SoundTrap ST600 User Guide

December 2020

1 *About this guide*

This guide begins with a 'Quick start' section to help you get going with your new SoundTrap, including software installation and basic deployment instructions. This is followed by several sections containing more detailed information around operation, deployment, maintenance and troubleshooting. It is highly recommended you read the entire guide to ensure you have a good understanding of the instrument and how to get the most from its capabilities.

2 Quick start guide

2.1 Opening and closing the housing

Before opening underwater housings always check for flooding by shaking the recorder and listening for water sloshing around inside. If flooding is suspected, then be aware that the housing may be pressurised and therefore potentially dangerous. Carefully relieve any pressure by opening the small seal screw at the base of the housing.

Opening the housing:

- Ensure the housing is dry and free of fouling.
- Use the supplied 4mm hex key to release the lock screw by turning clockwise unit the screw bottoms out (figure 1).
- Open the top with a twist and pull motion, ensuring the hydrophone is pointing downward to any avoid any residual sea water entering the housing.
- Where seal is tight you may need to use a screw driver (in the slots provided) to lever the top open.

Closing the housing:

- Carefully check the O'rings. **Any nicks or scratches indicate they must be replaced.**
- Lubricate O'rings with silicone grease.
- Check O'rings are properly seated and absolutely free of stray hair/grit etc
- Insert the chassis in the housing, turning to align the locking screw.

Figure 1

- Engage the locking screw by turning anticlockwise with supplied hex key until screw is snug against the housing.

- Where heavy fouling is likely to occur we recommend sealing the gap and locking screw by means of a couple of turns of insulation tape (figure 2).

- *Replacement O'Rings should be type 48x3 N70 (Nitrile)*

The O'ring checks are critically important to avoid damage. Any detritus or damage to the O'rings may result in the housing being flooded which will almost certainly destroy the electronics.

Figure 2 – Avoid fouling of the locking screw by covering with insulation tape

2.2 Batteries

The SoundTrap ST600 is powered by up to 12 Panasonic NCR18650B lithium-ion batteries. These are loaded individually, meaning you can use anything from 1 to 12 batteries depending on desired length of deployment.

We strongly recommend only using Panasonic NCR18650B batteries. These are commonly available and all testing and advertised battery endurances have been based on this brand. Performance of other brands is unknown. Untested brands may leak acid, potentially causing damage to the electronics. Source the batteries from reputable suppliers to avoid inferior counterfeits.

Be careful to ensure correct battery polarity as indicated by the diagram in the battery compartment. Once loaded, double check each battery's polarity.

2.3 Memory

The SoundTrap ST600 series have capacity for up to 4 microSD cards.

Important things to note about memory:

1. You should only use the recommended memory cards – **Samsung Evo MicroSD**. Counterfeits of these cards are common, so only source from reputable suppliers. Using other card types or counterfeits may result in performance issues such as greatly increased power consumption, sampling gaps or unreliable recording.

2. The cards are used in the sequence 4->3->2->1 where 1 is the top-most card. Any full or missing cards will be skipped.

3. It is critical that each card is formatted prior to each deployment. This can only be done in the SoundTrap recorder using the 'Delete All Files' option. **This must be done for each card individually.**

4. SoundTrap uses a custom file system to maximise performance and reliability. This means the cards can only be read with the 'SoundTrap Card Reader' application supplied with the SoundTrap Host software. When inserting the memory cards into a PC you may receive a message like "Drive is not formatted, do you want to format it now?". **Agreeing to this will result in loss of data**. Instead select 'No thanks' and run the SoundTrap card reader software.

2.4   Install the SoundTrap host on your PC

To start using your SoundTrap you'll need to install the SoundTrap Host software.

For correct operation of your ST600 it is critical to use SoundTrap Host version 4.0.0 or later.

- Pre-installation Notes:
  - The SoundTrap host software supports Windows 7,8 & 10 (32 or 64 bit versions).
  - Do not connect the SoundTrap to your computer until you have completed the SoundTrap host software installation.
  - The installation will be smoother if you're logged into windows as an administrator.
- Visit www.OceanInstruments.co.nz/downloads/ to download the software.
- Download and run the installer.
- Once the install completes, run the SoundTrap Host application.

