
Sound Speed Manager Documentation

Release 2017.0.0

CCOM/JHC,UNH & CSDL,NOAA

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CHAPTER ONE

IN BRIEF

This package is part of the [HydrOffice](#) framework.

HydrOffice is a research development environment for ocean mapping. It provides a collection of hydro-packages, each of them dealing with a specific issue of the field. The main goal is to speed up both algorithms testing and research-2-operation.

This package provides both a library and an application with functionalities to manage sound speed profiles, and to provide pre-processing ocean mapping tools to help bridge the gap between sound speed profiling instrumentation and multibeam echosounder acquisition systems.

It has been developing with the aim to merge together functionalities present in several applications that process sound speed profiles (SSP) for underwater acoustic systems:

- *Velocipy*, an application originally developed at the [NOAA Coast Survey Development Laboratory \(CSDL\)](#) as part of the Pydro environment.
- *SVP Editor*, an application originally developed at the [Center for Coastal and Ocean Mapping \(CCOM, UNH\)](#) for the MAC project ([Multibeam Advisory Committee](#)) under the NSF grant 1150574.
- *SSP Manager*, an application developed at the [Center for Coastal and Ocean Mapping \(CCOM, UNH\)](#) as part of the HydrOffice framework.

In the integration of all these implementations to the current package several improvements have been introduced to enhance code maintainability, as well as to also to support Python 3 (from the original Python 2 only implementation) and to store the collected data for further processing and analysis.

Operation modes

Currently, the hydro-package can operate in two mutually exclusive operation modes:

1. *Operator Mode*
2. *Synthetic Profile Server Mode*

The *Operator Mode* represents the primary mode, and it is used to convert data from different source formats, to graphically edit them, and to export/send the resulting profiles for use by underwater acoustic systems. Optional steps are the augmentation with measurements from a reference cast (to either improve salinity modeling or extrapolate the cast to the required depth), either manually specifying a loaded profile as reference cast, or deriving the reference from oceanographic models (currently, WOA09, WOA13 and RTOFS) as described in [Appendix A - Oceanographic Atlases](#).

The *Synthetic Profile Server Mode* was developed to deliver WOA/RTOFS-derived synthetic SSPs to one or more network clients in a continuous manner, enabling opportunistic mapping while underway. Given the uncertainty of such an approach, this mode is expected to only be used in transit, capturing the current position and using it as input to lookup into the selected oceanographic model.

Currently implemented features

- Import of several commonly used sensor/file formats:
 - Castaway (.csv)
 - Digibar Pro (.txt), and S (.csv)
 - Elac Hydrostar (.sva)
 - Idronaut (.txt)
 - ISS Fugro (.svp, .v*, .d*)
 - Kongsberg Maritime (.asvp)
 - SAIV (.txt)
 - Seabird (.cnv)
 - Sippican XBT, XSV, and XCTD (.EDF)
 - Sonardyne (.pro)
 - Turo XBT (.nc)
 - University of New Brunswick (.unb)
 - Valeport Midas, MiniSVP, Monitor, and RapidSVT (.000, .txt)
- Network reception of data from:
 - Kongsberg Maritime SIS
 - Sippican systems
 - Moving Vessel Profiler (MVP) systems
- Data visualization and interactive graphical inspection (e.g., outlier removal, point additions) of sound speed, temperature and salinity profiles
- Use of the World Ocean Atlas of 2009/2013 (WOA09/13) and Real-Time Ocean Forecast System (RTOFS) for tasks such as:
 - Salinity augmentation for Sippican XBT probes
 - Temperature/salinity augmentation for Sippican XSV probes and SVP sensors
 - Vertical extrapolation of measured profiles
 - Creation of synthetic sound speed profiles from the model of choice
- Augmentation of sound speed profile surface layer with measured surface sound speed (from Kongsberg SIS or manually)
- Designation of a reference profile, for example from a deep CTD, for use in tasks such as:
 - Salinity augmentation for Sippican XBT probes
 - Temperature/salinity augmentation for Sippican XSV probes and SVP sensors
 - Vertical extrapolation of measured profiles
- Export of several file formats:
 - Caris (.svp) (V2, multiple casts supported)
 - Comma separated values (.csv)

- Elac Hydrostar (.sva)
- Hypack (.vel)
- IXBLUE (.txt)
- Kongsberg Maritime (.asvp)
- NCEI (.nc)
- QPS (.bsvp)
- Sonardyne (.pro)
- University of New Brunswick (.unb)
- Network transmission of processed casts to data acquisition systems (see *Appendix B - Connection Settings*):
 - Kongsberg Maritime SIS
 - QPS QINSy
 - Reson PDS2000
 - Hypack
- Persistent storage of collected SSP data in a SQLite database

USER MANUAL

Installation

Requirements

Note: If you download the frozen application ([from the download page](#)), you don't need to care about dependencies (and may just skip this section).

If you decide to install the package in a Python environment, the dependencies are:

- `basemap`
- `gdal`
- `gsw`
- `matplotlib`
- `pillow`
- `netcdf4`
- `numpy`
- `pyproj`
- `pyserial`
- `PySide` (*only for the application*)

If you want to install the last stable version (from PyPI):

- `pip install hydroffice.soundspeed`

Or, if you prefer the last bleeding edge code:

- `pip install https://github.com/hydroffice/hyo_soundspeed/archive/master.zip`

Configurations

Suggested configurations

Given its specific aim, *Sound Speed Manager* is usually installed to run in one of two configurations:

On the machine used for sound speed profile acquisition

This represents a quite common choice since many of the operations accomplished in the software are typically done immediately after acquisition of a cast.

If the machine is on the same network as the multibeam acquisition workstation, the processed profile can be directly delivered via network.

When this is not possible, the package can export the processed data to files that can then be manually uploaded to the multibeam workstation.

On the multibeam acquisition workstation

This configuration is particularly useful when it is anticipated that the software will run in *Server Mode*. In fact, it is important that multibeam watch standers are able to monitor the server, and to disable it in the event that a measured profile is to be uploaded.

Upgrading

It is possible to copy configuration settings from a previous installation. When a new installation is performed, the user is prompted to select existing configuration settings (if any).

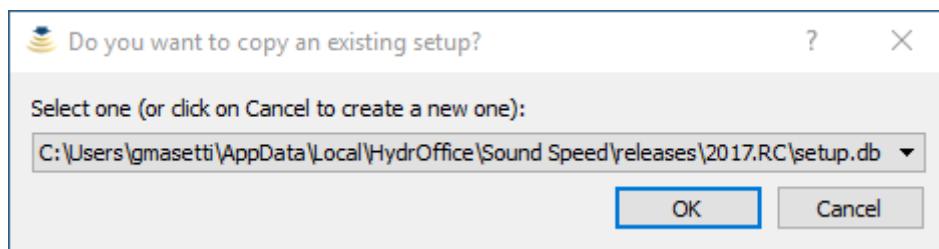


Fig. 2.1: Select the desired setup and click on the *OK* button to copy an existing setup.

Space requirements

Approximately 500 MB of additional disk space is required for the WOA09 db set optionally required (but warmly suggested) by this hydro-package. If not available, the package will attempt to download it.

Alternatively, it is also possible to manually download, unpack the WOA09 data set, and modify the configuration file to point to the correct path (see *Package configuration*).

Among other improvements, the WOA13 db provides a much better spatial resolution, but this comes with a much larger data size (~18 GB).

Note: If a previous version of the application was installed, *Sound Speed Manager* will try to localize already installed WOA databases (WOA09 or WOA13).

Package configuration

In the *Sound Speed* release data folder, you can find a configuration file: `setup.db`.

This SQLite database file has to be modified to reflect the chosen software deployment and environment-specific configuration settings (e.g., the SIS IP address and ports).

Use the *Setup* tab to view the available configuration options in the database. If you want to modify them, click on the ‘Lock/Unlock’ button.

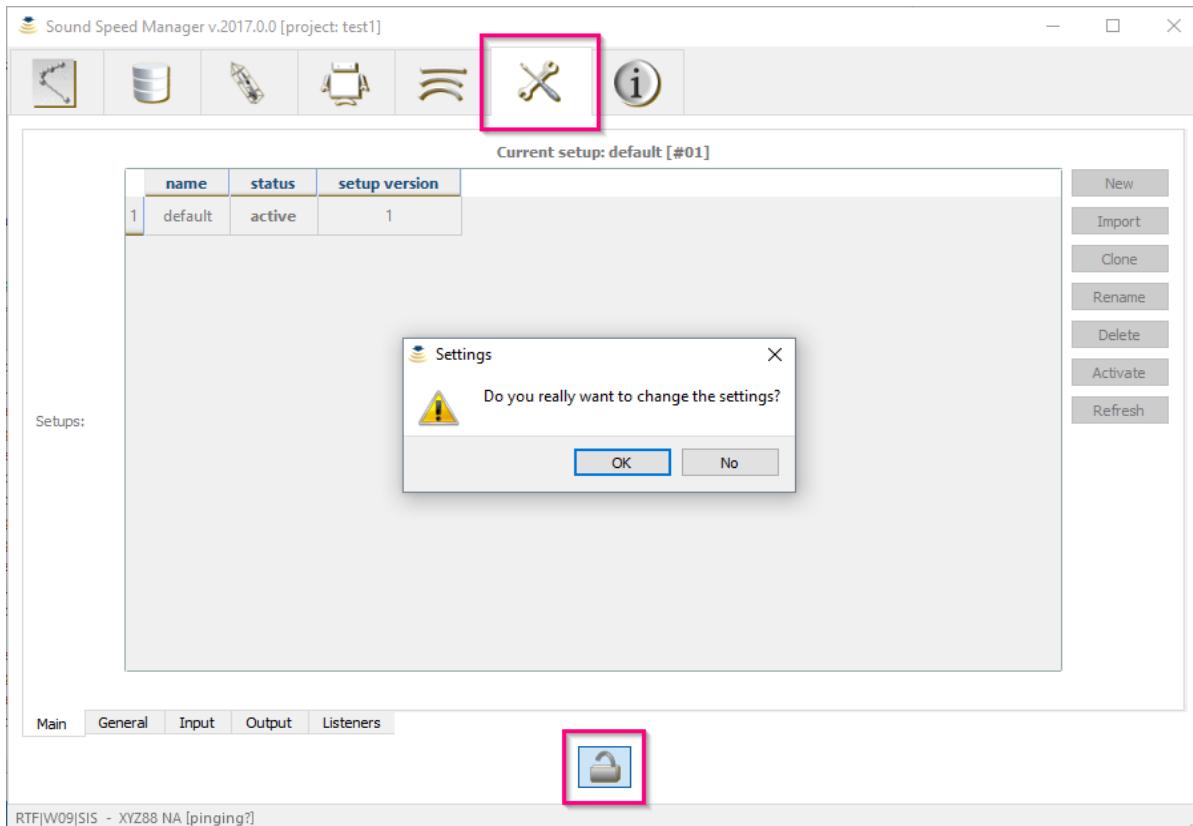


Fig. 2.2: You will be asked to confirm that you want to modify the setup.

Warning: If you want to use the RTOFS data, Internet (and the port 9090) must be accessible from the machine in use.

Sound Speed Manager - SIS interaction

In order to automatically interact with *Kongsberg SIS*, some initial configuration are required on the *SIS* side to make it to broadcast a specific subset of datagrams that can then be interpreted by the *SSP* hydro-package (identification codes in parentheses):

- **Position** ('P', 80, 0x50): for retrieving current date and position
- **Sound Speed Profile** ('U', 85, 0x55): checking whether a SSP transmission was successful
- **XYZ88** ('X', 88, 0x58): to retrieve:
 - The surface sound speed (used in beam forming and steering) and the transducer draft (both used when augmenting SSPs with the measured surface sound speed value).

- The depth (to estimate the approximate water depth). This is used in the sound speed, temperature and salinity plots to help the user appreciate the minimal depth to which the profiles should be extended.

Kongsberg *SIS* can be configured to broadcast datagrams in three different ways as discussed in the next sections.

Method #1

This method is usually used for the case where the hydro-package and *SIS* are installed on the same machine. However, since the *User Defined UDP* port cannot be modified, this method may not be suitable if this mechanism is already in use by another program. In such a case, the *DataDistrib.exe* program explored in [Method #3](#) may be attempted.

The configuration for this method is actually quite simple:

- Stop pinging
- Access the *Installation Parameters* dialog (see [SIS Installation parameters dialog, with key settings in red for method_1.](#)) from the *View* menu by choosing *Tear off* and then *Installation Parameters*
- Select the *PU Communication Setup* tab and then choose the *Output Setup* sub-tab.
- Choose *User Defined* from the *UDP Host Port* dropdown menu (the default output port varies with the MBES model). Take a note of this for configuring SSP Manager later.
- Select the following datagrams: *Depth*, *Position*, and *Sound Speed Profile*.
- Click the *OK* button at the top left of the tabbed panels.
- Restart pinging.

Method #2

This method is more general, and it can be used for data transmission to other computers on the network (by specifying IP address and port, as well as transmission rate).

Note: *SIS* needs to be restarted for the changes to take effect. Furthermore, since the software does not seem to validate user inputs, mistakes made cannot be easily discovered and undone (unsubscribe).

- From the *Tools* menu, choose *Custom...* and then *Datagram Distribution* (see [Datagram Distribution dialog, with key settings in red for method_2.](#)).
- Choose the datagram from the drop down menu, starting with *Position (P)*.
- Type in the IP address of the remote machine where this hydro-package is installed, immediately followed by a colon (:), then the port number that the data should be delivered to on the remote machine: e.g., 192.168.1.67:16103.
- Click the *Subscribe* button.
- Repeat Steps 2-4 for the *SVP (U)* and the *XYZ88 (X)* datagrams.

Method #3

This method is required when multiple software packages need to receive data from *SIS*, and it represents an extension of the previous two methods. It uses a standalone program, named *DataDistrib.exe*, bundled with *SIS* and usually installed in *C:\Program Files\Kongsberg Maritime\SIS\bin* (together with a configuration file *DataDistrib.ini* with all the subscriptions).

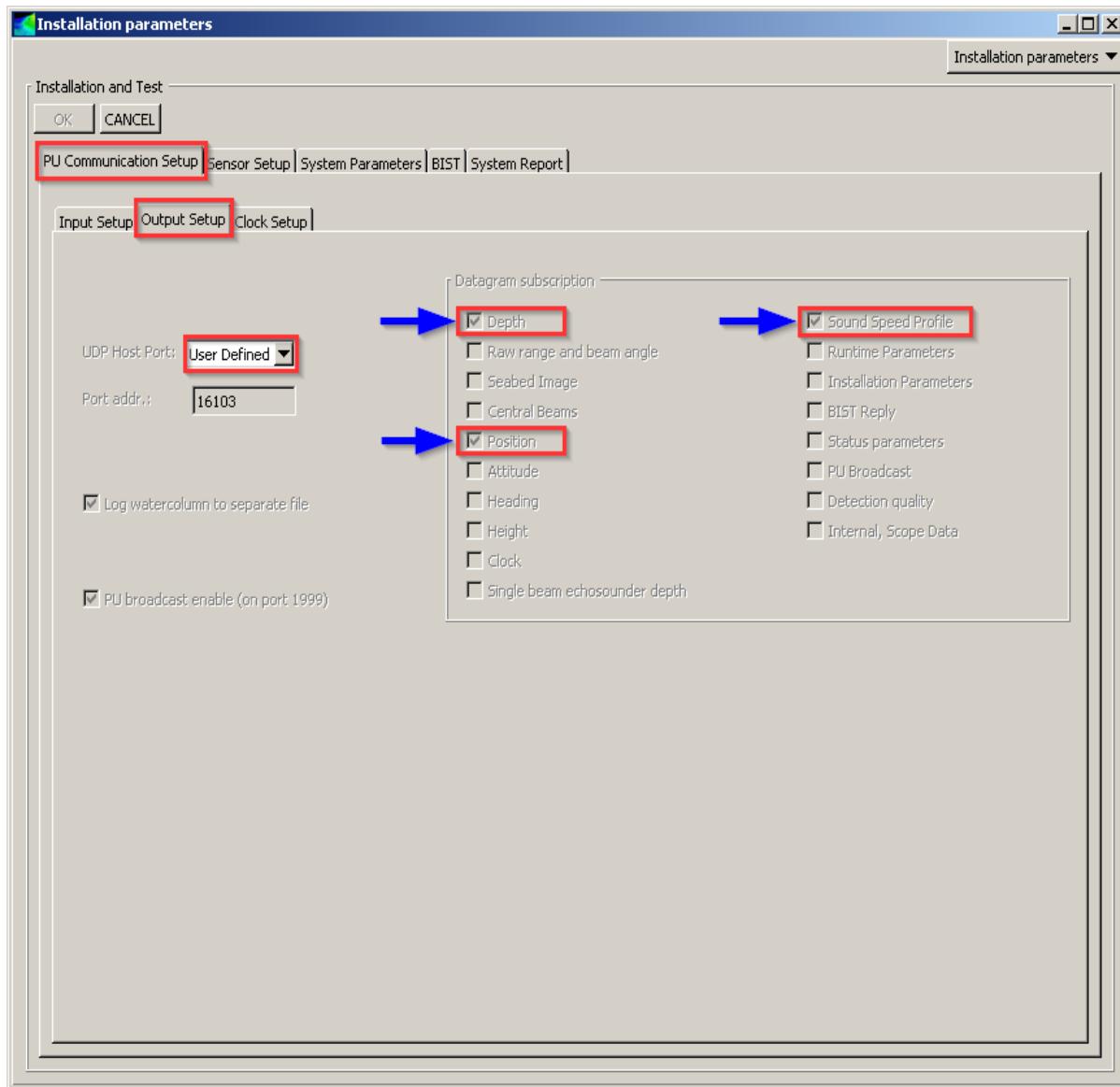


Fig. 2.3: SIS Installation parameters dialog, with key settings in red for *Method #1*.



Fig. 2.4: *Datagram Distribution* dialog, with key settings in red for *Method #2*.

It is suggested to add the *DataDistrib.exe* to the *Startup* menu (so that it is automatically started). However, common backsides of this method is that the executable can be accidentally closed (stopping the data distribution to this package), or it can accidentally runs twice corrupting the configuration file (to prevent this, it could be made ‘read only’).

The setup of this method is summarized as follows:

- If the program is running already, click the icon in the taskbar to launch the graphical user interface (see *The Data Distribution application, with key settings in red for method #3.*). If not, navigate to *C:\Program Files\Kongsberg Maritime\SIS\bin* and double click on *DataDistrib.exe* to launch it

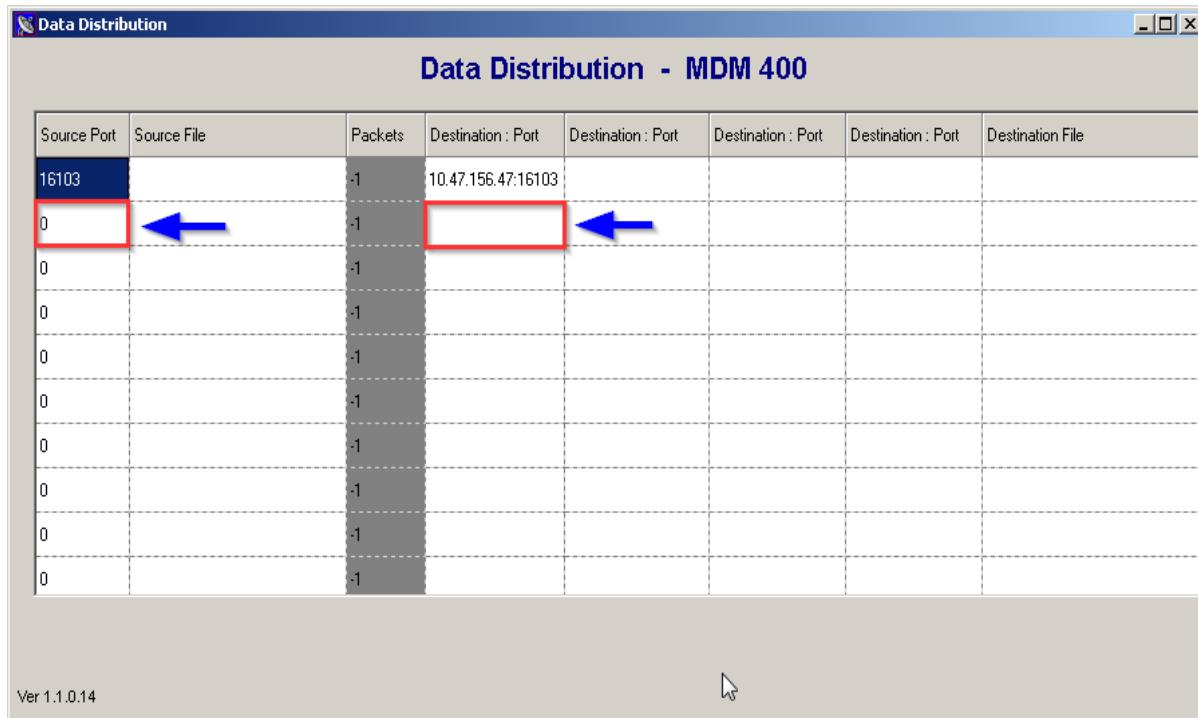


Fig. 2.5: The *Data Distribution* application, with key settings in red for *Method #3*.

- Find the first empty row and enter the UDP port to which *SIS* has to distribute data in the left most column. Hit the *Enter* key to finalize the entry
- In the same row, click on the fourth column and type in the IP address of the remote machine on which this package is installed, immediately followed by a colon (:), then port number that the data should be delivered to on the remote machine: e.g., 192.168.1.67:16103. Again, hit the *Enter* key to finalize the entry. If *SIS* is pinging and distributing the data, you should see the packet count increase steadily in the third column.

Sound Speed Manager side

The parameters, present in *setup.db*, can be modified using the *Setup* tab.

By default, the *Setup* tab is in read-only mode. To be able to modify the package settings, you need to unlock it.

Once unlocked, you can add a new setup, or you may want to modify one of the existing ones. For the interaction with *SIS*, you need to access the *Output* sub-tab and the *Listeners* sub-tab.

