaa.gov/>); under the "**Products**" tab, using the following links.

1) "[Water Levels](#)" -- On the "Water Levels - Station Selection" page select the "Active & Historic Stations" tab. On the "Historic Water Levels - Station Selection" page, you can either enter in the station identification number for your station or search by state. After selecting a station, the interface allows the retrieval of water level data observed at the station selected. To retrieve High/Low water level data, change the "Interval" to H/L which stands for High/Low.

Please note, most stations are not continuously operated. The majority of station are operated to support a specific project, program or study. Once that project ends, the station is removed.

Above the plot there is a tab/drop down menu called "Station Info", click on "Station Info" and select "Data Inventory". The "Data Inventory" will display the time series of collected data for each product produced from the station.

- 2) "**IOOS Data Portal**" -- then selecting the link for "[CO-OPS SOAP Web Services](#)". This section of our website is designed for allowing a "download" of data. This section provides txt, html, xml, and SOAP data formats. There is also information on creating a Java script using predefined data queries to access/retrieve data. The "Try Me" link next to any data type provides a simple user interface for retrieving data.
- 3) "**IOOS Data Portal**" -- then selecting the link for "[CO-OPS OPeNDAP server](#)". This section of our website is more designed for allowing a "download" of data. This sections provides txt, DDS, and DAS data formats.
- 4) "**IOOS Data Portal**" -- then selecting the link for "[CO-OPS SOS](#)". This section of our website is more designed for allowing a "download" of sensor data. Select for the "Offering" as a "Single", Time Event as "Time Series", select a "Product" from the drop-down menu, "Output format" select CSV, TSV, XML or KML, and the rest of the options are self explanatory.
- 5) "[CO-OPS Data API](#)" -- This section of our website provides means for developing a URL query (API) that will retrieve data from our database.

To prevent numerous large data requests slowing data access through the internet services; ALL internet data services have limits on the amount of data which can be retrieved per request. These limits are based on the interval of data requested.

** 6-Minute Interval data is limited to 1 month of data **

** Hourly Interval data is limited to 1 year of data **

** High/Low data is limited to 1 year of data **

** Monthly Means data is limited to 200 years **