2.5   Connect SoundTrap to your PC

- Connect the SoundTrap using the USB cable provided.
- The drivers will take a couple of minutes to install. Once complete you should see your SoundTrap appear in the 'Device List' on the left, as shown in figure 3.
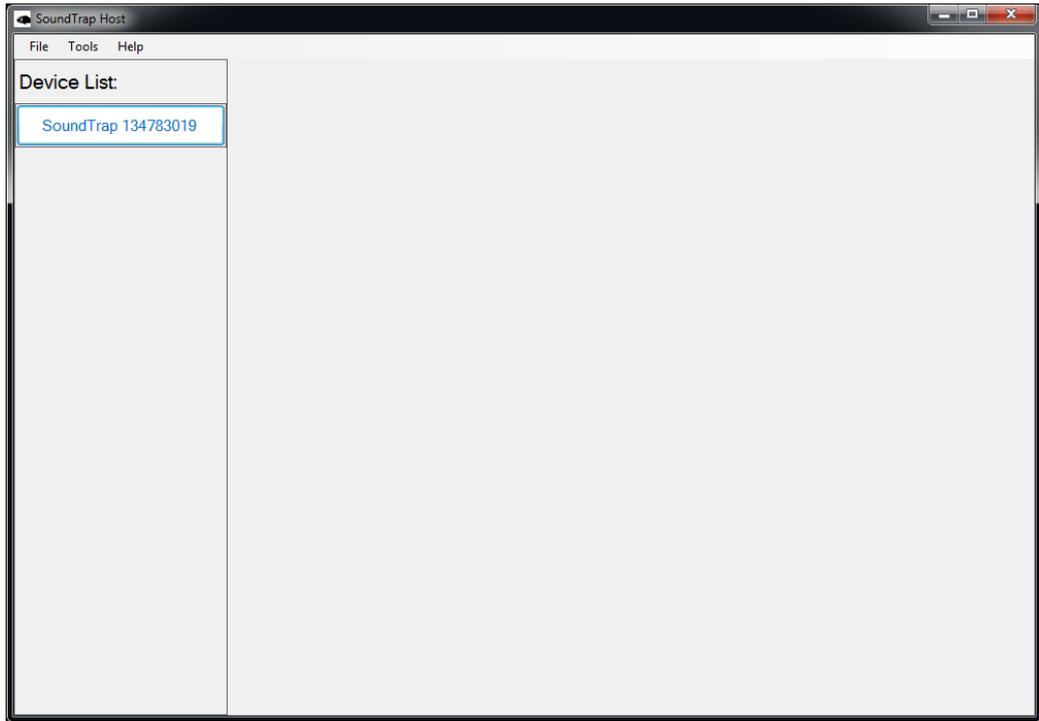- Select your SoundTrap by clicking its label on the left.