In the *Output* sub-tab, you have to add a client to the *client list* you need to specify:

- a name for the client (for ease of recognition)

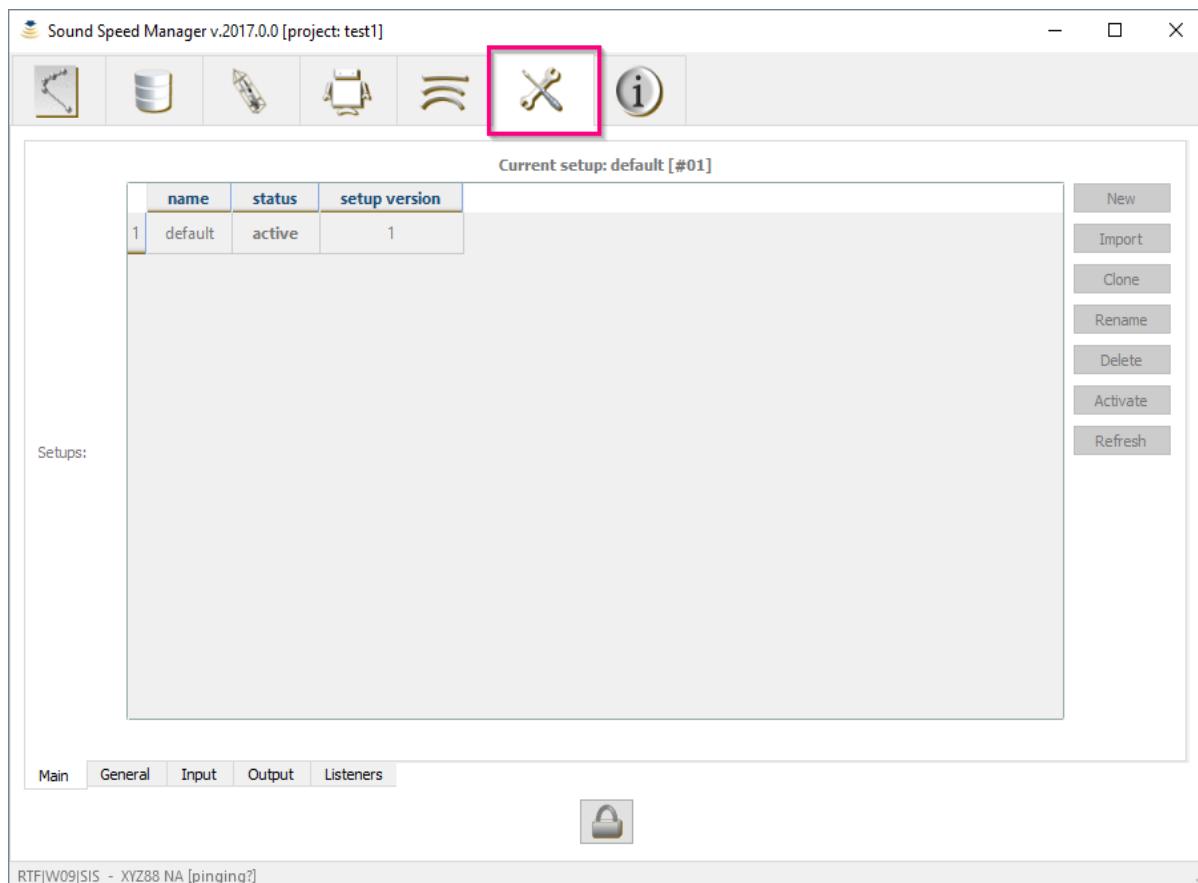


Fig. 2.6: The *Setup* tab, in red, can be used to inspect/modify the package settings.

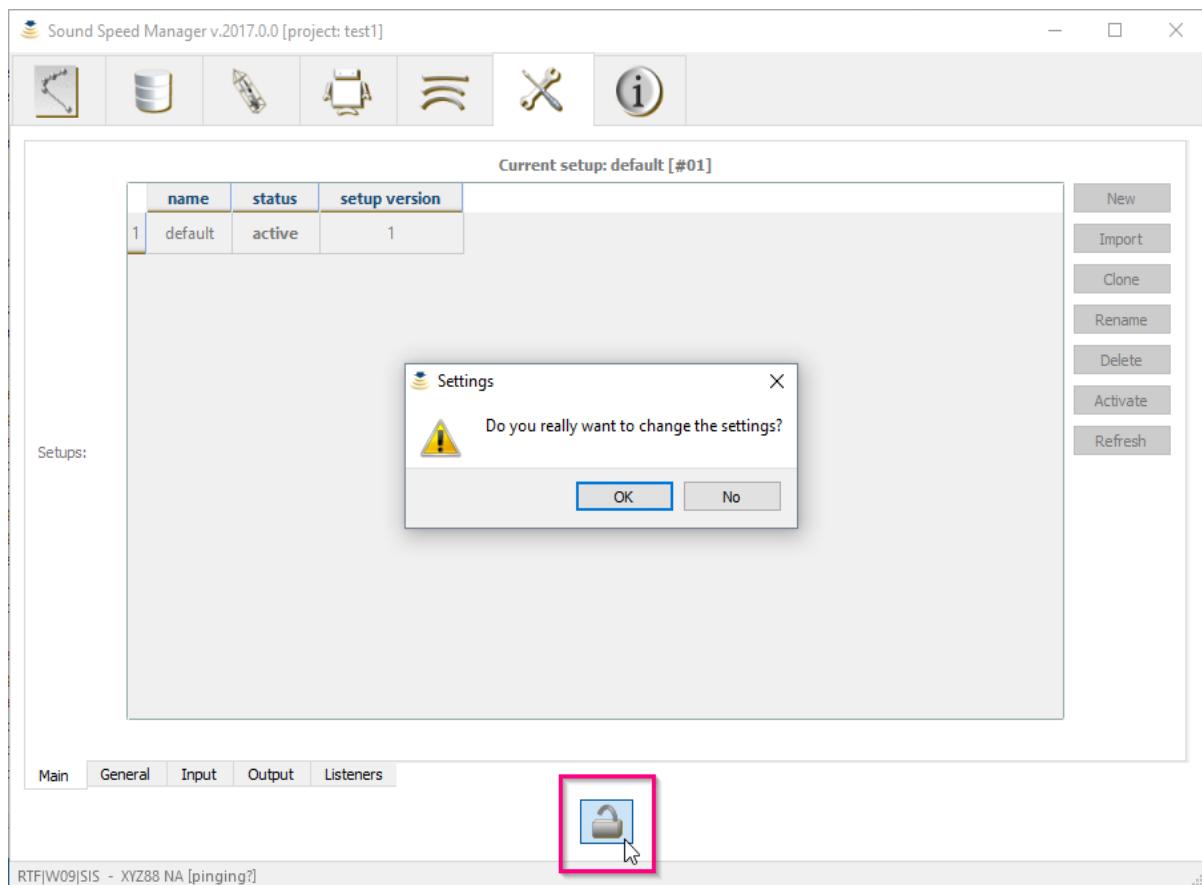


Fig. 2.7: The *Setup* tab must be unlocked for settings modifications.

- the client IP address to which the data should be sent by *Sound Speed Manager* (if the package is installed on the same machine as *SIS*, this should be 127.0.0.1)
- the port to which the client is listening for the sound speed profile (*SIS* always listens port 4001 for SSP input)
- the protocol in use: SIS

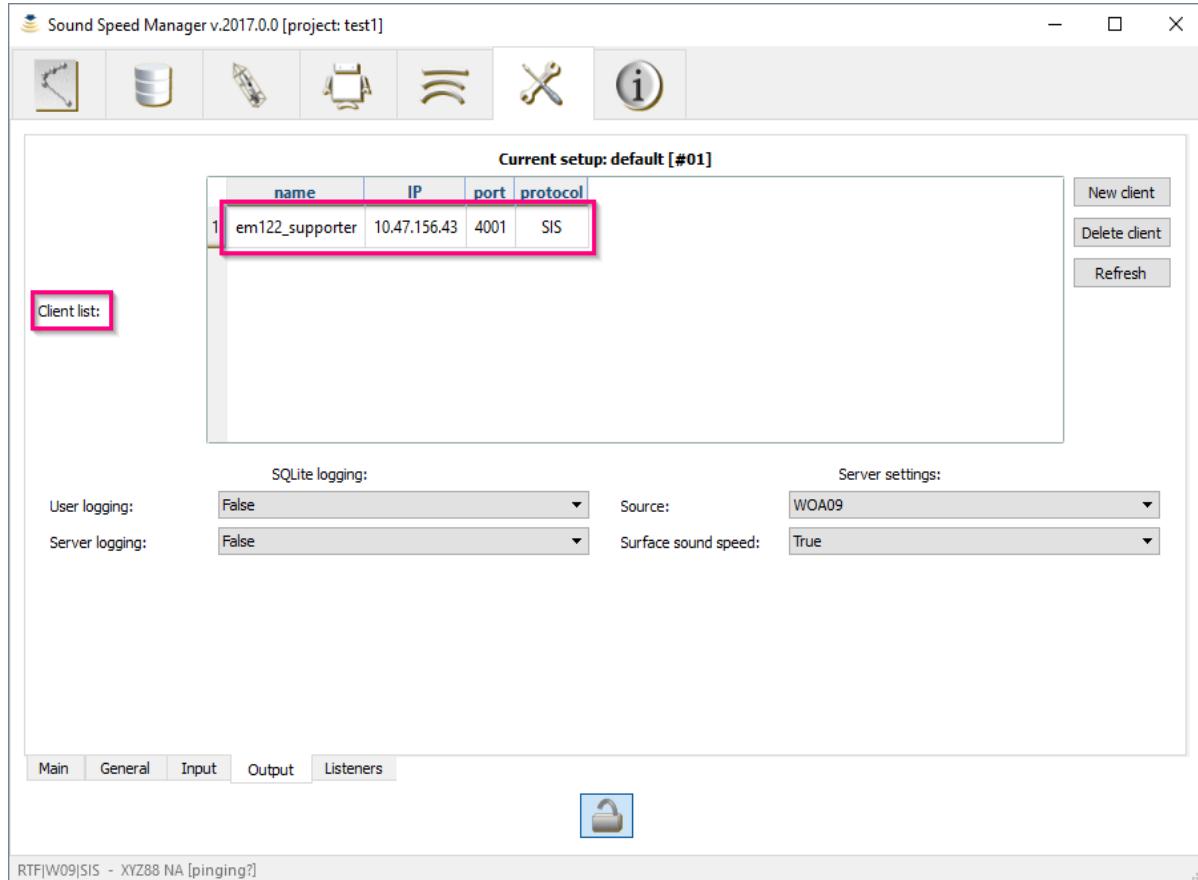


Fig. 2.8: The *Client list*, in red, is used to add the *SIS* client information.

In the *Listeners* sub-tab, the *Listen port* entry, in red, provides the port to which *SIS* has been configured to broadcast datagrams. This should match the port address selected in the previous methods. For instance, 16103.

If both *SIS* and *Sound Speed Manager* sides have been properly configured, *Sound Speed Manager* will show (in the right side of the lower window statusbar) the date, geographic position, surface sound speed and average depth (when *SIS* is pinging).

Note: The surface sound speed and depth will only update if the echosounder is pinging (since the surface sound speed information can only be extracted when *Sound Speed Manager* receives the depth datagram).

How to use

Operator Mode

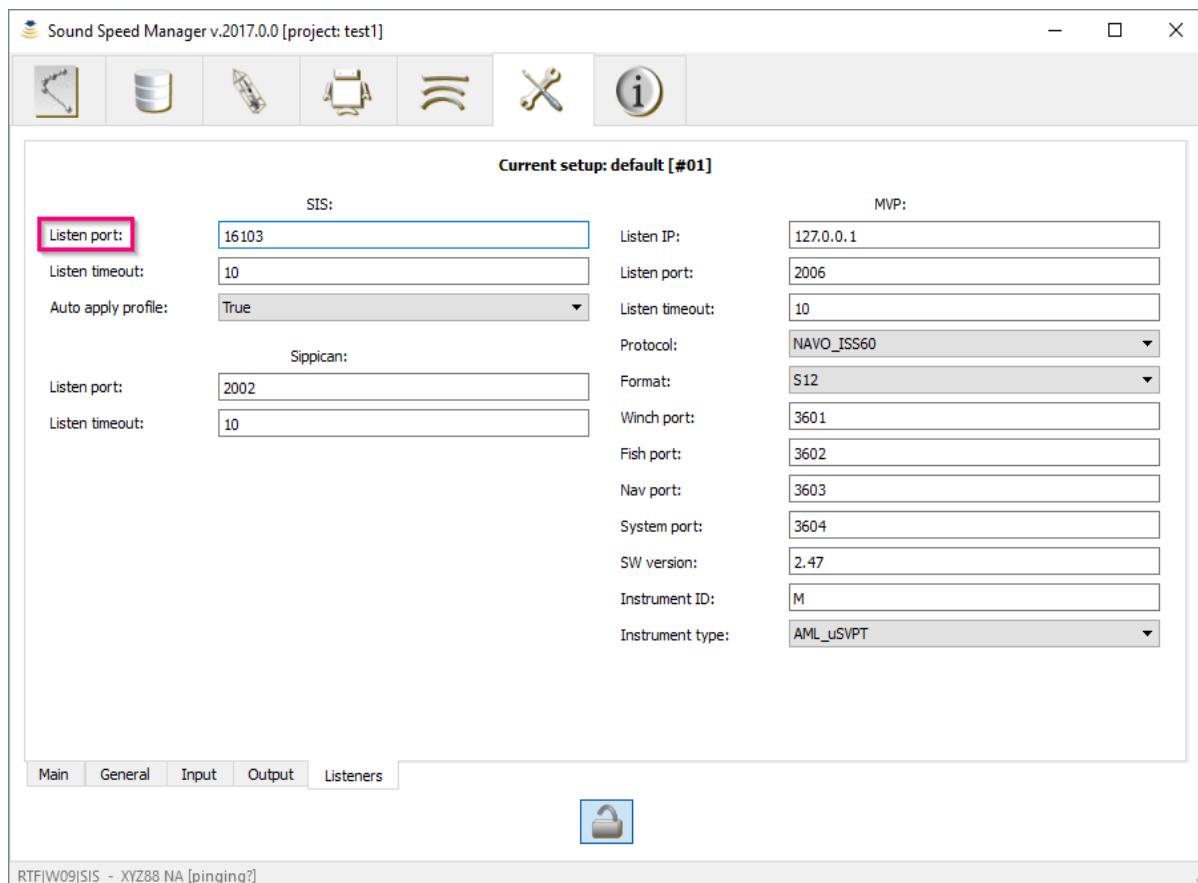
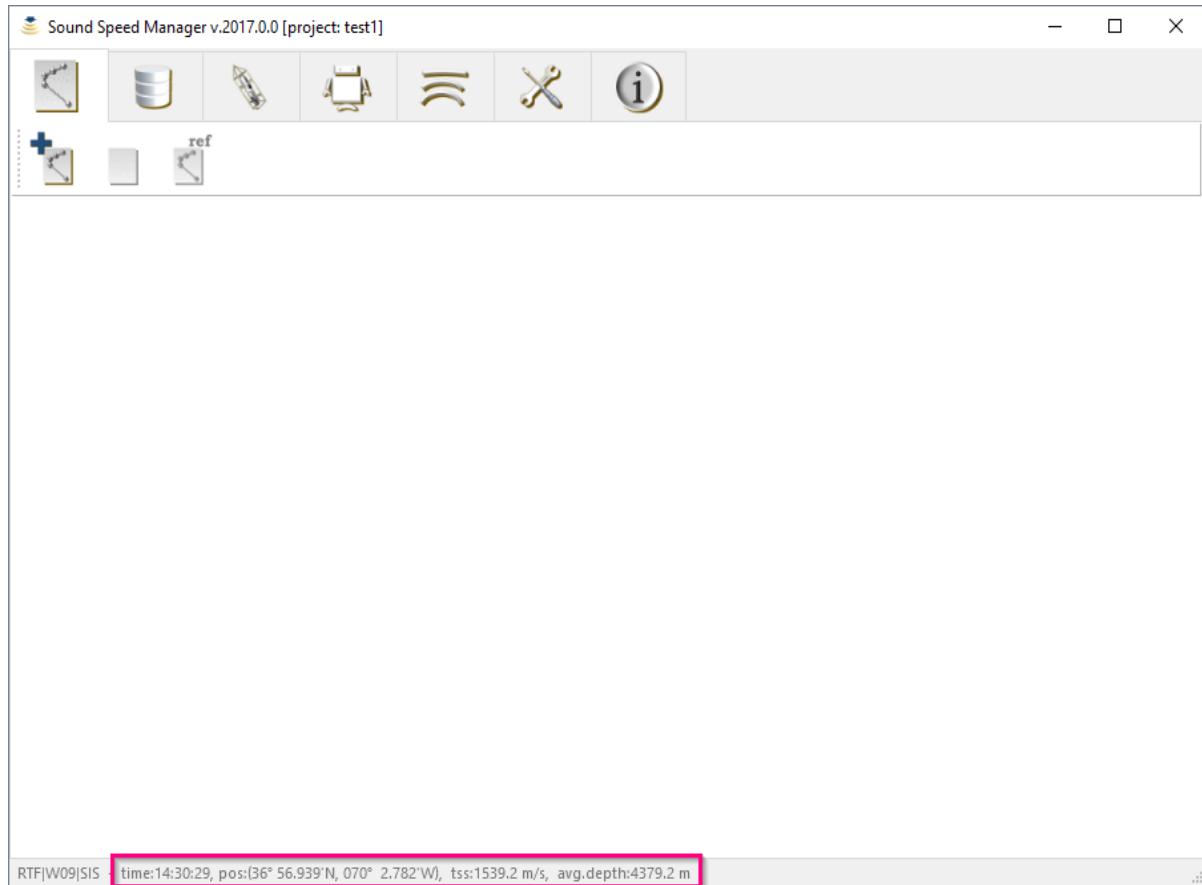


Fig. 2.9: The *Client list*, in red, is used to add the *SIS* client information.



Data import

From the *Editor* tab, select *Import data* and choose the desired import file type.

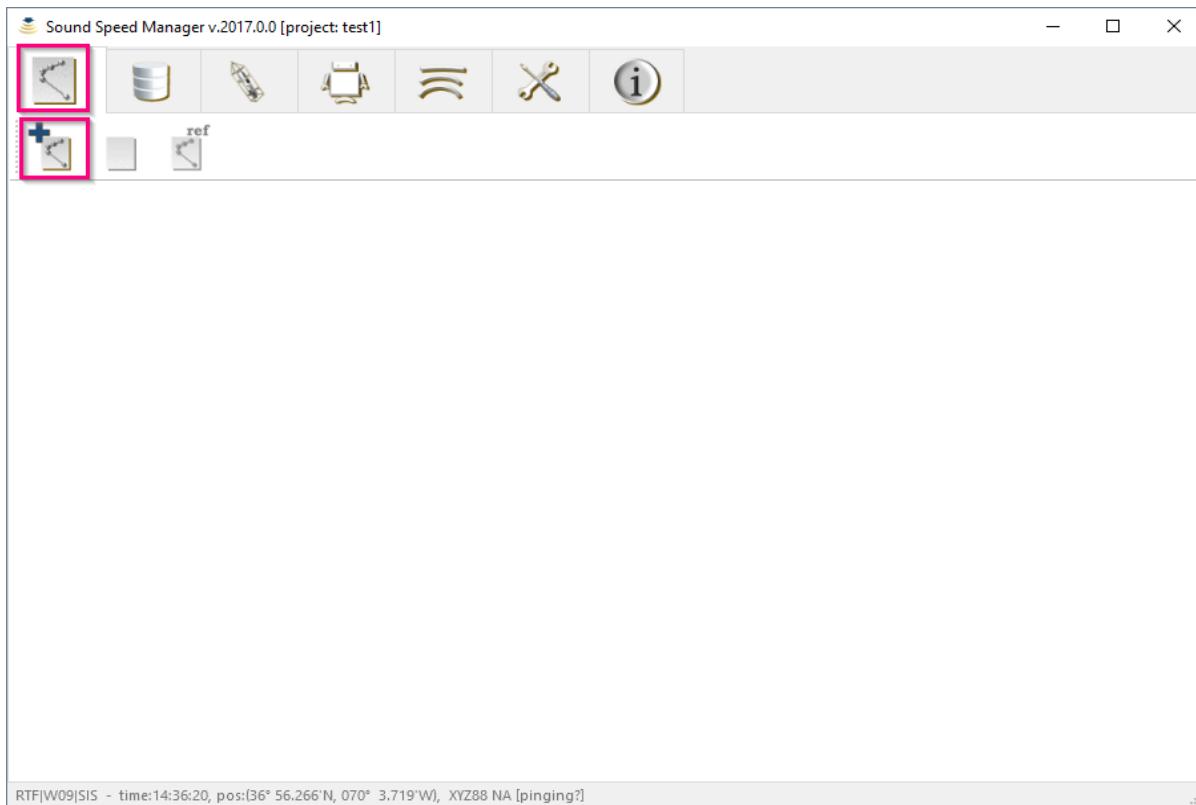


Fig. 2.10: Click on the *Import data* button in the *Editor* tab to start the import process.

This will launch a file selection dialog (with the expected file extension set as a filter, e.g. `.edf` for *Sippican* files).

Note: A number of sample data files can be downloaded from the project repository.

After the selection of the desired file, the window shows panels with the sound speed, temperature and salinity profiles drawn in solid blue (left to right, respectively, in the following figure).

During the import stage, the geographic position and date in the input file are used to query WOA or RTOFS atlases (if available) to obtain mean sound speed, temperature and salinity profiles (to provide a context during data editing), which are drawn in dashed colours. Thus, it is important that the cast positional metadata are correct for this lookup operation.

Furthermore, the position is also required by some formats to compute the pressure to depth conversion (since this has a latitudinal dependence). Since some file formats do not support recording of geographic position (e.g., *Valeport .000*) the user must enter these manually during import (if the SIS position datagram is not available).

Interactive data editing

The mouse interactive mode is set using the plotting toolbar at the bottom (or by directly right-clicking on the plots once a cast is loaded). Currently available inspection modes are:

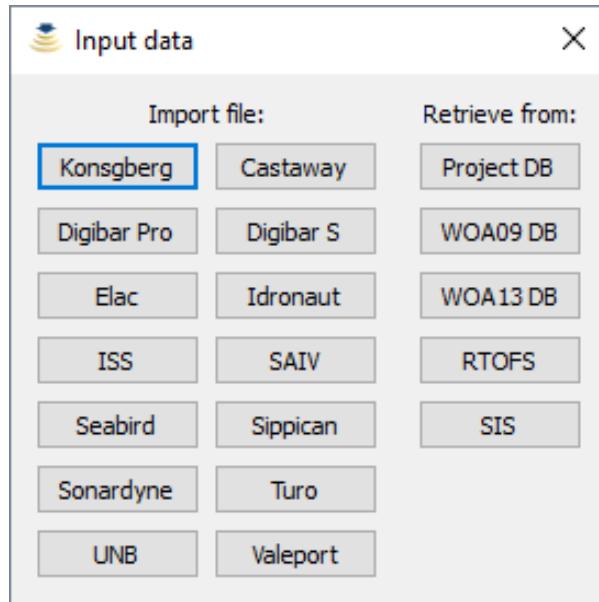


Fig. 2.11: Click on the desired import file type.

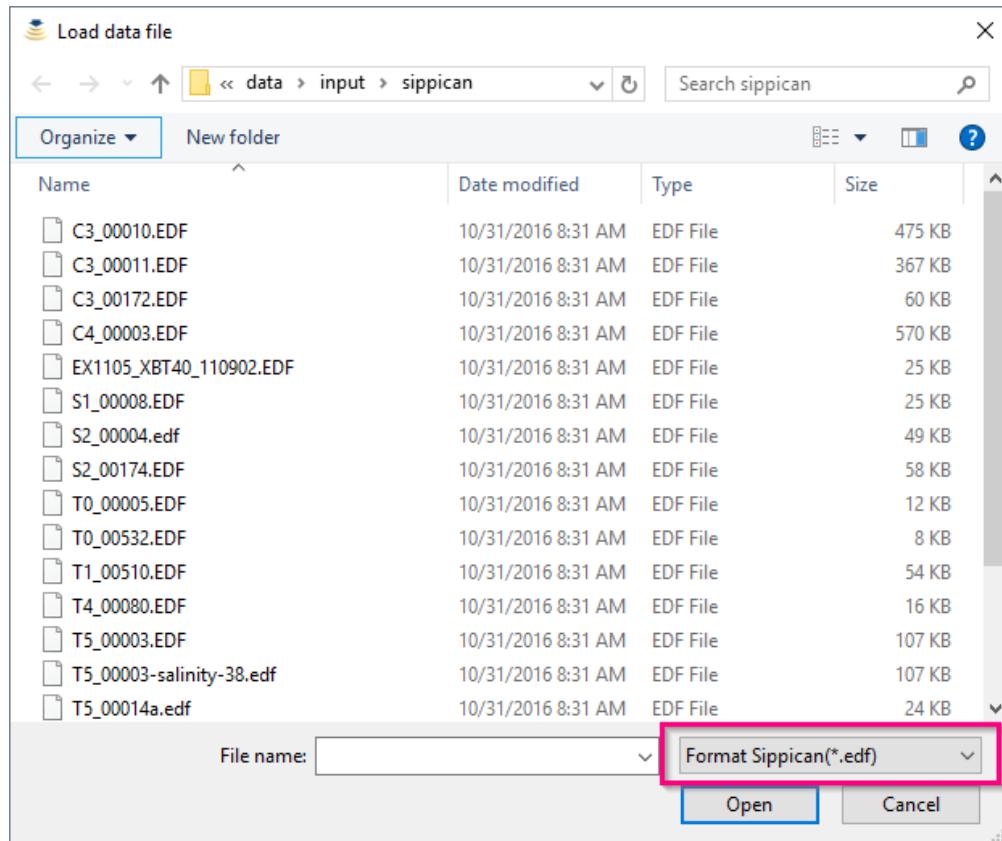


Fig. 2.12: Browse to the desired data file.

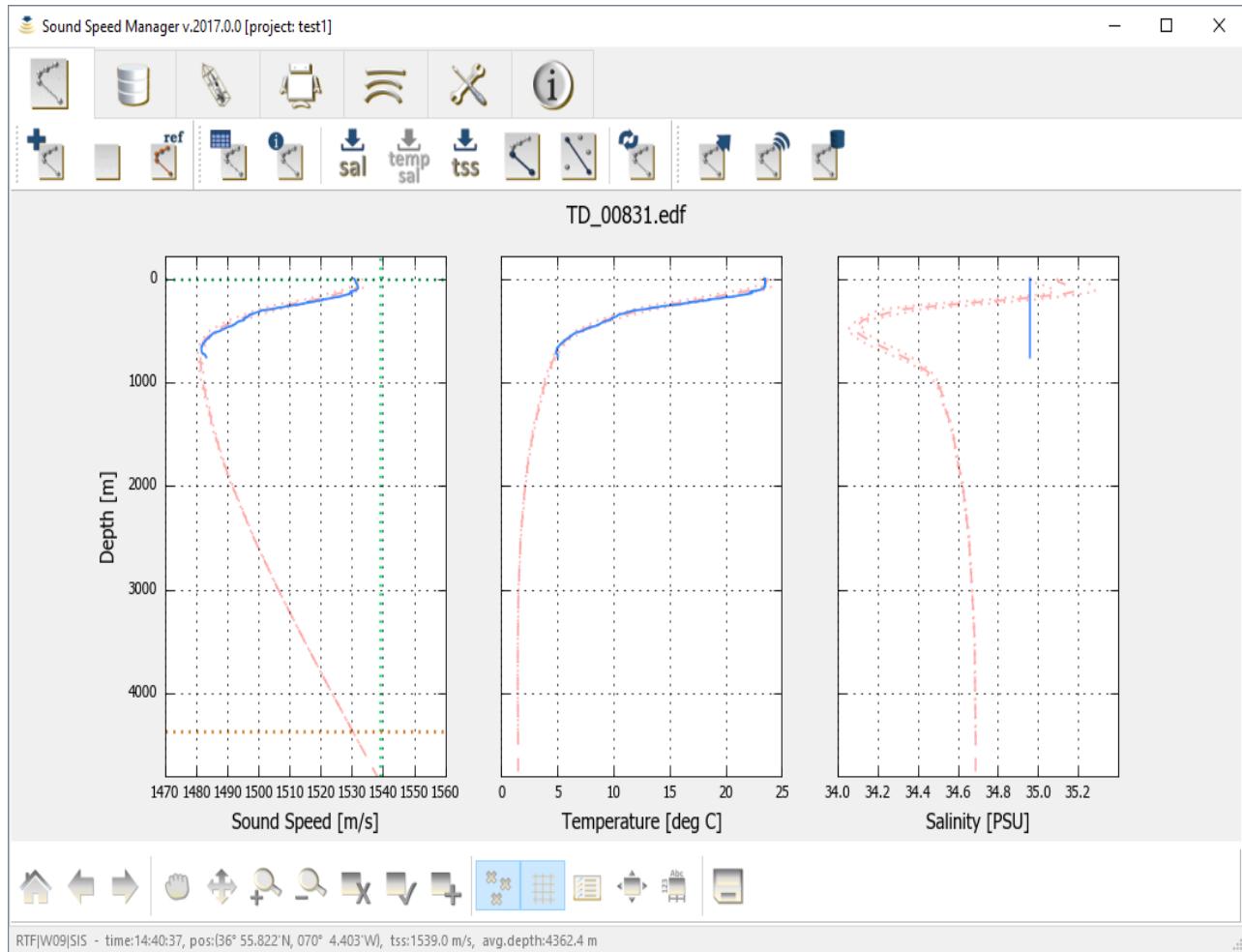


Fig. 2.13: *Sound Speed Manager* showing the three main plots: sound speed, temperature, and salinity.

- *Reset view*: to visualize the full profile
- *Pan*: to move the area visualized in the plot
- *Scale*: to modify the horizontal and vertical scales of the plots
- *Zoom in*: to zoom in to a selected area
- *Zoom out*: to zoom out from a selected area
- *Flag*: mark spurious measurements for removal from any plot panel through a left-click drag motion over the bad data points. The flagged points will be drawn in red.
- *Unflag*: reclaiming previously flagged data, using the same left-click and drag motion as *Flag*.
- *Insert*: manually adding points to the profiles can be useful to create a more realistic cast extension. This is particularly useful when the measured temperature and/or salinity values deviate from WOA/RTOFS or the reference profile near the bottom of the profile.

Zooming back out to the full view is accomplished by choosing *Reset view* from the plotting toolbar (or by directly right-clicking on the plot and selecting *Reset view*). The *Hide flagged* option in the plotting toolbar will toggle the display of flagged points.

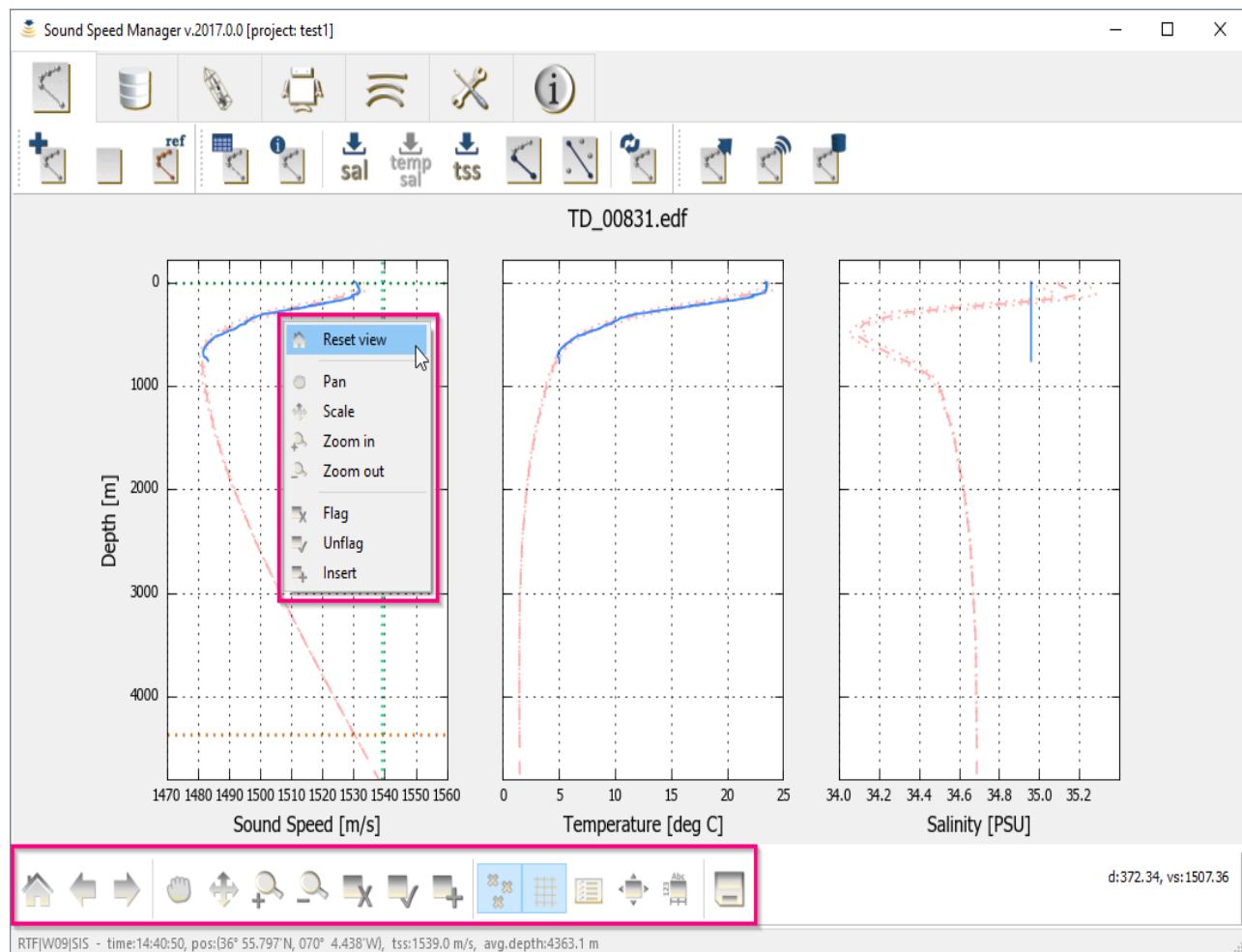


Fig. 2.14: Interactive data editing of a loaded profile.

Data augmentation

Sound speed data can be augmented with WOA/RTOFS/reference salinity and/or temperature. If a reference cast has been set, then the reference cast will be used to augment salinity and/or temperature profiles instead of the WOA/RTOFS profiles.

XBT probes

XBT probes measure the temperature of water as they drop to the seafloor. Since the speed of sound in water is strongly affected by water temperature, this measurement can be used to estimate the sound speed profile. Since salinity can also influence the speed of sound in water, the accuracy of the sound speed estimate can be improved through better approximation of the water's salinity. This approximation can be as simple as assuming that the salinity is constant over all depths or it could be as sophisticated as using an independent salinity depth profile from an alternate sensor such as a CTD or perhaps from an oceanographic model.

The package follows this second approach. The salinity profile is specified by selecting *Retrieve salinity* from the *Editor* toolbar (the option is only active when an XBT cast is loaded). With this command, the dashed WOA or RTOFS salinity profile is used to augment the XBT temperature measurement. Since the vertical resolution of the WOA/RTOFS grids is coarse compared to the typical sampling interval of the measured data, the salinity estimates are linearly interpolated to the depths associated with each of the temperature observations in the measured XBT profile.

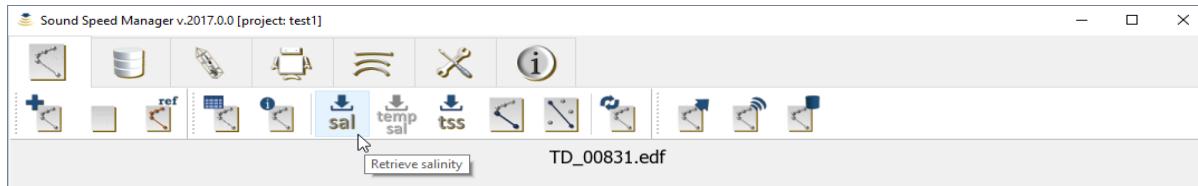


Fig. 2.15: The *Retrieve salinity* button in the *Editor* toolbar.

The salinity plot (right-most of the three panels) will update with a salinity profile and sound speed plot (the left-most panel) are updated with sound speed (recalculated using the new salinity estimates). Sound speed values are calculated using the UNESCO equation (*Fofonoff and Millard, 1983*).

XSV probes

In the case of an XSV file, the user can decide to augment the measured sound speed with WOA/RTOFS temperature and salinity through the XSV load temperature/salinity option under the *Process* menu (the option is only active when an XSV cast is loaded).

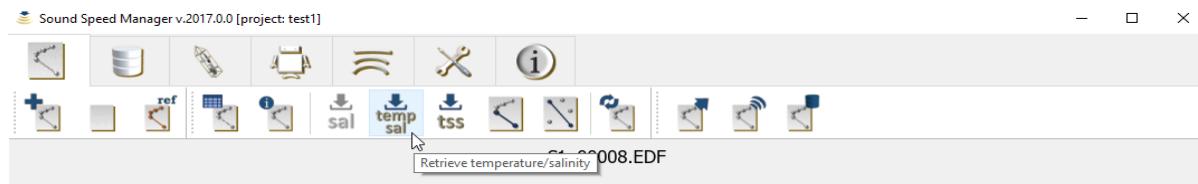


Fig. 2.16: The *Retrieve temperature/salinity* button in the *Editor* toolbar.

Note: In this mode, the sound speed is NOT recalculated, the temperature and salinity are meant merely for SIS to compute transmission loss corrections for improved backscatter normalization. Thus, the application disallows the

Retrieve salinity button in the *Editor* toolbar for XSV profiles.

Manual user insertions

There are two methods to add points, after having selected the *Insert* mode in the right-click menu or in the plotting toolbar:

1. *Adding sound speed points in the sound speed plot.* This method adds points to the sound speed profile only and it holds the last observed temperature and salinity constant (i.e., it makes no attempt to update the temperature/salinity profiles for the chosen sound speed). Thus, this method is well suited for output formats or transmission protocols in which the temperature/salinity values are not used.
2. *Adding salinity and temperature points.* This method adds salinity and temperature points in their respective plots and then calculates the resulting sound speed based on the temperature/salinity plots. A first click in the salinity plot adds a salinity point. Then, a second click is required in the temperature profile (the depth of the first point in the salinity plot will be adjusted to match the depth of the second click). Finally, a third click in the sound speed plot computes the new sound speed point based on the previously selected depth/temperature/salinity values (the depth from the last click in the sound speed plot is NOT used, i.e., you can click anywhere in the sound speed plot).

Multipoint extensions are achieved through repeating the above sequence. If a deep extension that exceeds the view limits is required, repeatedly clicking near the bottom of the plots will automatically adjust the view bounds.

Applying surface sound speed

If configured to receive data from SIS, the surface sound speed and transducer draft from the depth datagram broadcast can be used to create a surface layer of thickness equal to the transducer draft and of sound speed equal to the value used in beam forming (this is based on the assumption that the value comes from the surface sound speed probe). This operation can be achieved by selecting *Retrieve Surface Sound Speed* from the *Editor* toolbar.

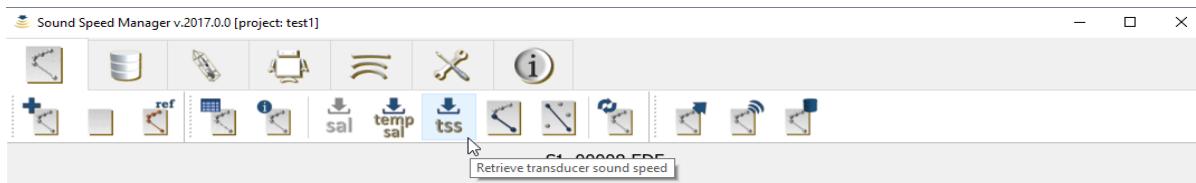


Fig. 2.17: The *Retrieve Surface Sound Speed* button in the *Editor* toolbar.

If neither the surface sound speed or transducer draft values are available from a SIS data broadcast, the software will prompt the user to input values for both.

The intent of this feature is to keep the sound speed profile and sound speed sensor values similar such that the numerical display monitors in SIS do not warn against sound speed discrepancies between the two measurements. It should be noted that this is done internally in SIS during their ray tracing operations, regardless of this external processing stage: “transducer depth sound speed is used as the initial entry in the sound speed profile used in the ray tracing calculations” (Kongsberg, 2012).

Using this package method, keeps the system from warning against discrepancies based on:

- The uncertainty in XBT temperature measurements ($\pm 0.1^\circ\text{C}$, roughly equivalent to $\pm 0.4 \text{ m/s}$)
- Inadequate choice of salinity in the Sippican acquisition system
- Deviations of true salinity from the mean surface salinity in the WOA/RTOFS.

Profile extension using WOA/RTOFS atlases or a reference cast

Profile extension can be applied by selecting *Extend profile* from the *Editor* toolbar. This operation will extend the observed cast in depth as much as possible using the WOA/RTOFS profile. After that, the three plot panels will be updated. If necessary, users should edit any discontinuities between the cast in depth and the extension in the vicinity of the maximum observation depth.

The extension will only go as deep as 5,500 m as this is the deepest depth layer that the WOA/RTOFS atlases support (more details on such an operation are provided in [Appendix A - Oceanographic Atlases](#)).

However, when files are transmitted to *SIS* or exported in *.asvp* format, the software extends the profile to 12,000 m depth to meet *SIS* input criteria (thus, there is no need for the user do this manually). Similar to data augmentation for XBT probes and for XSV probes, when a reference cast is set, this will be used to extend the cast instead of WOA/RTOFS atlases data.

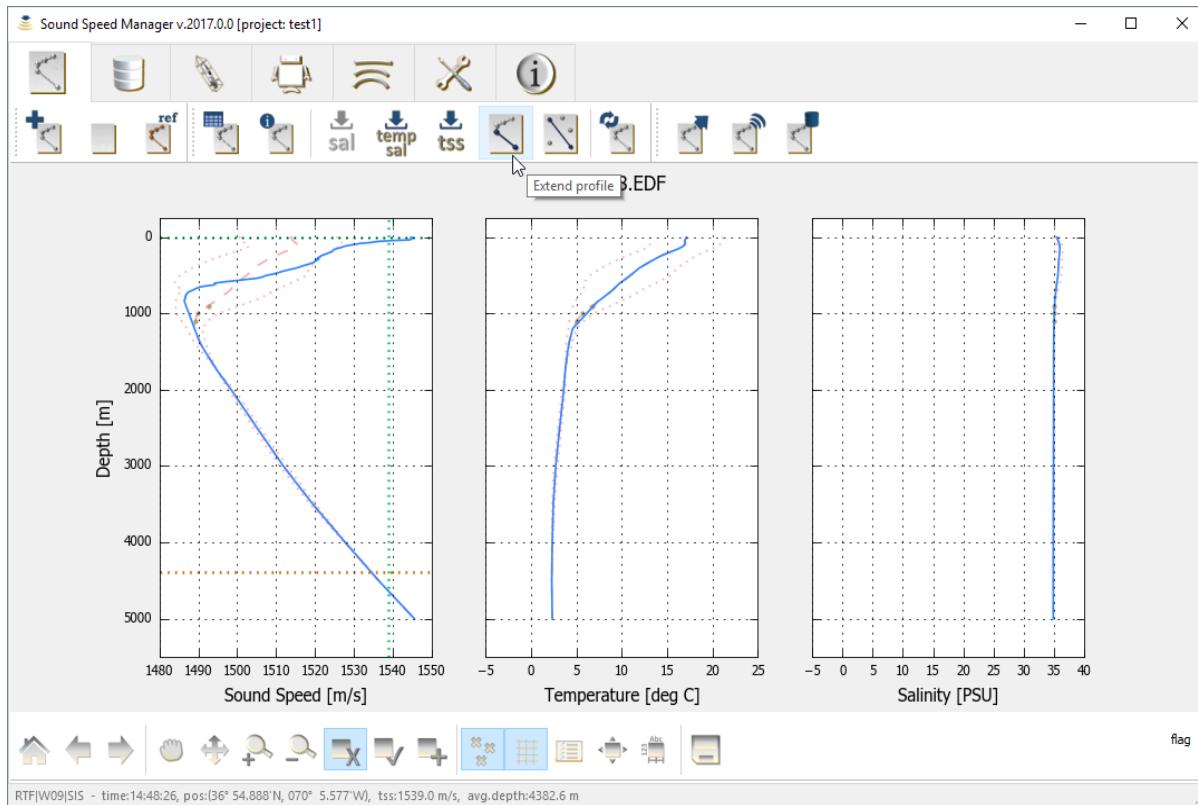


Fig. 2.18: The *Extend profile* button in the *Editor* toolbar.

Data export

Any file that is loaded into the package can be exported by accessing the *Export data* from the *Editor* toolbar.

Several formats are currently supported, so the user must select the format of interest and then choose *Export selected formats* to actually perform the export.

The export function will prompt the user for an output prefix prior to export.

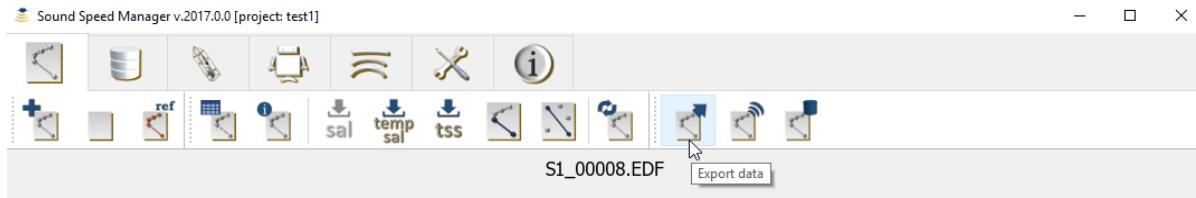


Fig. 2.19: The *Export data* button in the *Editor* toolbar.