Figure 3 - The Device List

2.6 Check SoundTrap Status

Note the 'Status' panel on the right (Figure 4). Carefully review the state of memory and batteries in the right-hand pane, checking that all batteries show 100% charge and all memory show 0% used.
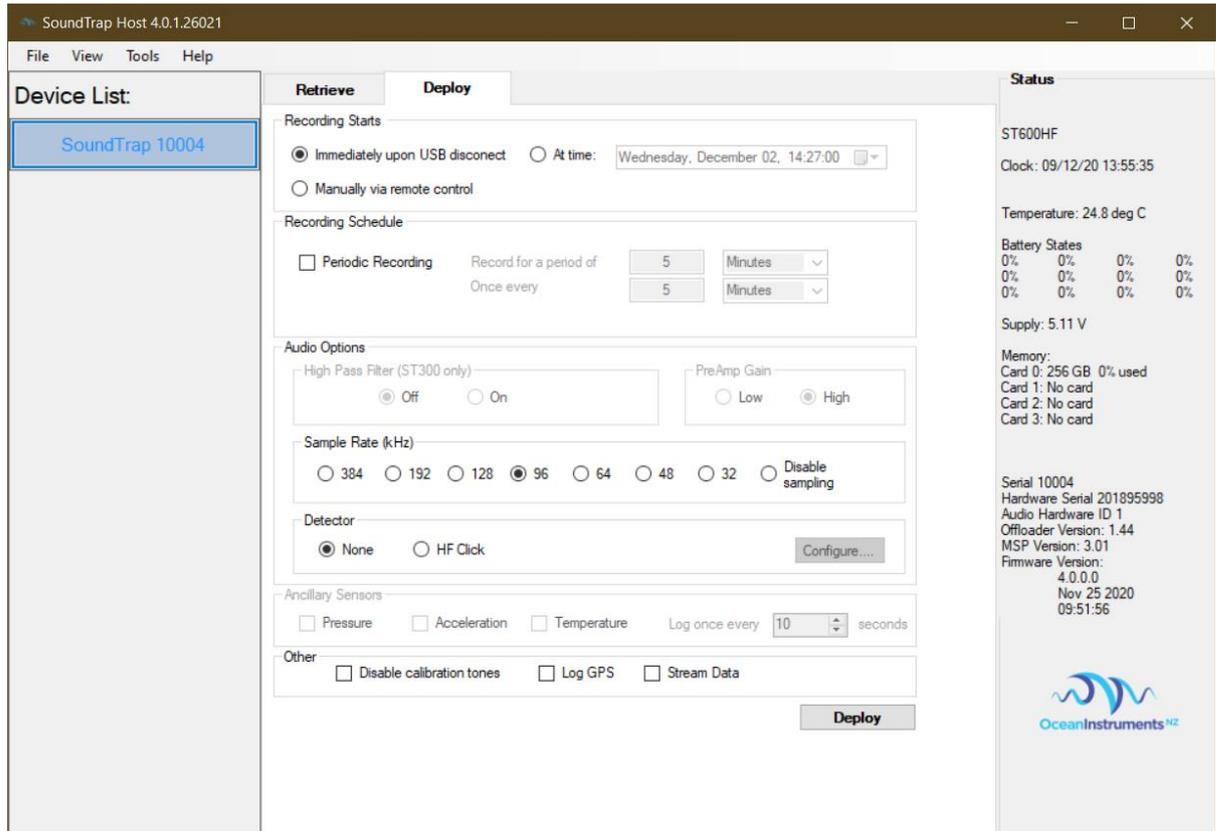
Figure 4 – Deploy Control

2.7 Configure the deployment
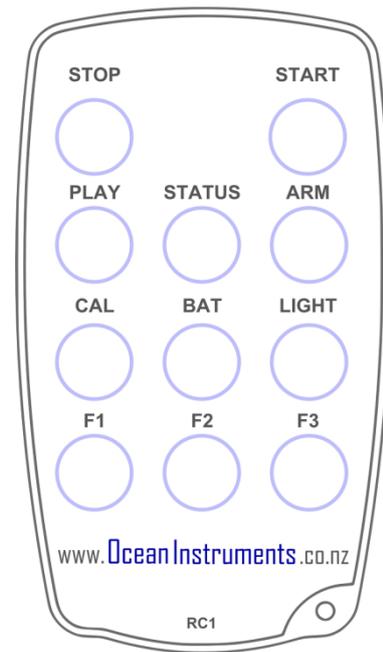
- Select the 'Deploy' tab as shown in figure 4.
- Configure the deployment parameters as follows:
    - The '**Recording Starts**' section determines when recording will begin. Recording can begin immediately on disconnection of the USB cable, at a pre-determined date and time, or manually using the IR remote control. Note that the remote can always be used to override the other options.

- The '**Recording Schedule**' section provides selection of continuous or periodic recording. For continuous recording simply leave the 'Periodic Recording' option unchecked.
- Options available in the '**Audio Options'** will vary according to your device's capabilities. Options include the following:
    - **Channel Selection** selects which channels to record on.
    - *Sample Rate* should be set based on the frequency band of interest and data rate considerations. A 96 kHz sampling rate is often a good choice for general environmental noise measurements. Contact OI support if unsure.
    - *Preamp Gain* should usually be set to 'High'. This will result in a maximum SPL before clipping of approximately 175 dB re 1 uPa. The 'Low' setting should be used for very noisy environments such as in the vicinity of pile driving. The low setting increases the maximum SPL to around 187 dB, but comes at the cost of lower sensitivity.
    - *High pass filter*. This should usually be turned off. This only used in very high energy sites or when towing a SoundTrap behind a boat. Turning this on reduces sensitivity in the band 0 to 600 Hz, while leaving higher frequencies unaffected.

- Detector – see HF Click Detector section below.