Data transmission

Data transmission is triggered by selecting the *Transmit data* from the *Editor* toolbar.

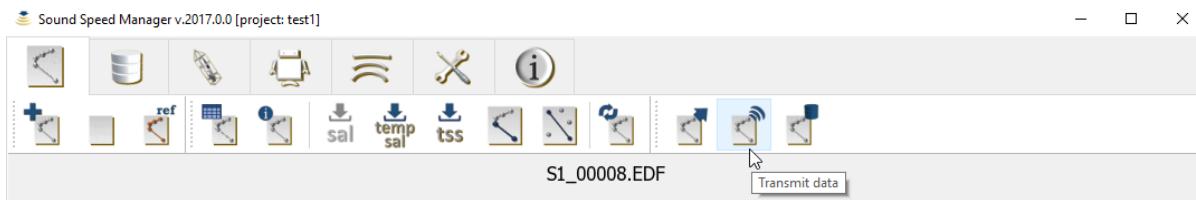


Fig. 2.20: The *Transmit data* button in the *Editor* toolbar.

The recipients of such a transmission are configured in the configuration file (see [Package configuration](#)). Given that the profile accepted by *SIS* often requires the application of a thinning algorithm, a method *Preview thinning* is provided to inspect the result of such an algorithm before the actual transmission.

Data storage

The package provides also functionalities to permanently storage, delete and retrieve the sound speed data. A profile can be store using *Save to database* in the *Editor* toolbar.

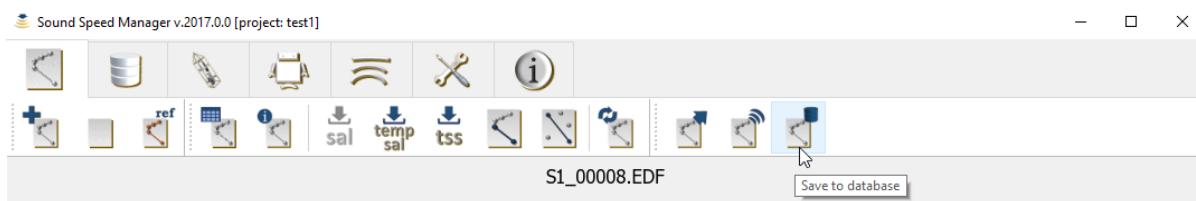


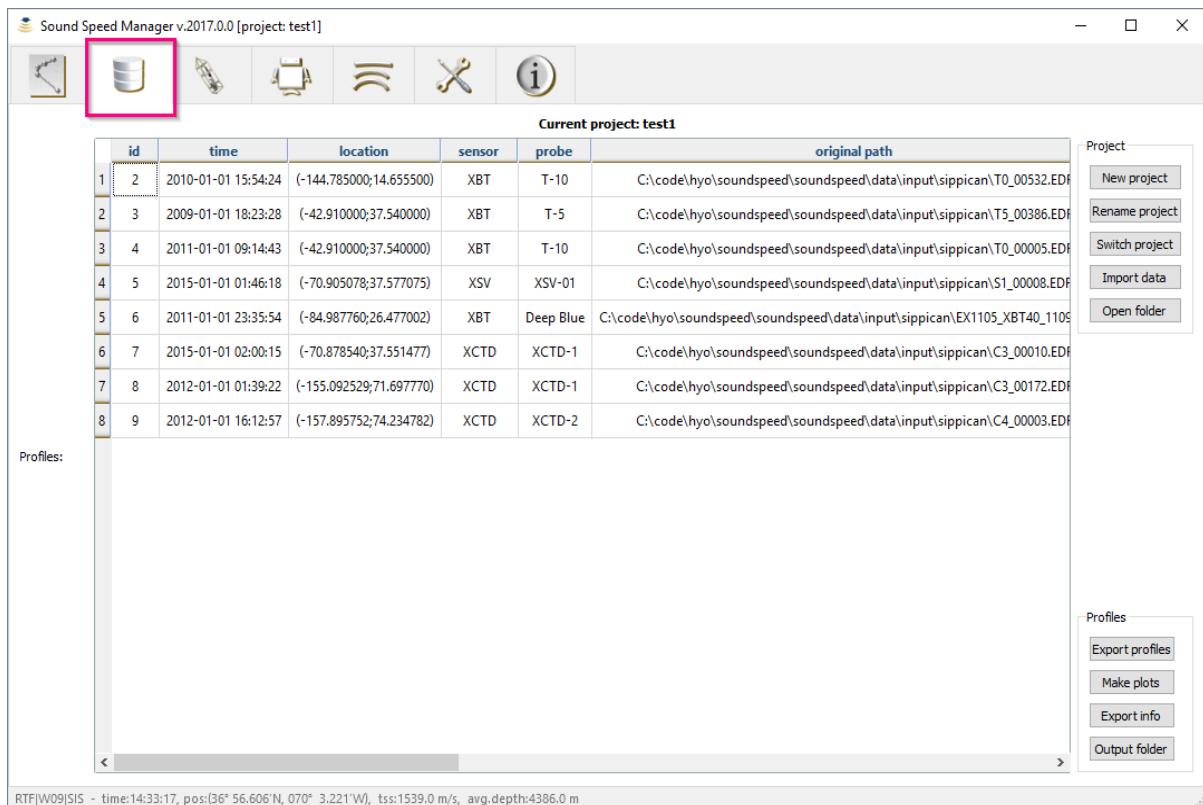
Fig. 2.21: The *Save to database* button in the *Editor* toolbar.

In particular, each profile may contain three types of stored data:

1. The raw data (that makes possible to redo the processing from scratch).
2. The processed samples (with flags to identify the various different source of data).
3. An optional SIS profile (that represents the result of the thinning process required by *Kongsberg SIS*).

Once stored in the database, the *Database* tab provides analysis functions and tools to manage the collected profiles.

For instance, it is possible to export the profile metadata in several geographic formats (csv, kml, shapefile).



Additional functionalities

Create a WOA or RTOFS profile

It is possible to upload a single WOA or RTOFS profile to *SIS*. This can be done by first select WOA09 atlas or RTOFS atlas under the *Input data* button in the *Editor* toolbar.

This will trigger a series of question dialogs that will determine use of the *SIS* date/position input for the query position or an user provided input. After that, a surface sound speed can be applied, and finally the resulting cast can be sent as described in [Data transmission](#).

The new cast will be given the filename YYYYMMDD_HHMMSS_WOA or YYYYMMDD_HHMMSS_RTOFS with the date/time in the filename based on the query time of the cast.

Request profile from SIS

The *Input data* in the *Editor* toolbar can also be used to retrieve the cast currently being used by *SIS* and use it to create a new profile.

This is only possible if the package is receiving data transmissions from *SIS*. If it is not, the package will request a cast and will wait a few seconds until it times out on the request. During this wait period, the package will be unresponsive to further user interaction.

If a profile is received, it will be given the name YYYYMMDD_HHMMSS_SIS with the date/time in the filename based on the cast time recorded by *SIS*.

There are a number of shortcomings regarding the Kongsberg datagram format for sound speed profiles:

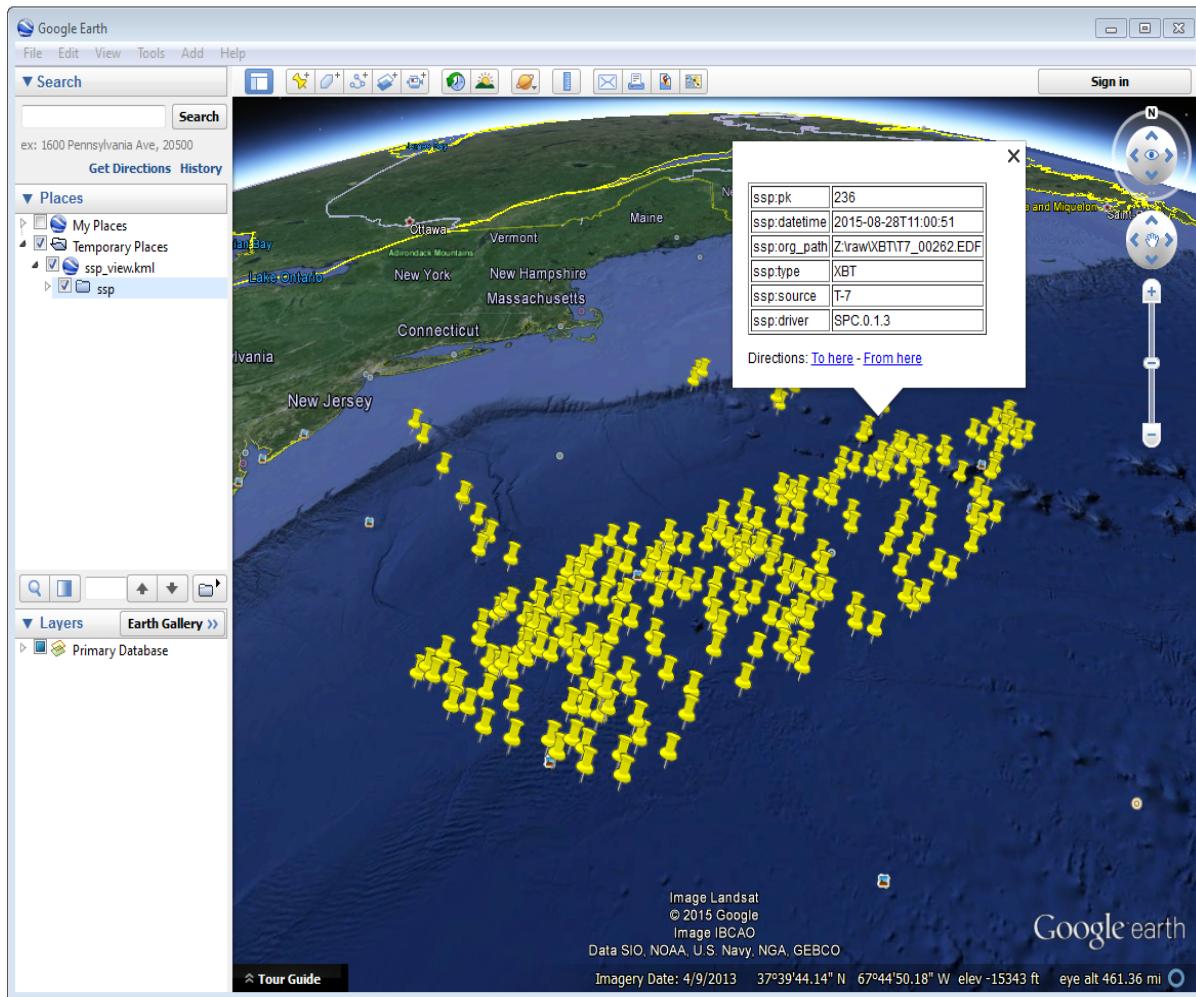


Fig. 2.22: Loading result of the exported metadata (kml format) in Google Earth.

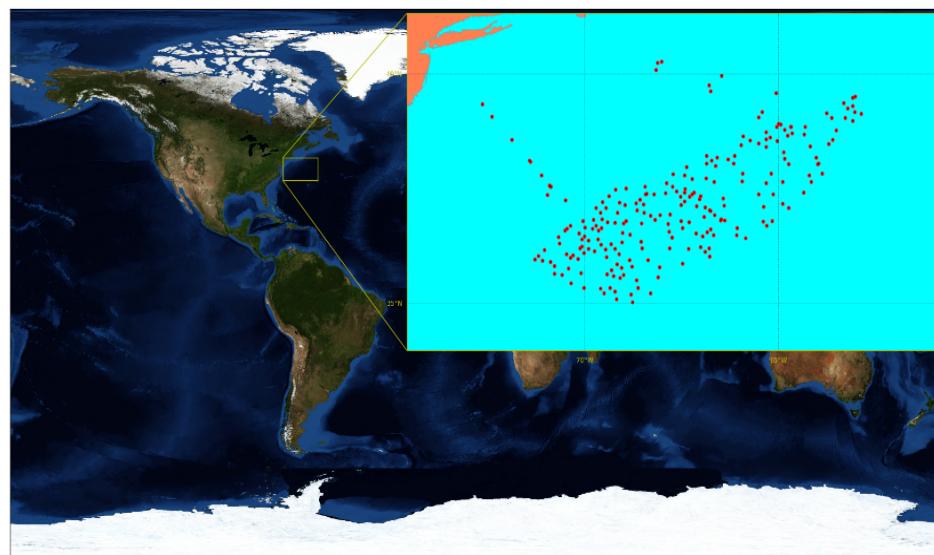


Fig. 2.23: Example of a map created from a stored SSP data set.

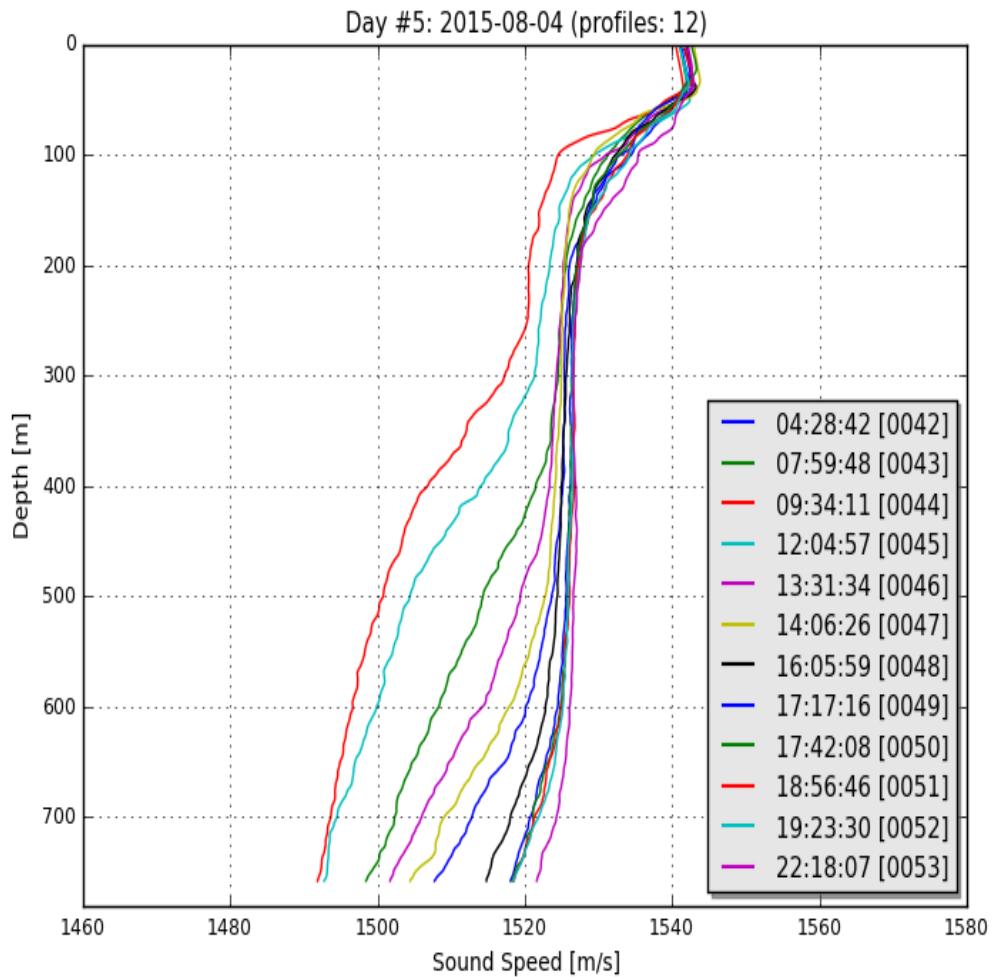


Fig. 2.24: Example of a daily plot that can be created from a stored SSP data set.

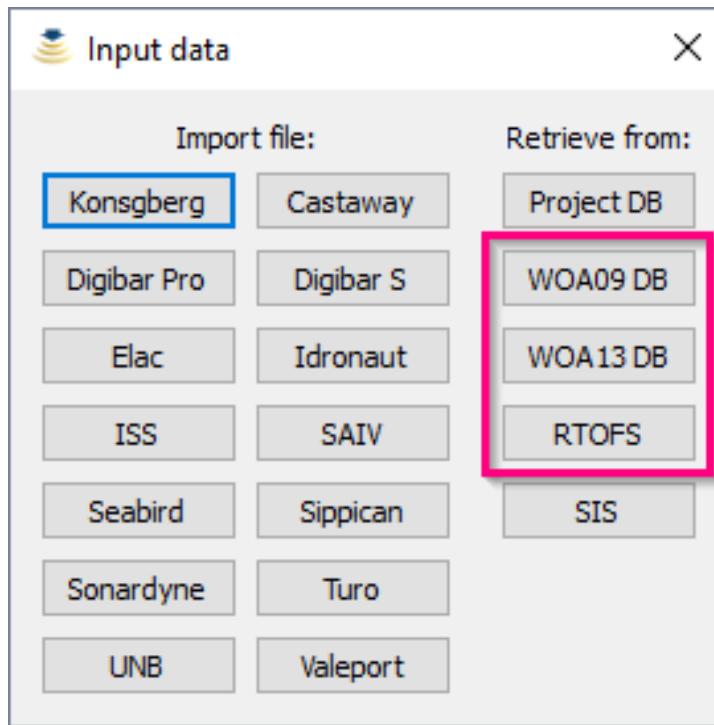


Fig. 2.25: The *Input data* button in the *Editor* toolbar.

- It does not preserve the latitude/longitude of the observed cast. You will be prompted to enter the position of the cast when you request the cast from SIS. It is up to you to determine the position as accurately as you require it to be, perhaps by consulting CTD/XBT logs.
- The observation time associated with the cast is known to be incorrect in the *SIS* sound speed profile datagram format so it is not necessarily straightforward to use the observation time to look up the navigation.
- Temperature and salinity are not included in the datagram, even if they are provided to *SIS* when the associated cast was originally uploaded (they are preserved internally in *SIS*, however).

These shortcomings are overcome through the use of the “W” datagram in *SIS*, however, it is not currently possible to dynamically request this datagram from *SIS* (though it is possible to have *SIS* broadcast it as discussed in the section *Method #2*).

Using a reference cast

There are several scenarios where a CTD profile can be used as a reference cast by this package:

- To support XBT measurements by providing a salinity profile measurement in place of using an assumed constant salinity
- To augment SVP/XSV casts with temperature and salinity profiles to improve seafloor backscatter attenuation corrections
- Since CTD cast typically sample much deeper than most XBT probes, to provide an improved vertical extrapolation to the XBT cast.

To establish a reference cast, the desired cast is imported using the same mechanism described in *Data import*. After that the profile is verified, edited and perhaps extended further in depth using an oceanographic database, it is set as the reference profile by selecting “Reference cast” in the *Editor* toolbar.

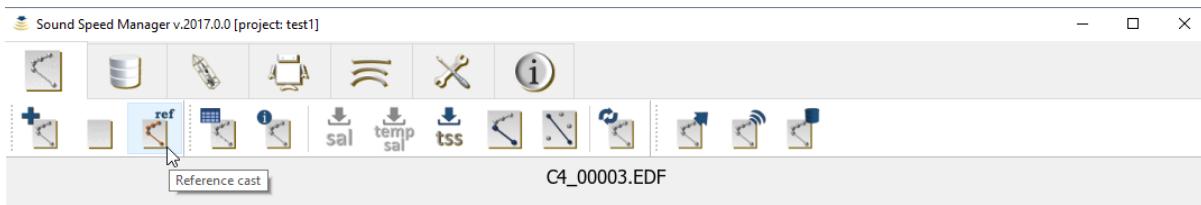
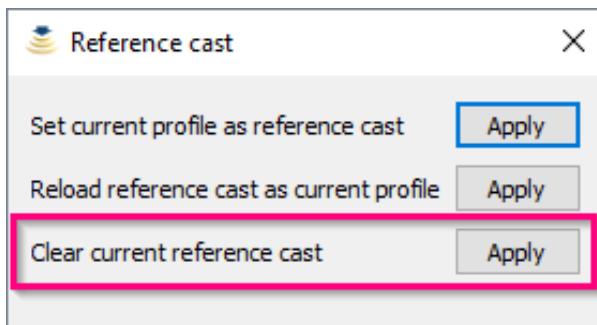


Fig. 2.26: The *Reference cast* button in the *Editor* toolbar.

Once a profile is set as the reference cast, the reference profile is drawn in orange. This cast is retained in memory as the currently loaded cast to allow for additional operations, such as exporting or transmission to a sounder. The reference profile can be cleared from memory at any time via the *Clear reference cast* option under the *Reference cast* menu. Further extensions and augmentations will then use WOA/RTOFS.



The reference cast can be reimported into memory by choosing *Reload reference cast as current profile* from the *Reference cast* menu. This will load a copy of the reference cast into memory for further manipulation. If desired, the edited version can then be set as the new reference cast and will replace the previous version. Prior to setting a cast as the reference cast, it is advisable to store it in database such that future sessions do not need to repeat any reference cast processing.

Refraction monitor

Note: This plugin is currently disabled.

An experimental feature has been set up to allow the user to establish the impact of their currently loaded sound speed profile on the refraction correction by plotting swath data with the new sound speed profile applied prior to sending the profile to the multibeam echosounder.

This provides a preview of the effect of the new sound speed profile allowing appropriate action if the results are not as expected without introducing artifacts into the multibeam data stream.

Network data reception

The package is configurable to listen on specified ports for UDP input of sound speed cast data. Currently supported systems are *MVP* and *Sippican*. See [Appendix B - Connection Settings](#) for more on how to configure these systems. The port numbers associated with various data sources can be changed in the *setup.db* file using the *Setup* tab.

Upon reception of a network cast, the display panels will be colored red to indicate that operator intervention is required in order to further process the data and deliver it to the multibeam acquisition system. Once the cast has been

processed and delivered, the statusbar color-coding will return to the normal background.

If the *Server mode* happened to have been running at the moment of reception, it will be stopped and the received cast will be displayed as described above.

Synthetic Profile Server Mode

The *Synthetic Profile Server mode* is meant for transits during which perhaps one XBT per day might be thrown. For much of the world oceans, using the WOA is a reasonable substitute for *in situ* measurements (*Beaudoin et al., 2011*).

Given that transit data are usually a lower priority, this mode supports continuous underway logging of multibeam data that are refraction corrected, using the mean temperature and salinity profiles provided by oceanographic models. This mode should not be used if SSPs are going to be collected on a regular basis.

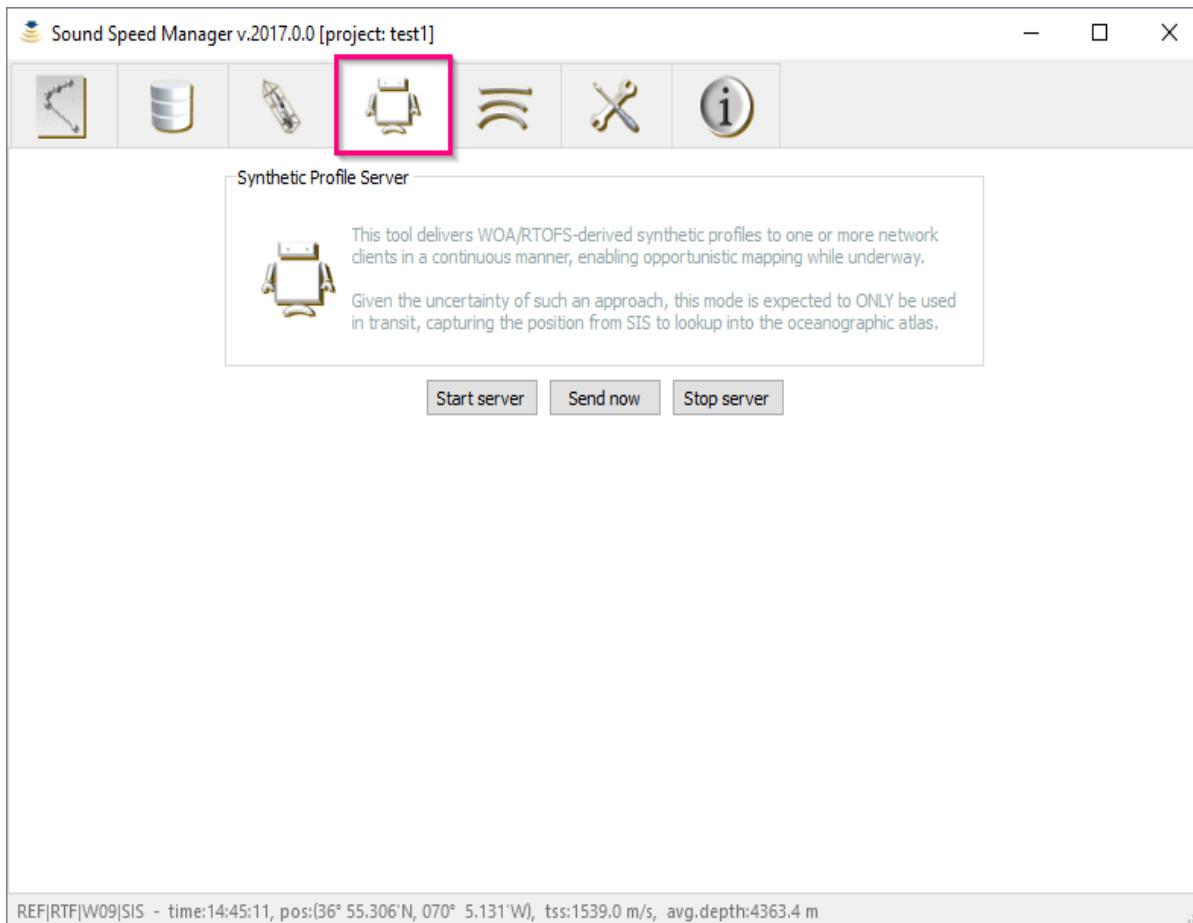


Fig. 2.27: The *Synthetic Profile Server* tab provides the controls to manage the *Server mode*.

A preliminary requirement to run the *Server Mode* is that position and surface sound speed are received from *SIS*. This can be checked by looking in the status bar.

When this mode is active, all the user's manual functionalities becomes unavailable until the *Server mode* is stopped. The last sent profile is displayed in the view panel and all three plot panels are colored green. The mode can be stopped by selecting *Stop* under the *Server* menu. Closing the application will also stop the server. To guard against accidentally overwriting a profile that was uploaded by the operator after the server was started, this mode verifies with *SIS* that nothing has been uploaded since the last synthetic cast was delivered.

If the package finds that a profile has been uploaded, either by another program or a person, it will stop serving WOA data to SIS and will notify the user.

Serving to multiple clients

For installations with multiple clients, the server will deliver the cast sequentially to all clients. Failure on transmission to one client will not interfere with other clients. Once a client is deemed “dead”, i.e., no reception confirmation is received, no further attempts to send to the client are made even if a “dead” client comes back to life (a restart is required). If all clients are deemed dead, then the server stops and notifies the user.

Note: SIS will accept and rebroadcast SVP datagrams even if it is not pinging. Thus, to make a client appearing “dead” to the server, you must shutdown SIS.

List of references

- Beaudoin, J., Smyth, S., Furlong, A., Floc'h, H., and Lurton, X., *Streamlining Sound Speed Profile Pre-Processing: Case Studies and Field Trials*, in Proceedings US Hydro Conference 2011, April 25-29, Tampa, FL, USA2011.
- Fofonoff, N. P., and Millard, R. C., 1983, *Algorithms for computation of fundamental properties of seawater*: Rep. No. 44, Division of Marine Sciences, UNESCO, Place de Fontenoy, 75700, Paris.
- Taira, K., Yanagimoto, D., and Kitagawa, S., 2005, *Deep CTD Casts in the Challenger Deep, Mariana Trench*: Journal of Oceanography, v. 61, no. 3, p. 447-454.

Note: For some examples on how to use the library: https://bitbucket.org/ccomjhc/hyo_soundspeed/src/master/examples/

Appendix A - Oceanographic Atlases

World Ocean Atlas

The World Ocean Atlas is a 3-dimensional grid of mean temperature and salinity for the world’s oceans that is based upon a large set of archived oceanographic measurements in the World Ocean Database.

More information about the World Ocean Atlas 2009 (WOA09) can be found [online](#)

The WOA09 netCDF temperature and salinity grids used by the package can be accessed from http://www.nodc.noaa.gov/OC5/WOA09/netcdf_data.html

The files required are:

- *temperature_annual_1deg.nc*
- *temperature_seasonal_1deg.nc*
- *temperature_monthly_1deg.nc*
- *salinity_annual_1deg.nc*
- *salinity_seasonal_1deg.nc*
- *salinity_monthly_1deg.nc*

Basin and land/sea masks can be downloaded from: <http://www.nodc.noaa.gov/OC5/WOA09/masks09.html>

Global Real-Time Ocean Forecast System

The Global Real-Time Ocean Forecast System (RTOFS Global) is a 1/12°, 3-D oceanographic forecast model. More information can be found online at: <http://polar.ncep.noaa.gov/global/>

Daily forecast/nowcast grids can be downloaded via the URL listed above, but the file sizes for the daily forecast are prohibitive for use at sea. Instead, the package relies on the OpenDAP portal to download only small segments of the nowcast grids for surrounding a specified query location. The downloaded subset is a 5x5 grid centered on the query location.

Synthetic cast values derived from atlases

The cast extrapolation algorithm vertically extends temperature and salinity profiles as deep as possible using the estimates immediately local to the area of the cast in either WOA or RTOFS.

WOA09-based profiles

The World Ocean Atlas 2009 (WOA09) extension algorithm uses a nearest neighbor lookup in each of the 33 depth levels in the grids within a 3x3 grid node search box centered on the cast's geographic position. This is roughly equivalent to a search radius of 1.5° or 90 nmi at the equator. Note that this grid node search box becomes rapidly narrower in the east-west direction with latitude. The nearest-neighbor geodetic distance is, however, correctly computed and the nearest neighbor will indeed be the geographically most proximal grid node; the only shortcoming is that the lookup will ignore potentially closer data in the east-west direction at high latitudes.

Future updates to the WOA09 extraction algorithms will remedy this shortcoming. The search radius is set this large to enable the extension to at least estimate deeper temperature and salinity values in the case where the true depth at the requested location is significantly larger than the coarse depth reported in the WOA09 grid for that location (the WOA09 grid depth will generally always be smaller than the true depth).

The search algorithm will not respect topographic boundaries and may extrapolate profiles using data from a neighboring oceanographic basin. Future versions of the algorithm will address this shortcoming as well, likely with the use of the basin mask file provided with the WOA09 data set.

WOA13-based profiles

WOA13 represents the ocean state variables of temperature and salinity with more detail and less uncertainty than WOA09 due to large increases in data holdings and better temporal and spatial coverage coupled with refined analysis and quality control techniques:

- Increased vertical resolution (3x in the upper ocean, 2x below 1500 m.)
- Increased spatial resolution (16x)
- Release of the decadal climatologies which were used to calculate the final 1955-2012 long-term climatological mean fields.

In the specific, the package uses the WOA13v2 release that was prepared to address both methodology concerns and, to a lesser extent, quality control concerns which have surfaced since the initial release of WOA13.

RTOFS-based profiles

The RTOFS extension algorithm differs in the size of the search area (5x5), roughly equivalent to a search radius of 0.2° or 12.5 nmi at the equator. All of the shortcomings of the WOA09 lookup described above also apply to the RTOFS lookup.

The final extrapolation to a depth of 12,000 m is done using the values measured by (*Taira et al., 2005*) in Challenger Deep. This could be improved by searching for the nearest neighbor grid node at the deepest level observed in the basin using the basin mask file.

Appendix B - Connection Settings

Settings for data reception

Moving Vessel Profiler

The MVP controller interface can be configured to transmit data via UDP using a variety of data format and transmission protocols (*Figure – MVP Controller configuration dialog. Boxes A through C are required for transmission of cast information. Box D can be configured to transmit sensor data.*).

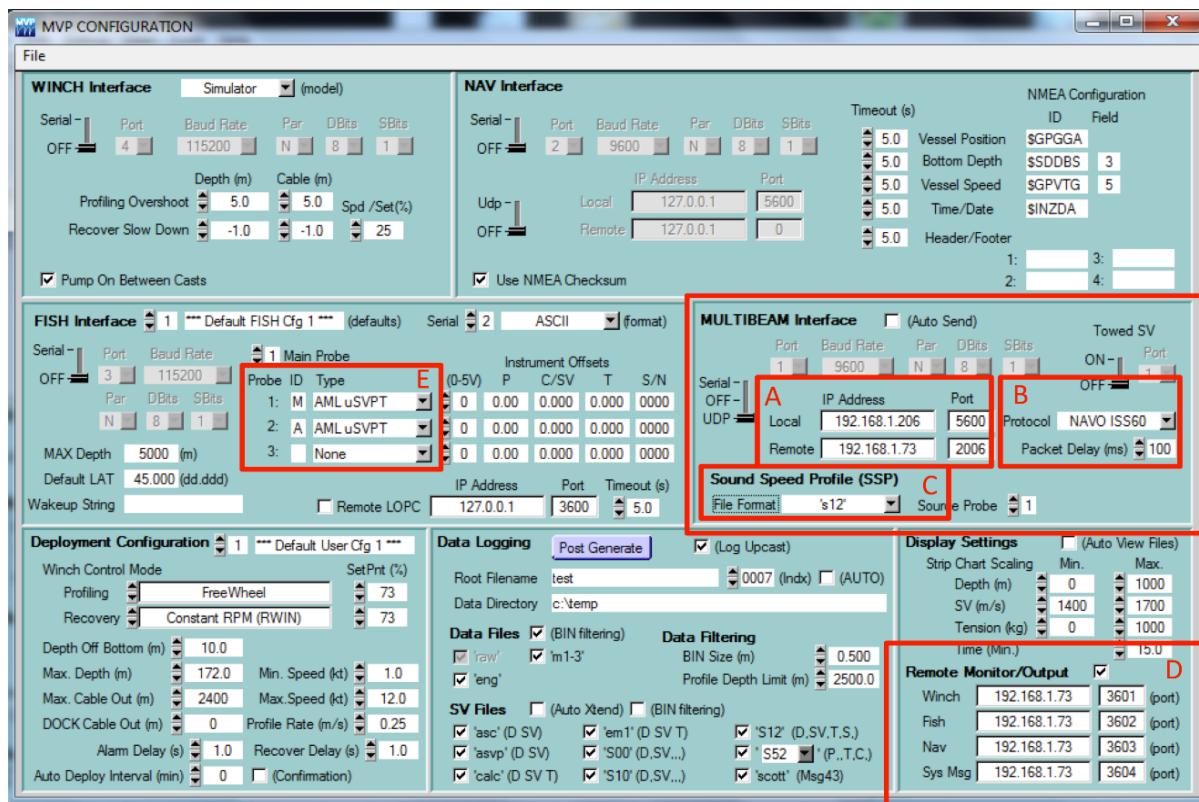


Fig. 2.28: Figure – MVP Controller configuration dialog. Boxes A through C are required for transmission of cast information. Box D can be configured to transmit sensor data.

The MVP computer IP address and the IP address of the machine running the SSP package can be configured in *Box A*. For newer versions of the MVP controller, it is recommended to choose the NAVO_ISS60 transmission protocol as this will allow for large cast files to be transmitted in several packets without overflowing the UDP maximum

packet size limitation (*Box B*). Older versions of the MVP controller software (up to version 2.35 to the best of our knowledge) do not support the NAVO_ISS60 protocol and the package must be configured to use the UNDEFINED protocol in the SSP package configuration file. The file format can be adjusted to accommodate a CTD with the S12 format or a sound speed sensor with the CALC or ASVP formats (*Box C*).

Note that the transmission protocol and file format must be configured in both the MVP controller interface and in the *Listeners* sub-tab of the *Setup* tab.

Boxes D and E refer to raw instrument transmission settings that are configurable for future use. Since casts received from an MVP system do not have a filename embedded in the data stream, the *Sound Speed* package will name casts received using the following convention: YYYYMMDD_HHMMSS_MVP. The date/time stamp embedded in the filename will be the time of the cast.

Sippican

There does not currently exist any internal mechanism in the Sippican software to broadcast data via UDP, this capability has been included to accommodate vessels that use UDP network broadcasts to log data from various systems. The expected data format is the Sippican native .EDF file format.

Note that a single Sippican data file can sometimes exceed the maximum buffer size for UDP packet transmissions. If software is written to transmit Sippican data files via UDP, this limitation should be kept in mind. The *Sound Speed* package currently only accepts transfer of a single UDP packet thus transmission software may need to reduce the data by thinning the profile. Received profiles will use the filename embedded in the .EDF.

Settings for data transmission

The *Sound Speed* package can be configured to transmit data to a number of systems by selecting the *Transmit data* button in the *Editor* tab.

For installations with multiple clients, the *Sound Speed* package will deliver the cast sequentially to all clients. Failure on transmission to one client will not interfere with other clients though it will slow down the transmission sequence through all clients for any clients who are timing out on confirmation of reception as the *Sound Speed* package will wait up to the ‘RX timeout’ value defined in the setup (default: 20 seconds) for confirmation.

Note: Server mode will only currently work with the *SIS* transmission protocol.

Kongsberg SIS

SIS does not require additional configuration to receive sound speed files since it always listens on port 4001 for input sound speed data.

The following indications are useful for monitoring reception of sound speed profiles:

- The SSP profile filename will be updated in the Runtime parameters menu in the form: YYYYMMDD_HHMMSS .asvp. The date and time fields are populated based on the time stamp in the profile that was received from the SSP package. In the case of measured casts, this is the time of acquisition, as found in the input file. In the case of synthetic WOA profiles, the date/time is based on the time of transmission of the cast (using the computer clock where the SSP package is installed).
- *SIS* creates several files in the last location from which it loaded a sound speed profile.
- The SVP display window, if being viewed in *SIS*, will update with the new cast.
- In the event that a cast is rejected, *SIS* will launch a warning dialog to indicate that the cast it received was rejected.

Although *SIS* always will allow incoming sound speed transmissions, it has several restrictions that must be observed in order for the data to be accepted (see *Kongsberg manual*). As this particular transmission protocol is used by other acquisition systems, it is worth describing in detail what the *Sound Speed* package does to the cast data to satisfy the input criteria for *SIS*.

The transmission procedure used by the SSP package will format the temperature and salinity profiles into the Kongsberg Maritime format. Since the WOA09/RTOFS grids only extend to a maximum depth of 5,500 m, the profile undergoes a final extrapolation to a depth of 12,000 m to satisfy *SIS* input criteria, this is done with temperature and salinity values measured in the Mariana Trench by *Taira et al. (2005)*.

Since *SIS* input profiles have a limit on the maximum allowable number of data points, the sound speed profile is thinned using a modified version of the Douglas-Peucker line reduction method as described by *Beaudoin et al. (2011)*. The algorithm begins with a small tolerance and increases it linearly until the number of points in the profile falls below the maximum allowed by *SIS*.

By default, the cast header is formatted to instruct *SIS* to accept the profile for immediate application without launching the *Kongsberg SVP Editor*. This behavior can be changed through the configuration file by setting *Auto apply profile* to *False* (in the *Setup* tab). In this case, *SIS* will accept the cast but will then launch its own editor interface and user interaction will be required on the *SIS* computer in order to have the cast applied to the multibeam system.

Once the cast has been prepared for transmission, it is sent to *SIS* via UDP transmission over the network. If *SIS* receives the profile and accepts it, it will rebroadcast the SVP datagram. The *Sound Speed* package waits for this rebroadcast to ensure reception of the cast. The profile that was re-broadcasted from *SIS* is compared against that which was sent. If they match, then the transmission is considered successful. If there is a discrepancy, or if no rebroadcast profile is received, the user is notified that reception could not be confirmed. The lower left status bar notifies the user of the various stages of this verification process.

In deep water, the rebroadcast event may take several seconds to occur and the software will wait up to a user-defined amount of time (e.g., 20 seconds) for reception of the re-broadcasted SVP. All other package functionalities are suspended during this wait period.

Hypack

The *Sound Speed* package can transmit data to *HYPACK* using *HYPACK*'s driver for Moving Vessel Profiler (MVP) systems (*MVP.dll*). Next figures provide a guidance on how to configure a Hypack project to receive data from SSP package.

QINSy

QINSy accepts the same SVP transmission protocol as *SIS*, but a method to verify reception of the cast is not currently known thus the user should confirm reception in the acquisition system.

PDS2000

PDS2000 accepts the same SVP transmission protocol as *SIS*, but a method to verify reception of the cast is not currently known thus the user must confirm reception in the acquisition system.

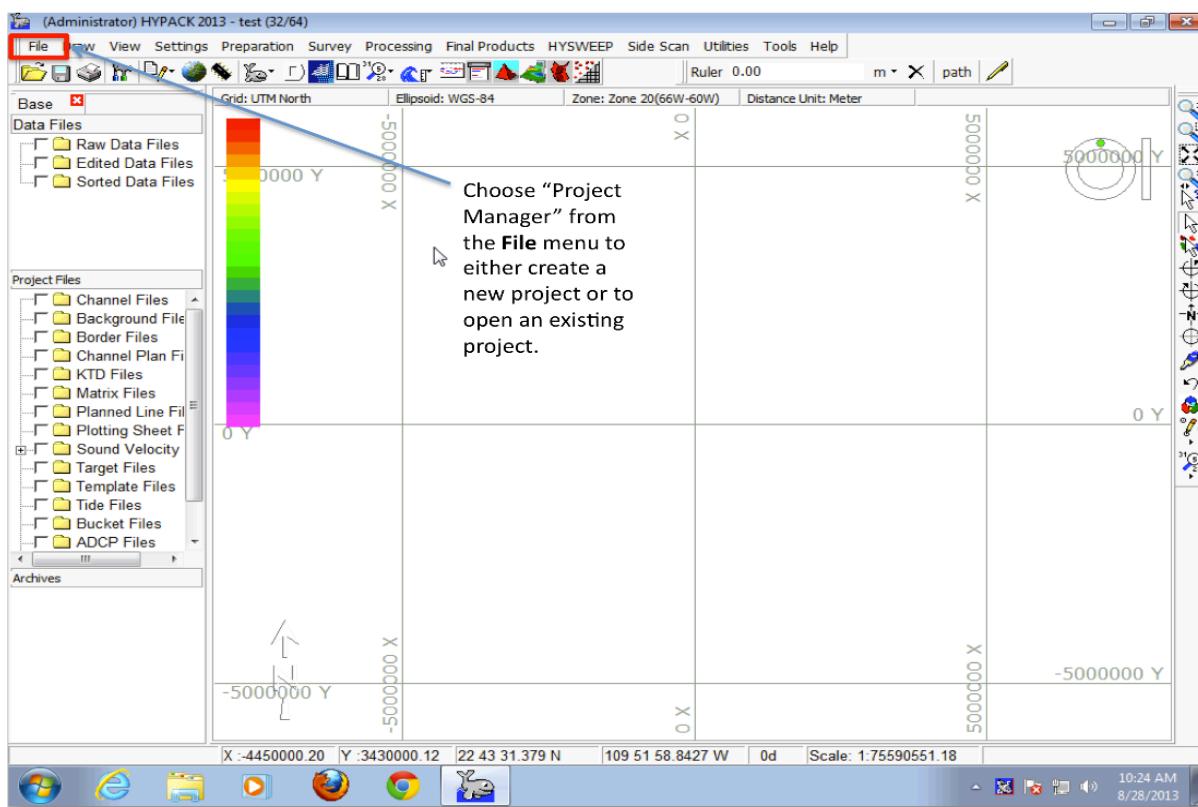


Fig. 2.29: Step 1: opening the project manager.

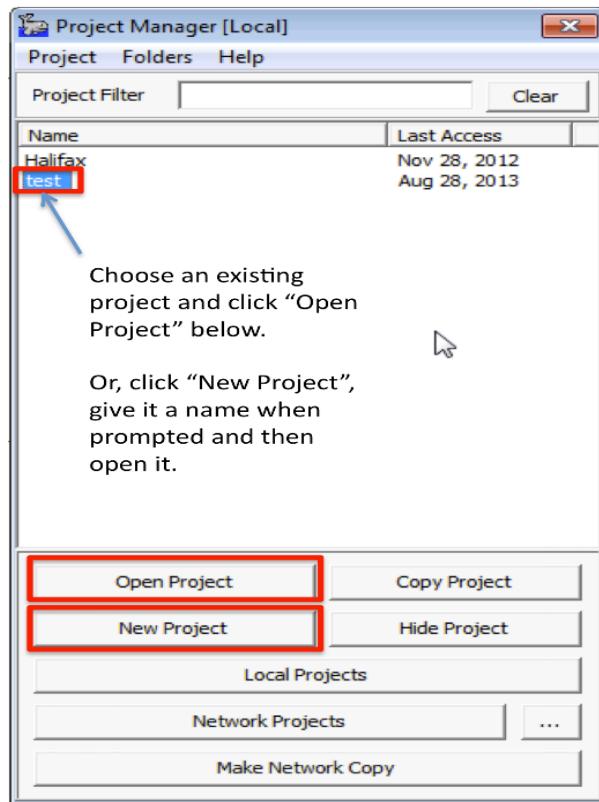


Fig. 2.30: Selecting or creating a Hypack project.