- Click the deploy button which will save the settings and you're ready to go. The instruments internal clock is synchronised to your PC when you click the deploy button. If you change your mind about something, just re-select the instrument from the 'Device List'.

2.8 Begin recording using the IR Remote Control

You may use the remote control to start recording. The recorder housing must be open to receive the signal from the remote.

- Press 'START' to start recording.
- Press 'STOP' to stop recording.
- If you have set a recording to start recording at a later time, the recorder will blink red to indicate it is 'armed' and waiting.
- The 'armed' state is cancelled by pressing Stop key.
- Re-enable the armed state by pressing the ARM button.

- You can verify recording has started by checking for slow blinking of the status (green) indicator.

2.9 Data Offload

Once you're done recording, reconnect your SoundTrap to your PC and select the Retrieve Tab, as shown in figure 5.
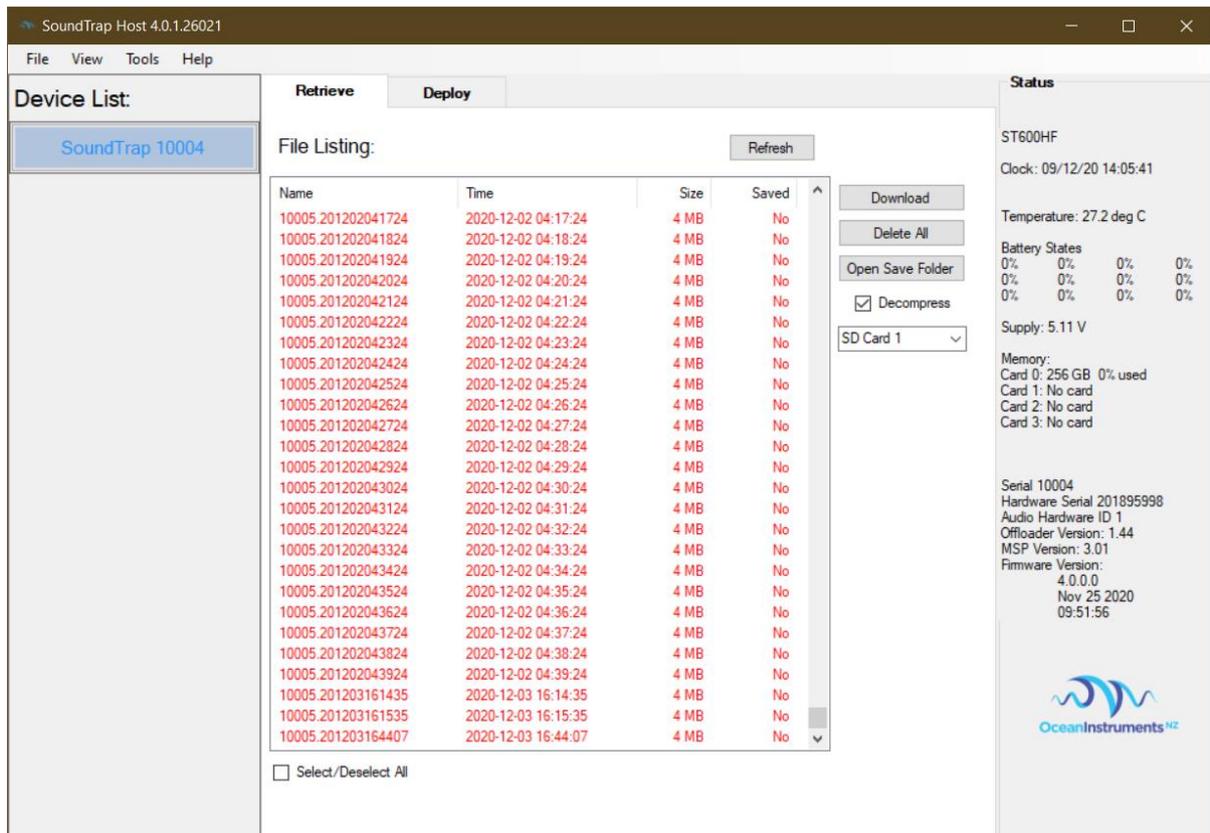

Figure 5 – Retrieve Tab

- Each memory card can be selected using the drop down list.
- You will see a list of files on the selected memory card, including the file name (made from the device serial number plus local date and time), date recorded, approximate size and whether it has yet been downloaded to your computer's hard drive.
- Download individual files by right clicking the file and selecting 'download'.
- By default, all files will be downloaded to a 'SoundTrap' folder under My Documents. This default location can be changed under the 'Tools' menu.
- Click the 'Open Save Folder' button to open the download folder location.
- To download all files, select all files using the shift key, then click the 'Download' button.
- To delete, click the 'Delete All' button. Files cannot be deleted individually.