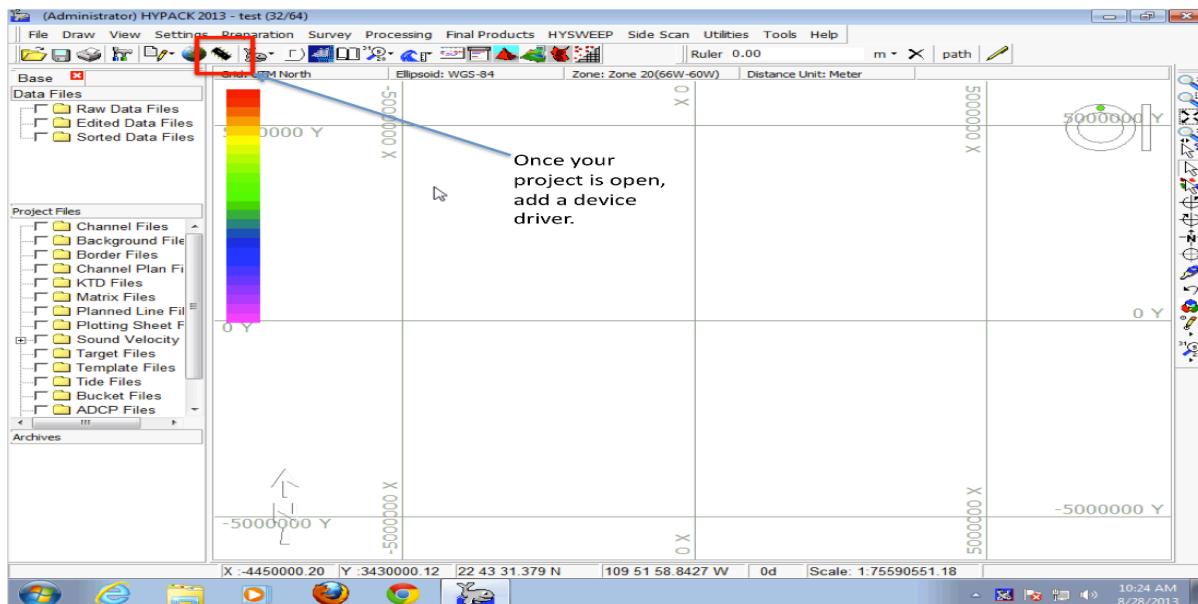


Fig. 2.31: Selecting the Add device button.

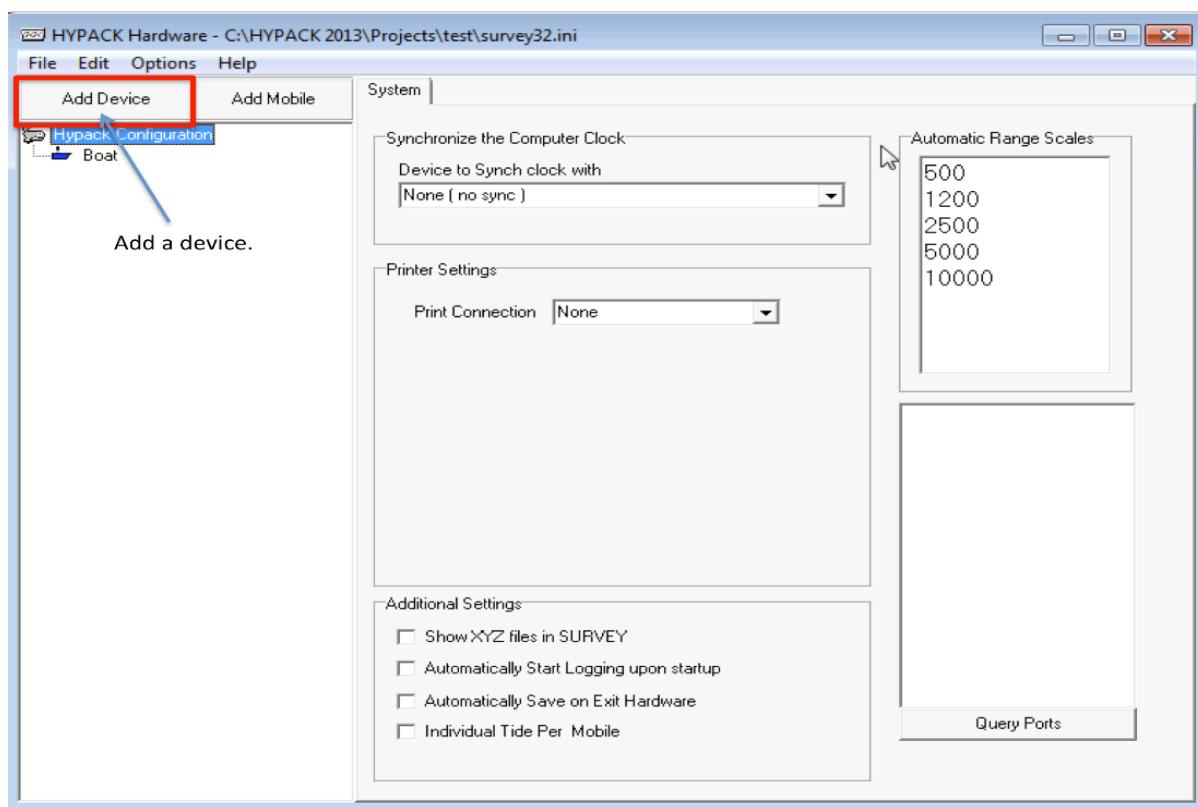


Fig. 2.32: Adding device drivers to a Hypack project.

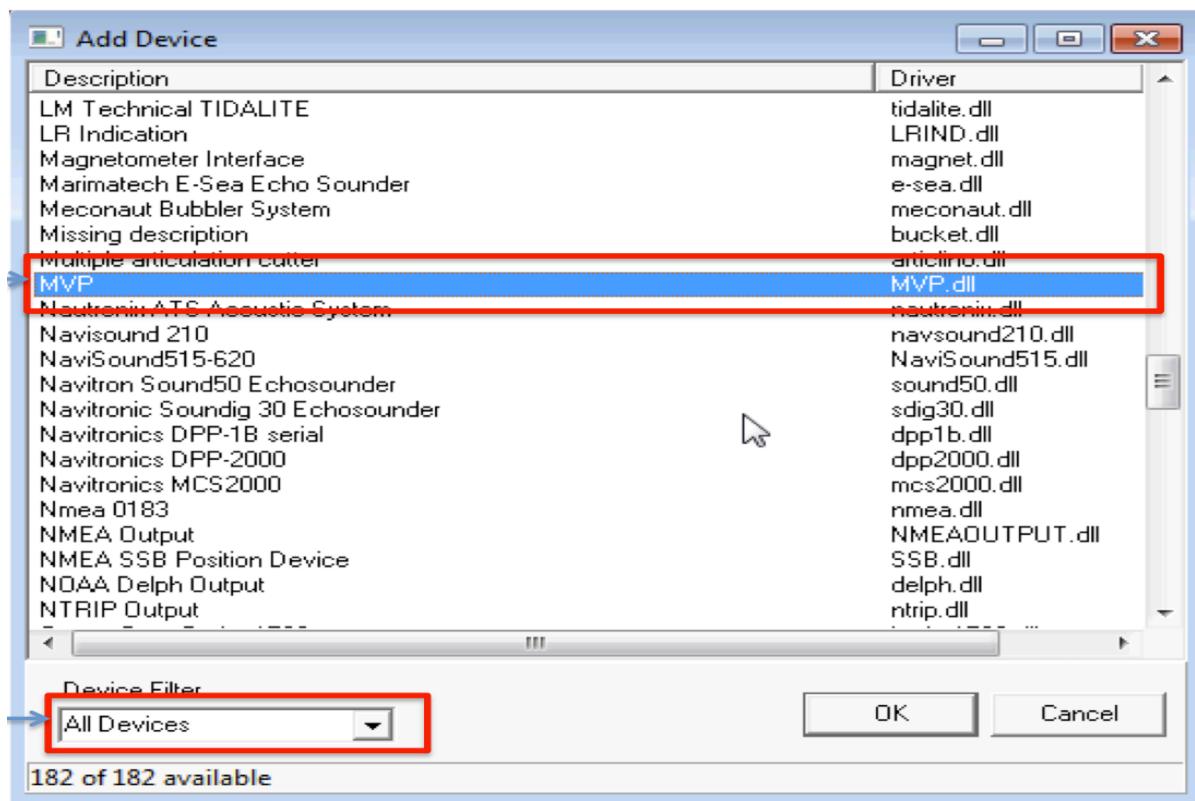


Fig. 2.33: Adding the MVP device driver.

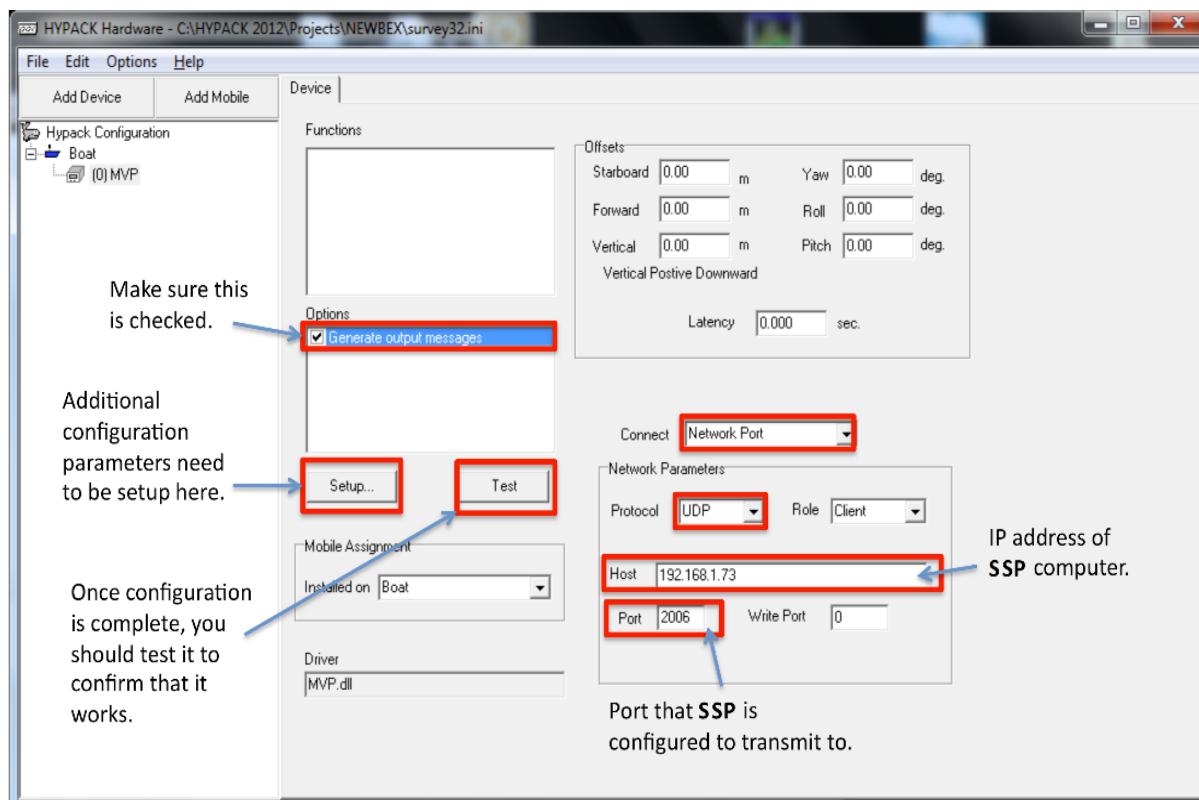


Fig. 2.34: Configuring the MVP driver. The network parameters of the driver are configured to use a UDP input protocol in a client role. The host IP address must match the address used by the computer running SSP and the reception port must match the port configuration chosen in the package configuration file. The “Write Port” is left as zero.

Optional, but handy to verify in real-time that a cast was received.

Make sure this is checked.

Choose a base filename.

Optional, but handy to for file management.

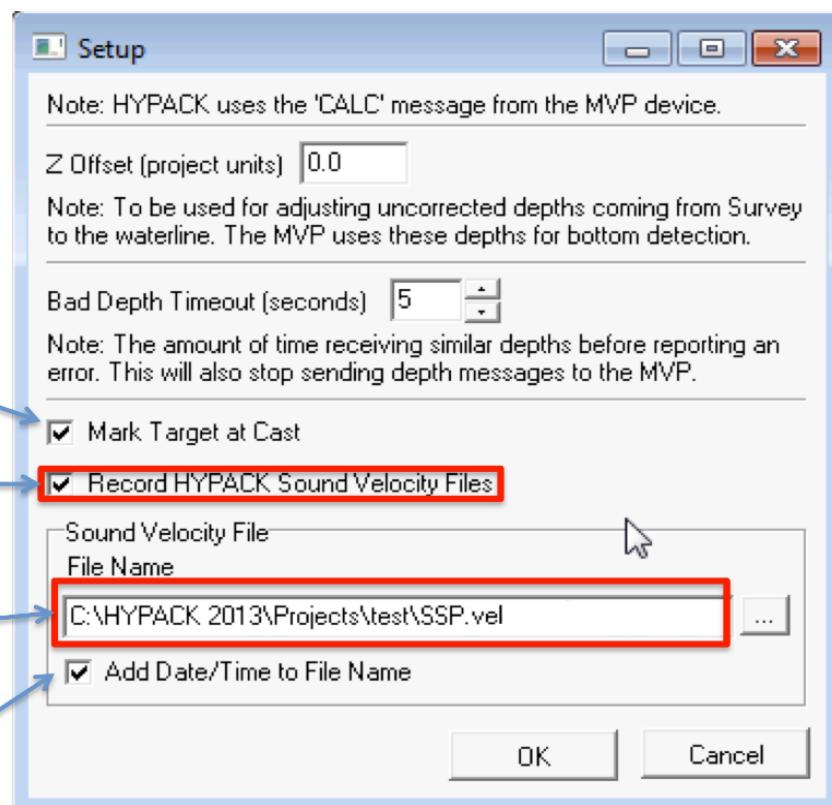


Fig. 2.35: Additional configuration of the MVP device driver.

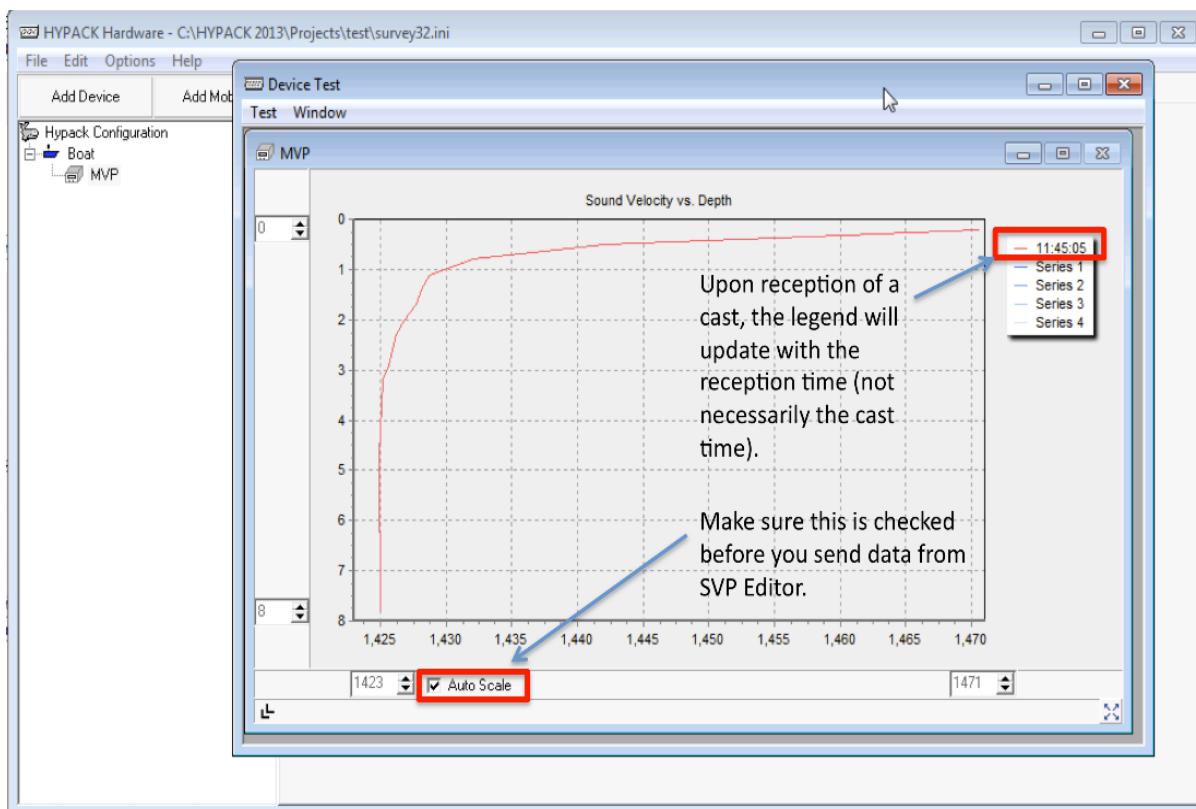


Fig. 2.36: Testing reception capabilities in Hypack. After having loaded a sample cast into SSP and send it, the profile should be visualized in Hypack (after clicking “Test” button).

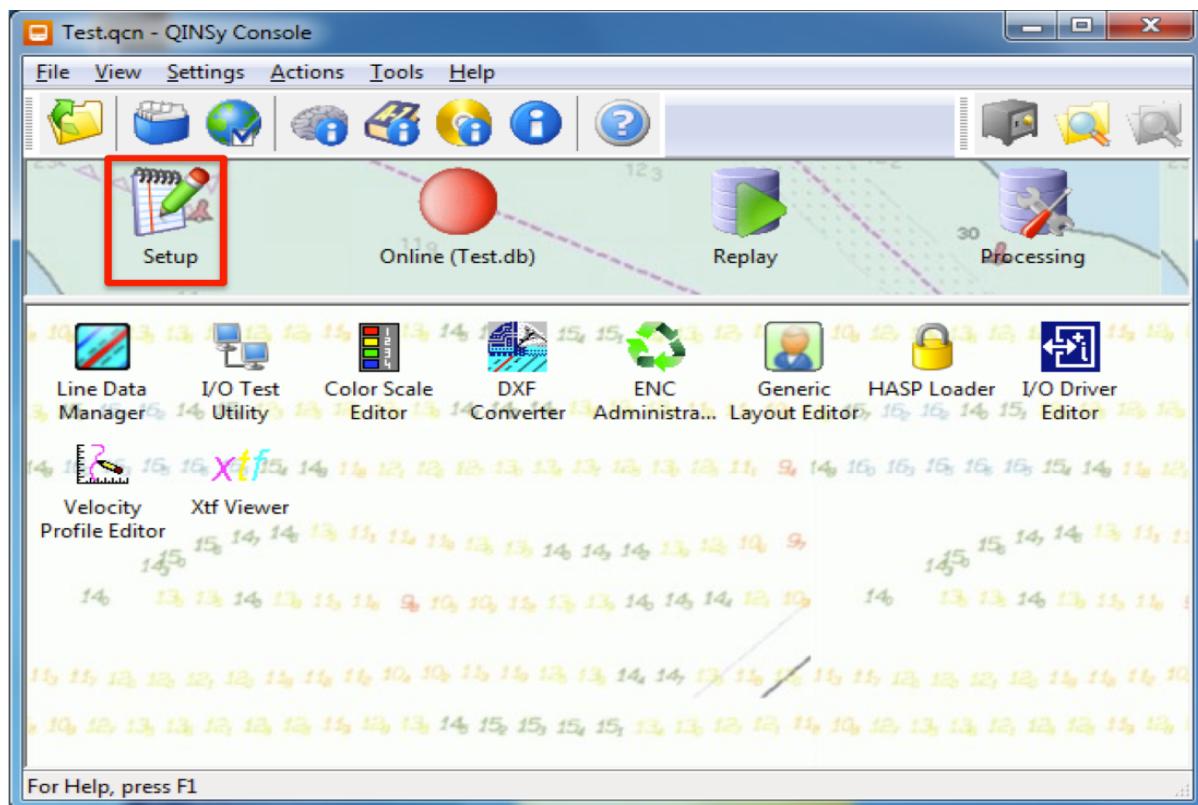


Fig. 2.37: Select *Setup* from the QINSy console after loading your project. Refer to QINSy documentation for information regarding setting up a project.

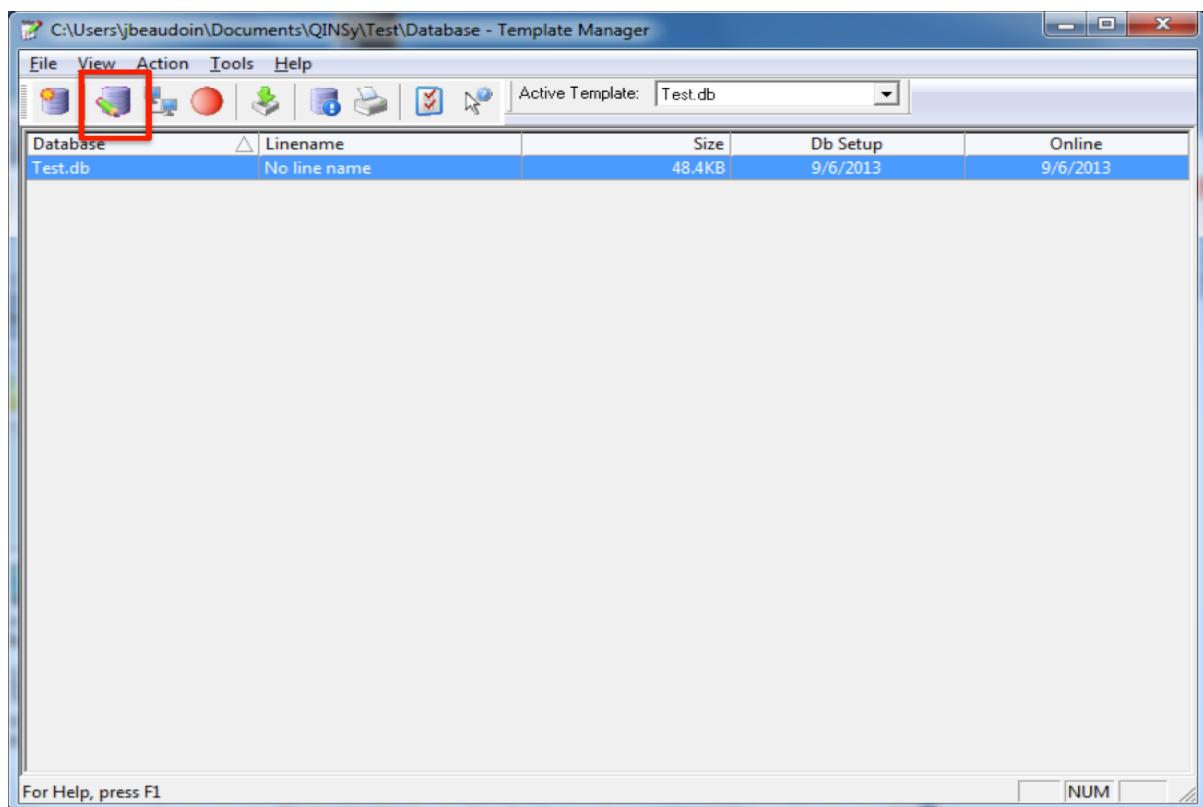


Fig. 2.38: Edit your project database

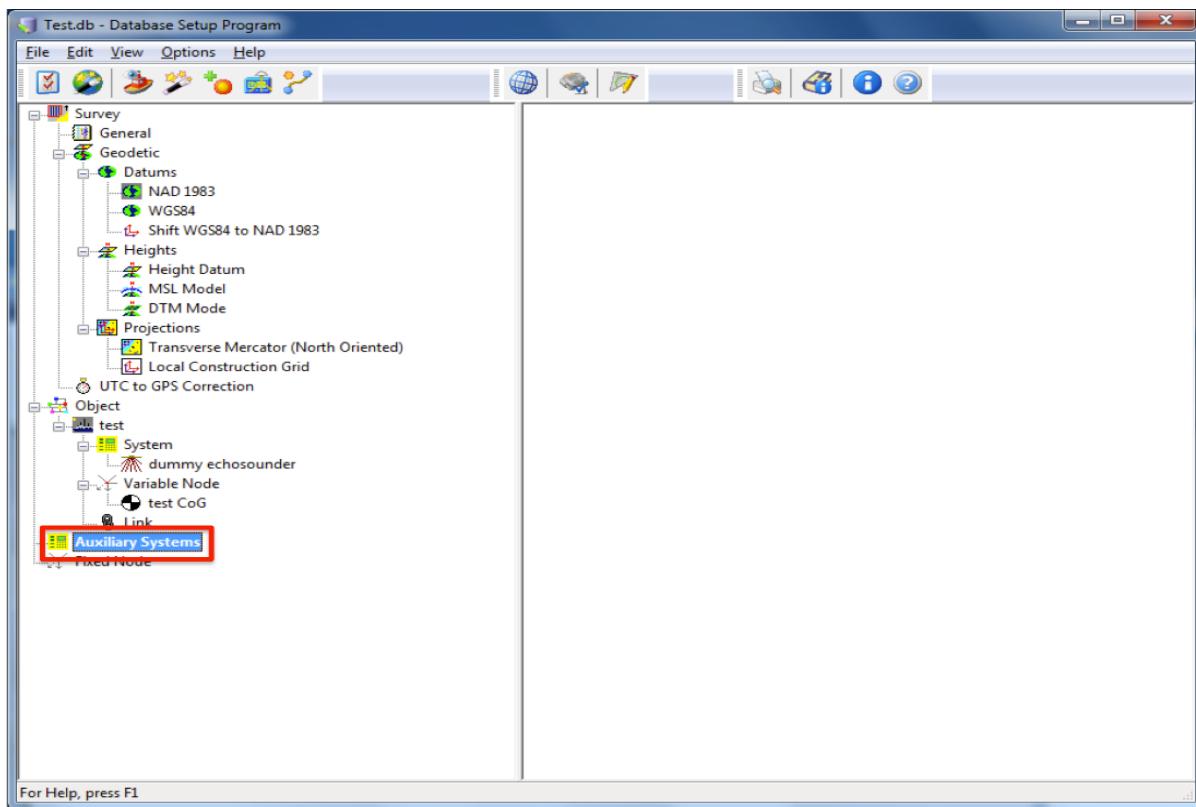


Fig. 2.39: Right click the *Auxiliary Systems* icon and select *New System*.

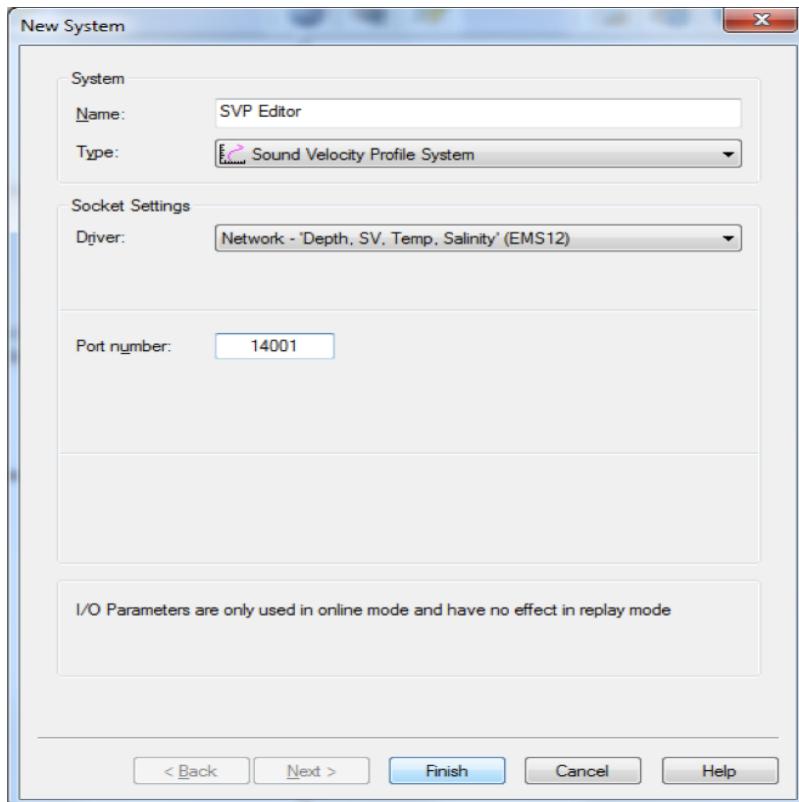


Fig. 2.40: Configure the new system as shown above. Choose the same port number that SSP package will be sending casts to (this is configured in the `__config__.db` file).

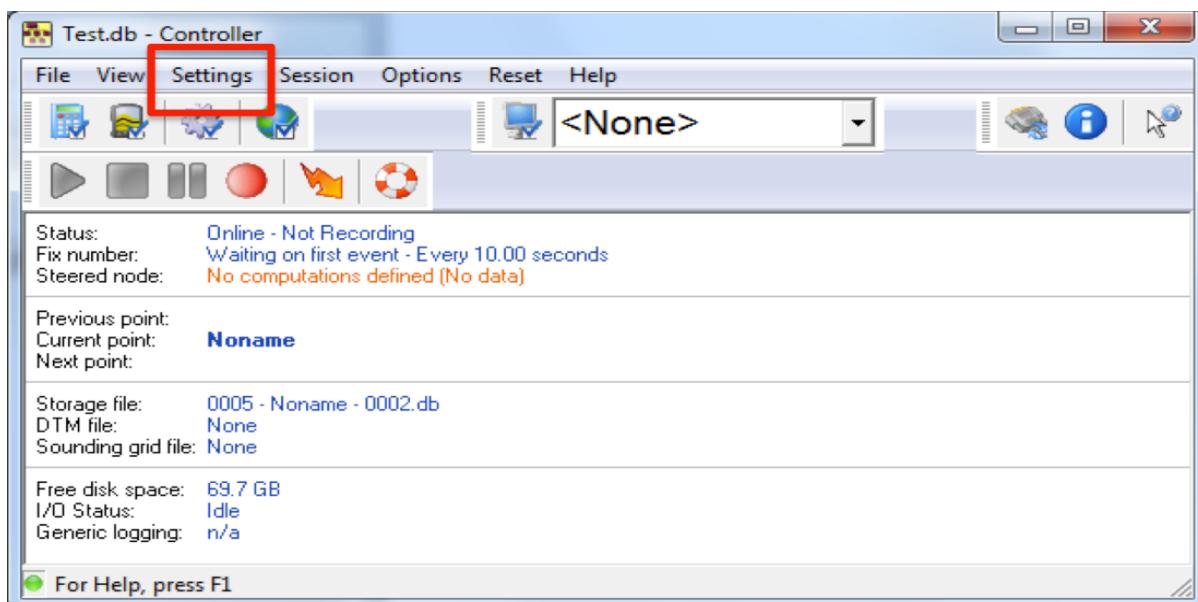


Fig. 2.41: Choose *Echosounder Settings* from the *Settings* menu. This will allow you to configure the behavior of QINSy when it receives new sound speed profiles from SSP package.

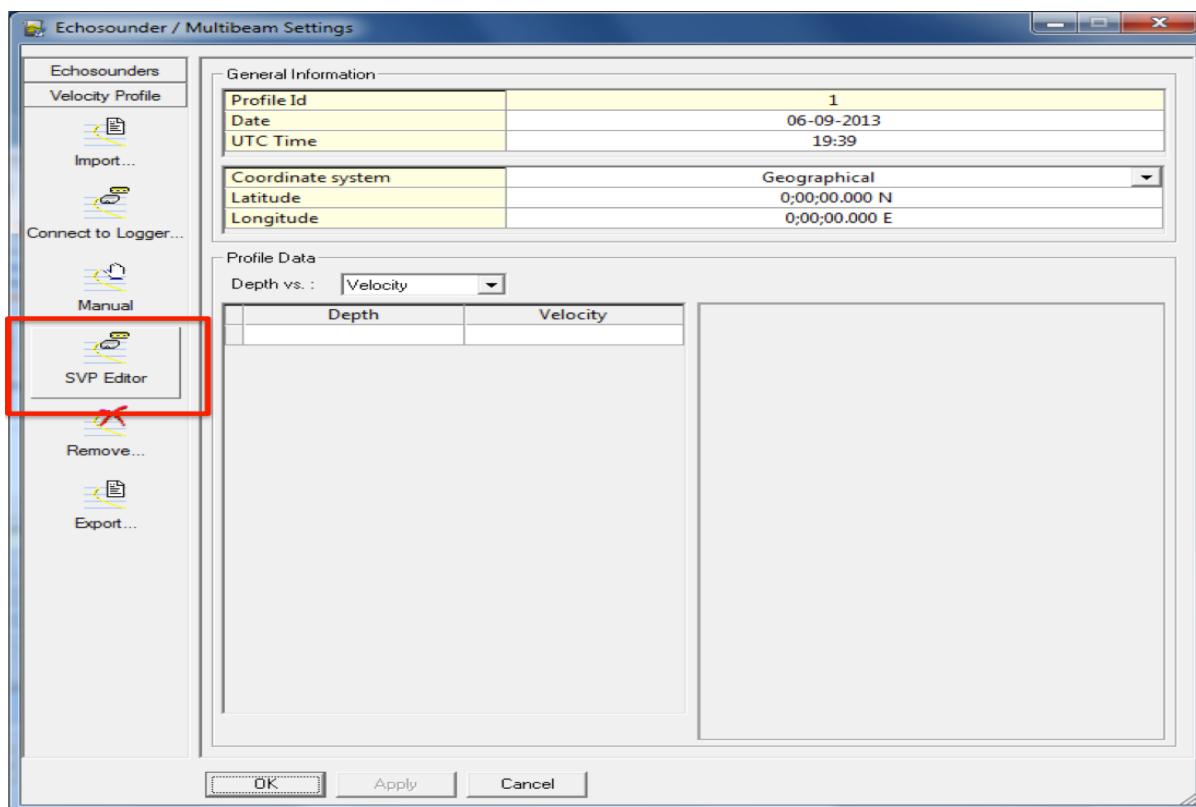


Fig. 2.42: Leftclick the icon for the *SVP Editor* device.

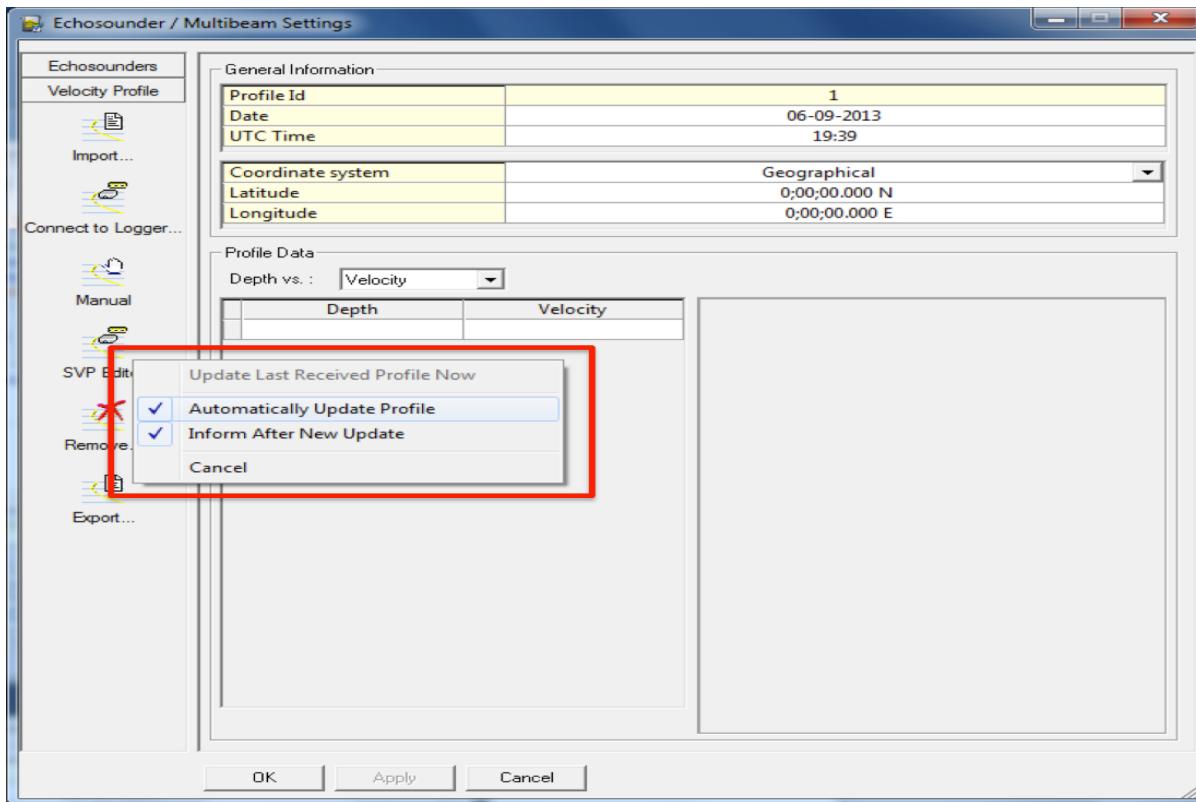


Fig. 2.43: Choose appropriate options to control QINSy's behavior when it receives casts from SSP package. For initial testing purposes, you should at least choose to be informed after a new update.

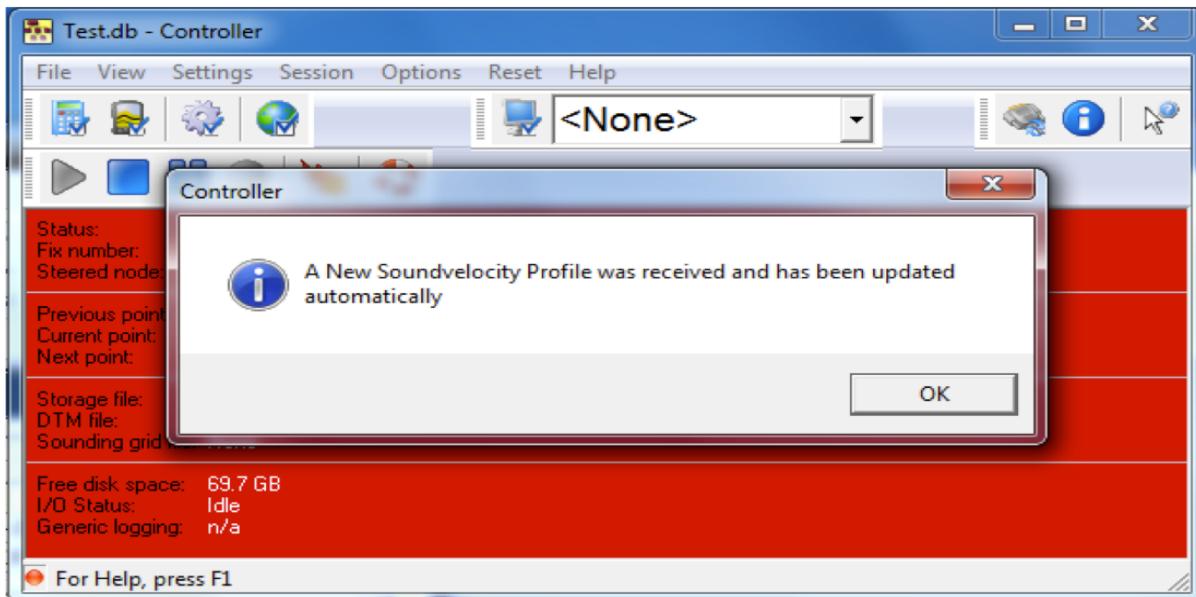


Fig. 2.44: With QINSy “online” and recording, send a test profile from SSP package. If you have chosen to be informed upon reception of a new cast, a message window will appear for acknowledgement.

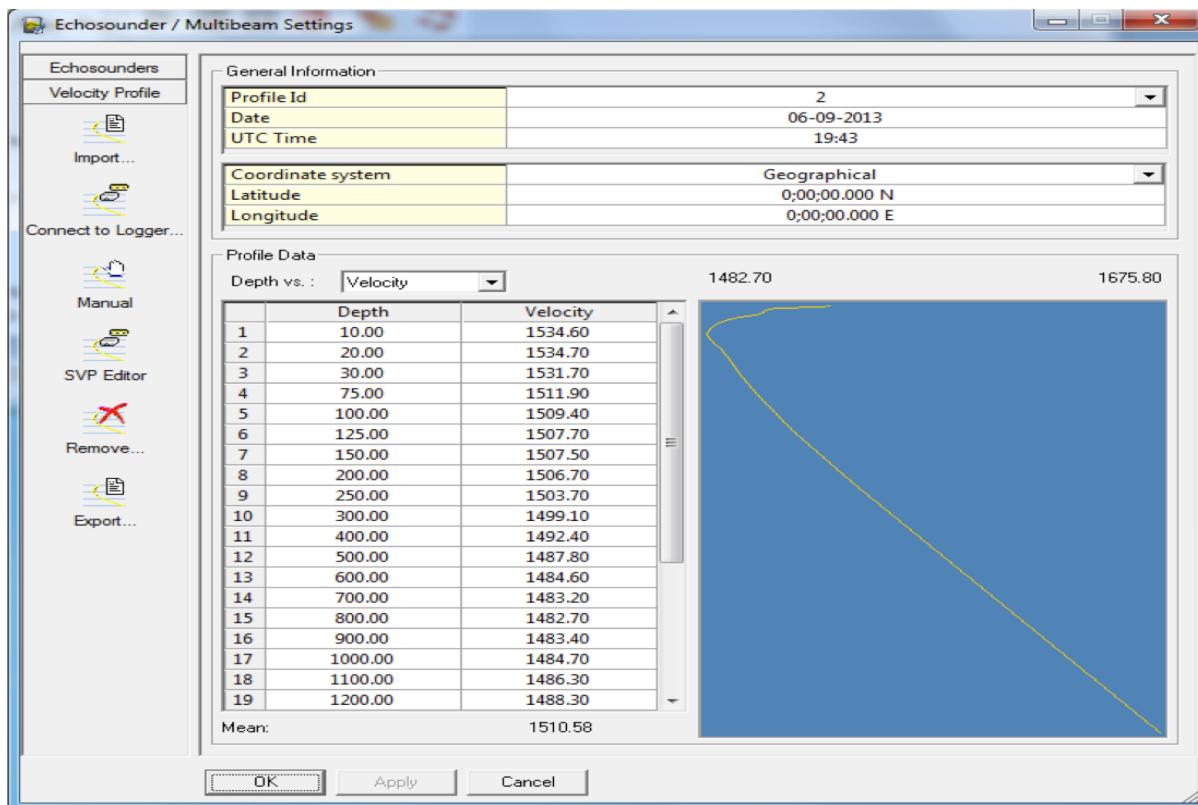


Fig. 2.45: By choosing *Echosounder Settings* from the *Settings* menu again, you can verify that the cast was received.

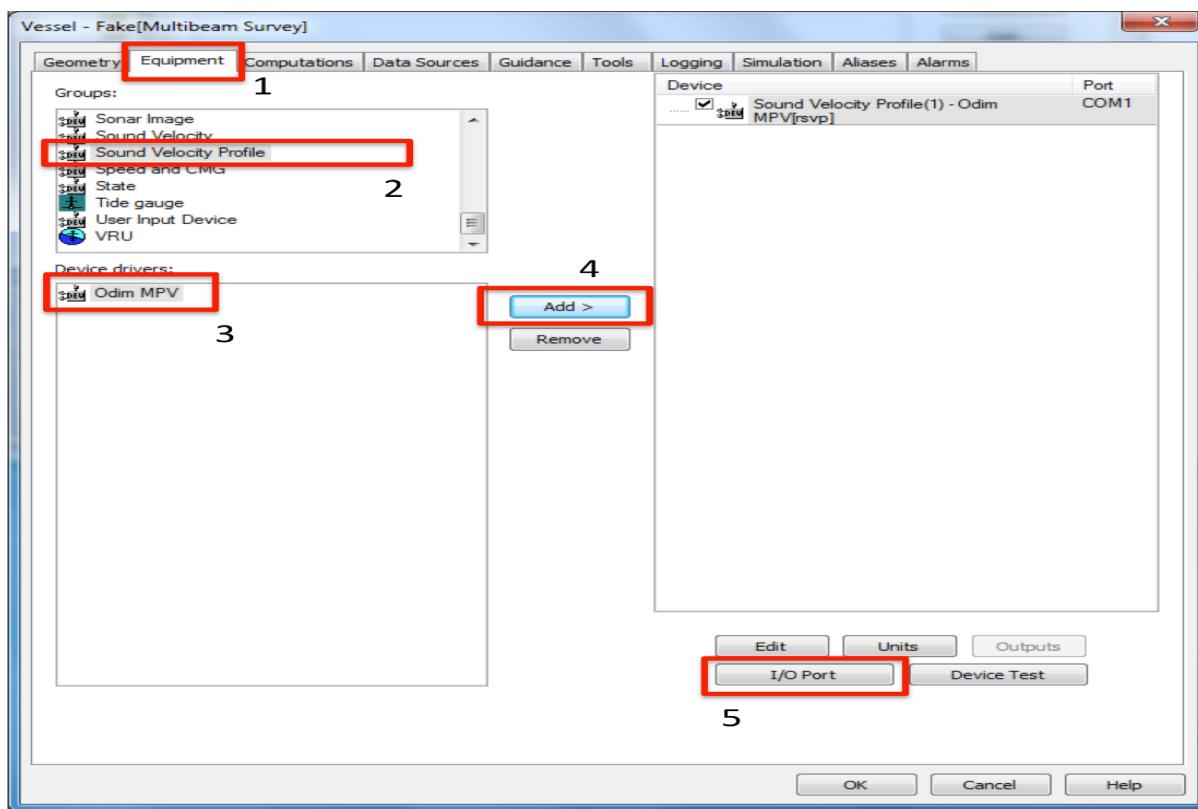


Fig. 2.46: Adding an MVP driver to PDS2000.