- For faster download in the field, or to save disk space, un-check the 'Decompress' checkbox. This will disable the decompression step of the offload process, meaning you will end up with 'sud' files only. These can be decompressed into wav files at a later time using the 'File Extraction' option under the tools menu.

3 More details

3.1 Data Files

Downloads produce several types of files:
- 'sud' files which are the raw downloaded file. This is a compressed file and therefore ideal for storing or sending of complete recordings. It can then be decompressed at a later time into the following constituent file formats.
- 'wav' files containing the audio. This is a Microsoft WAV format file that can be opened by any media player, matlab, raven etc.
- 'xml' files which contain metadata such as date recorded, gain setting, etc.
- 'csv' files containing ancillary sensor data (e.g. temperature)

All file types follow the same naming convention consisting of the device serial number followed by the date and time of the start of the recording in the format YYMMDDHHMMSS.

For duty cycled recording there will usually be one file per recording period. For continuous recording a maximum file length of 1036800000 samples (2GB of wav) will determine the length of the files. This equates to 1 hour recordings for a 288khz sample rate.

Where smaller than 2G files are desired for continuous recording it is recommended to set a duty cycle with 'zero off time'. For example, a duty cycle of 30 minutes every 30 minutes will result in continuous 30 minutes files with no missing samples between files.

3.2   Calculation of deployment endurance

An excel spreadsheet is provided on the website to help with the calculation of deployment times for differing deployment parameters. The spreadsheet provides deployment estimates, as well as identifying one of three possible deployment constraints: battery capacity, memory capacity, or file count. While the first two are obvious, the file count constraint requires explanation.

The file system used by SoundTrap currently has a minimum file size of 4 MB. When using periodic recording, if the programmed 'record for a period of' period is very short, the resultant file may be smaller than the minimum file size. This will result in inefficient usage of memory, and the deployment may be artificially memory limited. For example, a SoundTrap ST600 has 256 GB of memory; dividing this by the minimum file size of 4 MB gives a maximum of 64000 files.

This limitation becomes an issue when using low sample rates in combination with X3 compression. By experimenting with the periodic recording parameters in the deployment spreadsheet it will become clear how to best avoid this limitation.

3.3   Deployment hardware

The anchoring scheme used is very dependent on the goals of the data collection in combination with the deployment environment. Thankfully SoundTraps are more easily deployed than traditional acoustic recorders due to their small size. A SoundTrap ST600's weight in water is approximately 1.2 kg.

Most often the hydrophone is located near the sea floor, using an anchored line. This involves running a line between a heavy anchor weight and either a surface or sub-surface float. A sub-surface float is often best, as it is less affected by weather/swell and is less likely to be tampered with. The SoundTrap should be attached to the line a couple of meters off the bottom. The groove at the bottom of the housing provides an attachment point for one cable tie. This cable tie should be threaded through the associated hole so it cannot slip off. A second cable tie can then be used around the top of the titanium section of the housings, below the locking screw.

Avoid using the hydrophone cage as an attachment point. This is too close to the hydrophone and will likely introduce unwanted noise into the recordings.

 Be mindful that a taut line combined with strong currents may result in 'cable strum' which may disrupt your recordings. In this case a rigid frame may be more appropriate.

3.4   Depth rating and PRV requirements

As supplied the ST600 is rated for deployment up to 200m depth. This can be extended to 500m by adding a PRV safety valve. The safety value ensures the housing cannot become pressurised in the event of a slow leak. Failing to use a PRV risks injury to the user when the recorder is brought back to the surface.

PRVs must be purchased direct from Prevco USA, part code 03395-001

PRV Installation Procedure:

We strongly recommend this is carried out by someone with experience servicing underwater housings:

1. Unscrew gold coloured plug from recorder base using a 3/16 allen key.

2. Ensure sealing surface is perfectly clean.

3. Ensure PRV has good clean o'rings installed.

4. Screw PRV into recorder base using a small crescent wrench being careful not to over tighten.

3.5   Software updates

New software releases will be made available via the Ocean Instruments website. You may which to subscribe to our email list in order to receive notification of these updates. The update procedure is generally straightforward – simply install the new software over top of the existing, by running the msi file and following the usual Windows software install prompts.

The software updates will typically include updates to both the windows software as well as the device firmware. The updating of the device firmware is an automatic process that occurs when pressing the 'deploy' button.

3.6   MSP firmware updates

From time to time a software release may include an update to the 'MSP' firmware. This is a special section of the device firmware that changes infrequently. In the rare event that an MSP update is required, the user will be advised during the deploy procedure and will be asked to connect the 'reset battery'. This is a security feature that ensures the MSP firmware cannot be unintentionally modified. In the case of the ST600 the reset battery is replaced with a (somewhat hidden) reset switch. This is located adjacent #3 memory card slot and is activated by means of inserting a pin through a small hole in the electronics cover.

When asked to 'connect the reset battery' you must hold down the reset switch. Once the switch is held down you can click the OK button (may require second person!) as per the software instructions. You will then be asked to remove the reset battery (release the button). This done, the MSP firmware update will proceed and complete within a few seconds. If presented with the error message "MSP Erase failed", it is likely that the pressing of the reset button was interrupted – please try again.

3.7   Calibration

Each SoundTrap is factory calibrated from new. The standard factory calibration consists of a piston phone calibration at 250 Hz, performed for both low and high gain settings. The calibration data is

not shipped with the hydrophone, but instead made available online from the calibration page of the Ocean Instruments website http://www.oceaninstruments.co.nz/

The calibration data is provided as an end-to-end value. This measure is provided for both high and low gain settings, and represents the SPL that will result in a normalised (±1.0) wav file with a fullscale signal ie 2.0 units peak to peak.

Note that in contrast to traditional hydrophone systems, with SoundTraps there is no need to be concerned with sensitivity in voltage terms. Because SoundTraps integrate the recorder and hydrophone in a single package, there is a fixed relationship between sound pressure and the resultant wav file data, thereby simplifying calibration and eliminating the need for voltage calculations.

Application of the calibration data varies depending on the software used. Descriptions follow for some of the most commonly used software.

MATLAB

To convert wav data to units of uPa, simply scale by the end-to-end calibration value. Example code:

```
[y, Fs] = wavread(filename) ;      % read wav data from file
cal = 173.3;                       % value from calibration sheet
cal = power (10, cal / 20);        % convert calibration from dB into ratio
y = y * cal;                       % multiply wav data by calibration to convert to units of uPa
```

PAMGUARD

PAMGAURD expects calibration data in terms of gain and ADC range. To work around this, specify a preamplifier gain of the calibration value * -1.0 (eg -176.0) and specify the Peak-Peak voltage range as 2.0 V.

PAMGuide

PAMGuide provides several convenient calibration schemes. For SoundTrap data select the end-toend calibration type and enter a system sensitivity of the calibration value * -1.0 (eg -176.0).

Audacity

Audacity reports SPL in units of dB re full scale. To scale SoundTrap data use the following:

Value in dB re 1 uPa = audacity value + end-to-end calibration – 3dB;

For example, if the end-to-end value from the calibration sheet is 176.0 dB, and audacity reports a level of -70 dB, the calibrated SPL is 103.0 dB re 1 uPa.

Calibration Tones

By default, a series of calibration tones will be audible at the beginning of each recording. These can be used to check the calibration of the recording. After applying the calibration to a recording, the SPL of the 1 kHz tone should be equal to the calibration tone level stated on the calibration sheet. If the calibration tones are an annoyance, they can be disabled on the deploy tab. However, we recommend keeping them enabled where possible as they provide a useful check of system calibration and performance.