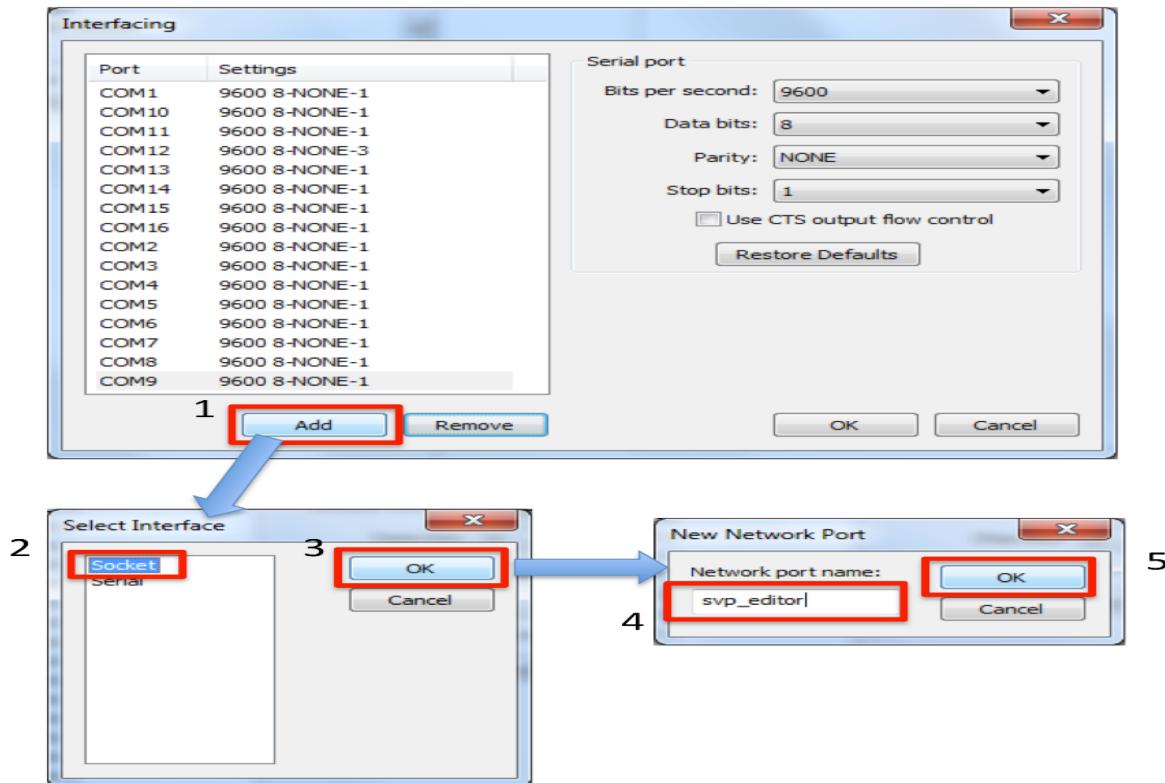


Fig. 2.47: Configuring the MVP driver for PDS2000.

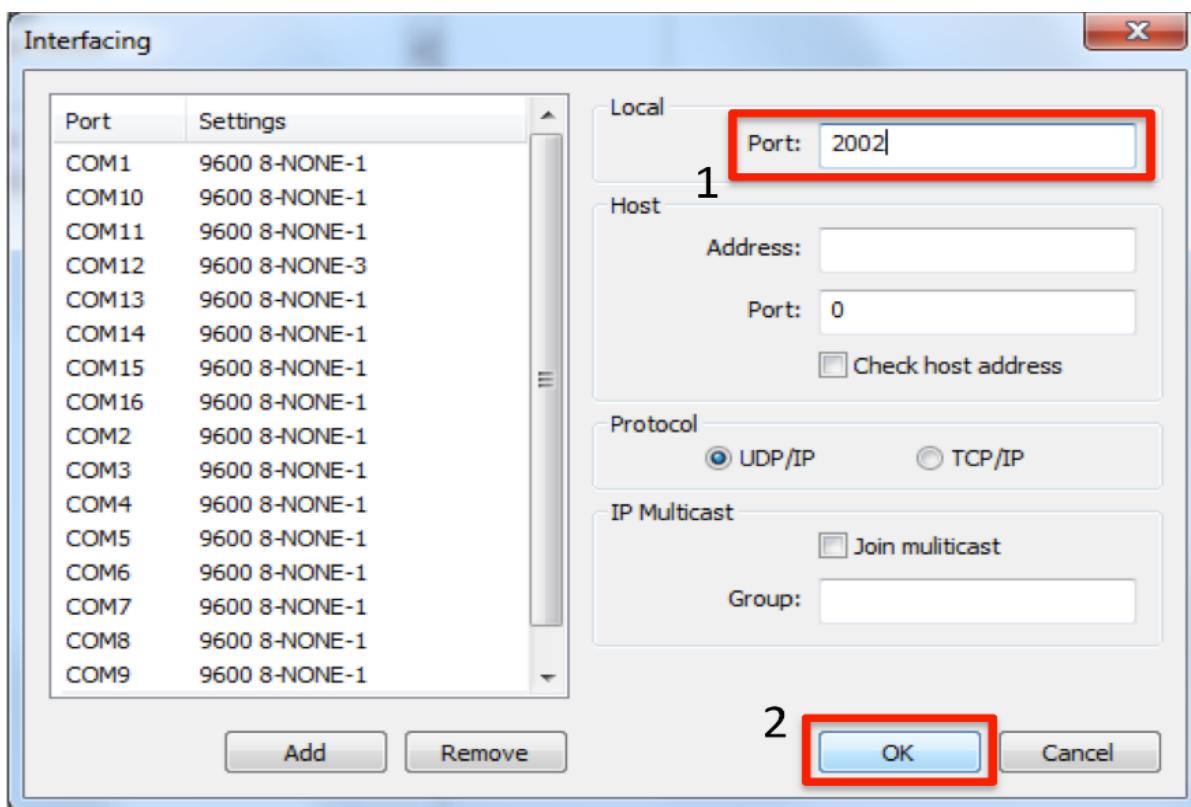


Fig. 2.48: Configuring an MVP driver for PDS2000. Be sure to scroll down in the list on the left side and choose the driver you added in the previous step before modifying the port number. The port number must match that which SSP package is sending data to (configured in the `__config__.db` file).

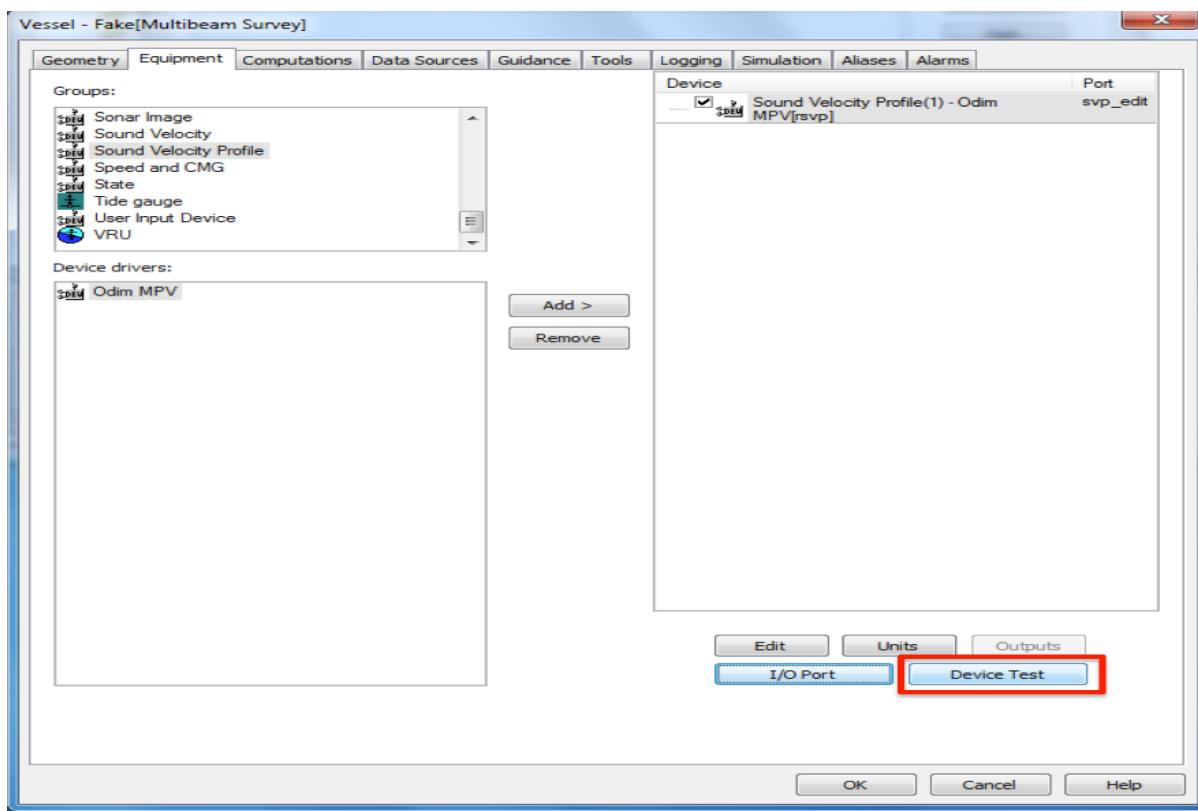


Fig. 2.49: After the driver is added, test the device to verify correct configuration of communication protocols.

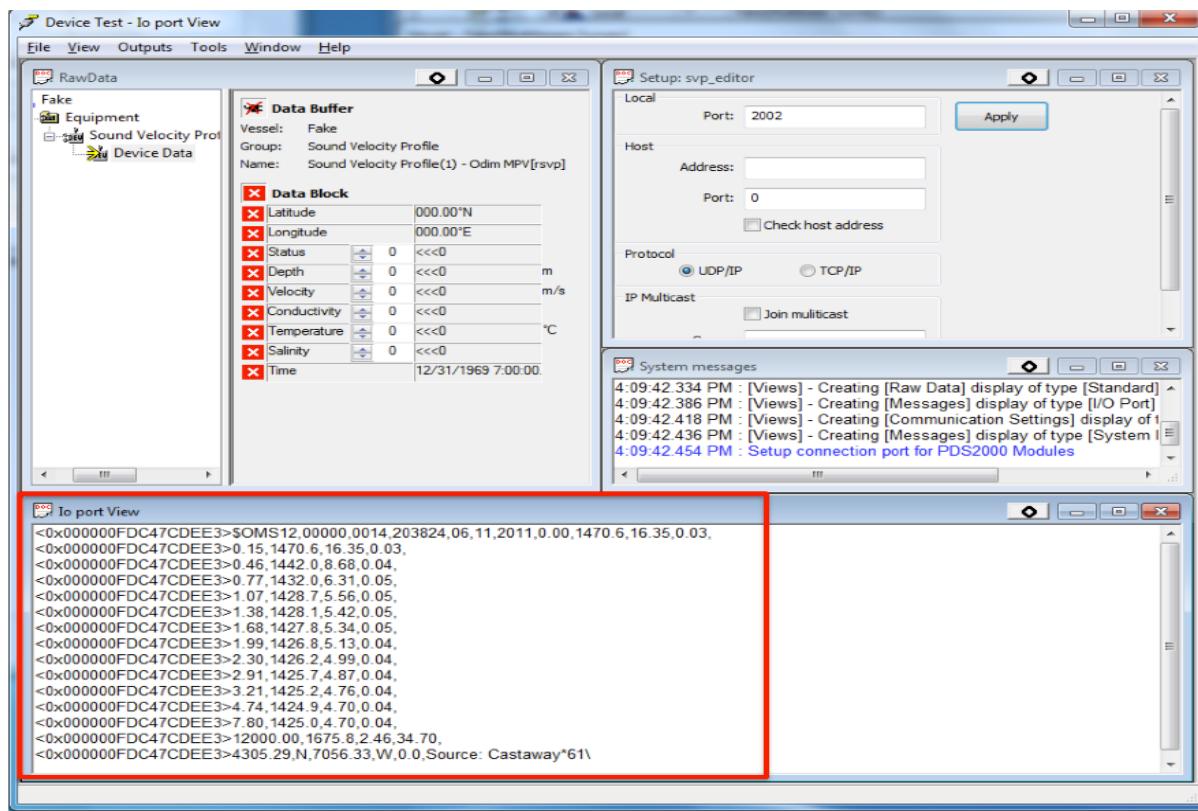


Fig. 2.50: With the device driver open, send a test cast from SSP package. The data should appear in the Io port View window. Be sure that the correct device driver is selected from the top left list window.

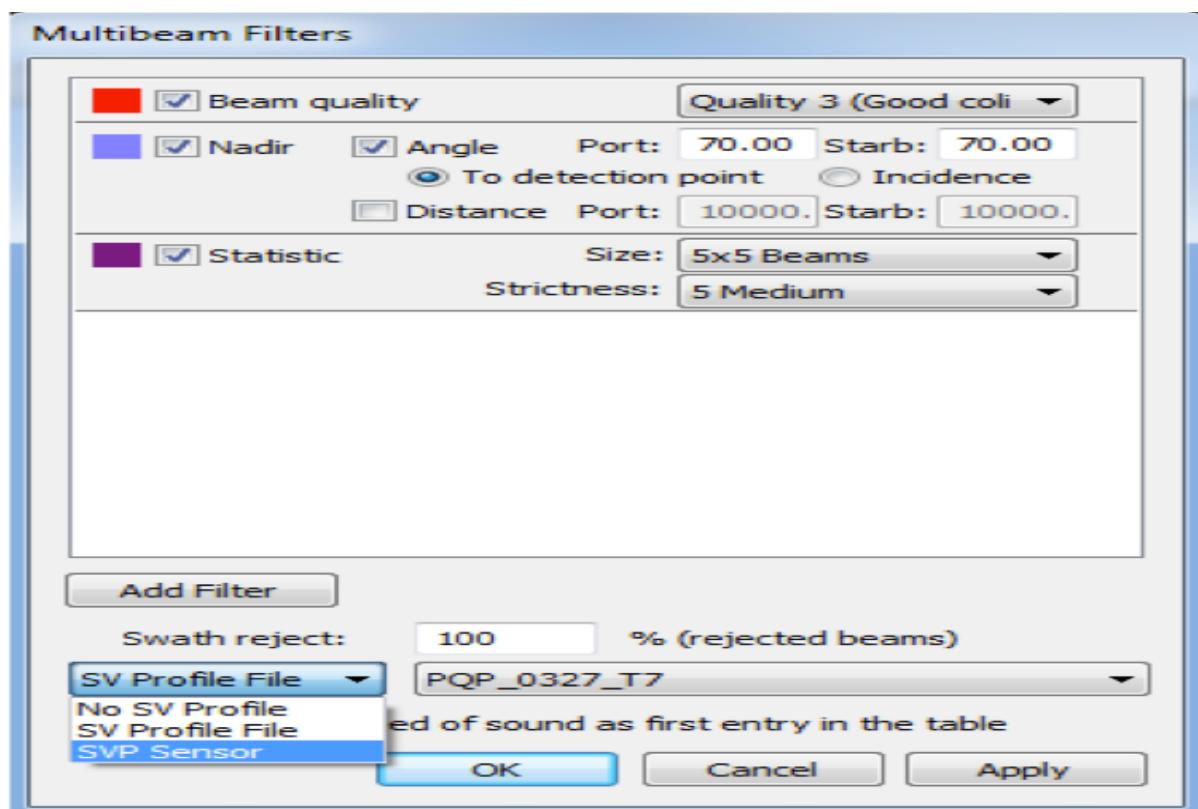


Fig. 2.51: While running PDS2000 in acquisition mode, right click in the multibeam raw profile display and choose “Multibeam filters”. Choose “SVP Sensor” as the source of sound speed profiles to be used.

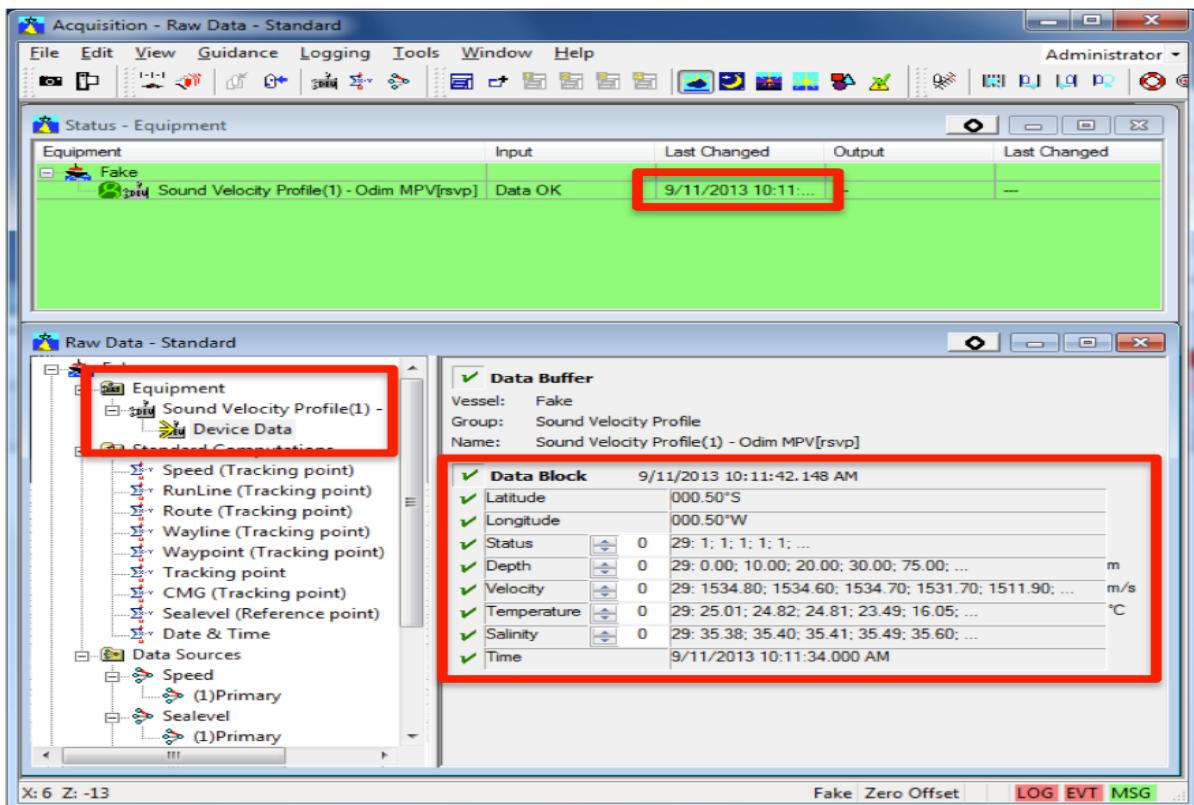


Fig. 2.52: While running PDS2000 in acquisition mode, you can verify reception in the Status displays and the “Raw Data” displays. Check the date, time, latitude, longitude against what you sent from SSP package.

DEVELOPER'S GUIDE

How to contribute

Every open source project lives from the generous help by contributors that sacrifice their time and this is no different. To make participation as pleasant as possible, this project adheres to the [Code of Conduct](#) by the Python Software Foundation.

Here are a few hints and rules to get you started:

- Add yourself to the [AUTHORS.txt](#) file in an alphabetical fashion. Every contribution is valuable and shall be credited.
- If your change is noteworthy, add an entry to the [changelog](#).
- No contribution is too small; please submit as many fixes for typos and grammar bloopers as you can!
- Don't *ever* break backward compatibility.
- *Always* add tests and docs for your code. This is a hard rule; patches with missing tests or documentation won't be merged. If a feature is not tested or documented, it does not exist.
- Obey [PEP 8](#) and [PEP 257](#).
- Write [good commit messages](#).
- Ideally, [collapse](#) your commits, i.e. make your pull requests just one commit.

Note: If you have something great but aren't sure whether it adheres – or even can adhere – to the rules above: **please submit a pull request anyway!** In the best case, we can mold it into something, in the worst case the pull request gets politely closed. There's absolutely nothing to fear.

Thank you for considering to contribute! If you have any question or concerns, feel free to reach out to us (see [Credits](#)).

How to build the documentation

Requirements

The documentation is built using `sphinx`, so you need to have it:

- `pip install sphinx sphinx-autobuild`

First-time creation of documentation template

Just once for each project, you can create the documentation template as follows:

- mkdir docs
- cd docs
- sphinx-quickstart

Generate the documentation

To create the html

- make html

How to distribute

Requirements

To bump the version, you need bumpversion:

- pip install bumpversion

Update the version

Once installed, you can run something like:

- bumpversion --allow-dirty --new-version 0.1.4.dev0 patch.

The above release value should then match with the variable `version` present in the `conf.py` under the `docs` folder.

How to freeze

- pyinstaller --clean -y freeze\SoundSpeedManager.1file.spec
- pyinstaller --clean -y freeze\SoundSpeedManager.1folder.spec

Todolist

Sound Speed

- Implement Fugro format
- Fix too many/few points in DP algorithm

Manager

- Plot x-y for additional fields
- Display a ‘-‘ close to tss, draft and bottom
- Rethink the Refraction Monitor

Research

- Evaluate when server mode is appropriate
- Planning tool: how many xbt?
- Real-time estimation of variability

**CHAPTER
FOUR**

LICENSE

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CHAPTER

FIVE

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Sound Speed library and manager are based on an ongoing joint development between the NOAA's [Office of Coastal Survey](#) and UNH's [Center for Coastal and Ocean Mapping](#).

HydrOffice Sound Speed is developed and maintained by:

- Giuseppe Masetti
- Barry Gallagher
- Brian R. Calder
- Chen Zhang
- Matthew J. Wilson
- Jack Riley

Feel free to contact us for comments and suggestions.

For bugs and feature requests: hydroffice.soundspeed@ccom.unh.edu

- genindex
- search

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