4   Appendices

4.1   SoundTrap HF Click Detector (ST600HF Only)

The SoundTrap 'HF Click' Detector is a general purpose high frequency click detector followed by a snippet extractor. The detector is designed to detect most odontocetes and is intended to be used as a first pass, guiding you to times in your recordings with lots of transients. You would typically use the detector with a low detection threshold so that it makes a lot of false detects but also detects most genuine clicks (i.e., high sensitivity, low specificity). You then evaluate the reported detections in Pamguard to reduce obvious false detects, to classify clicks into species groups, and to identify bouts, as you would with a continuous wideband recording. The benefits of doing on-board click detection are that you get much longer recording times from your SoundTrap and you can identify

times of interest more quickly when you get the data back. The downside of course is that you do not have the full wideband recording on the SoundTrap. This is mitigated in SoundTrap's detector by recording a short snippet of wideband sound around each detection. A few 100's of µs is often all that is needed to classify odontocete clicks into general classes. The detector can be configured to also make a continuous recording at lower bandwidth that allows you to quantify the general ambient noise conditions, an important factor affecting detector performance, as well as the presence of low frequency whistles that can help with species identification.

4.1.1 Click detector

The click detector comprises an approximate pre-whitening filter followed by a power-in-band Constant False Alarm Rate (CFAR) detector. The whitening filter (a 35kHz high-pass filter) corrects the typical low-frequency emphasis of underwater ambient noise creating a more spectrally-balanced signal for the detector. The power-in-band detector consists of a highpass Finite Impulse Response (FIR) filter (approximate 3 dB bandwidth 115 - 160 kHz) followed by a moving average power estimator. The duration of the moving average window is a user parameter (see below). In parallel, the power of the full bandwidth whitened signal is measured using a much longer exponential window to give an estimate of the ambient noise power. This is used to adjust the absolute detection threshold: a detection will be made if the power-in-band is greater than the ambient power by more than the Relative Detection Threshold (RDT) which is a user parameter. When a detection is made, the time of the detection and the ambient noise power at the time are passed to the snippet extractor. A user-selectable blanking time must then elapse before another detection can be made. This blanking-time is useful to avoid detecting echoes from a click or to prevent detecting a large number of clicks if an animal is buzzing near the recorder.

4.1.2 Snippet extractor

For each detection, an entry is added to the detection log and a snippet of wideband sound surrounding the detection time is saved. The snippet starts and ends a user-selectable time before and after the detection (user parameters: *pre-trigger* and *post-trigger*). Evidently, saving longer snippets per detection means that the memory is used up more rapidly so this feature allows the user to trade-off the amount of context that is saved for each detection against the total recording time. It is important to note that the snippet is taken from the whitened sound and so is high-pass filtered.

4.1.3 User parameters

The user parameters can be set by clicking the 'Configure' button in the Detector section.
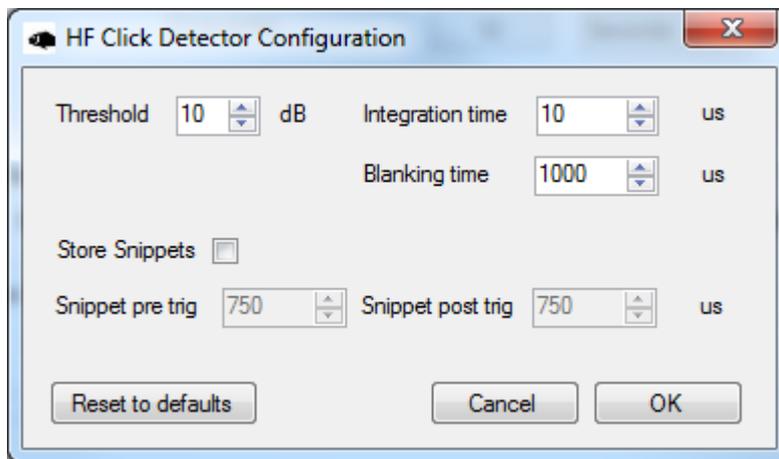
Threshold: The level in dB that the power-in-band must exceed the ambient noise level by for a detection to take place. A value of 12 dB will have a high detection rate but will produce many false positives. A value of 20 dB will detect only strong transients that are well above the ambient noise floor.

Integration Time: Set this to the approximate duration of the clicks of interest. For most delphinids you would use a short averaging time, e.g., 70 µs, while for beaked whales, porpoises and NBHF delphinids, an averaging time of 150-300 µs would be appropriate. If you are interested in detecting any toothed whale click, you can either go with a long averaging time (which will reduce the SNR of short transients and so give poorer detection of delphinids) or an intermediate value which will tend to reduce sensitivity to both short and long transients but not by much.

Blanking time: Time that must then elapse after a detection before another detection can be made. Useful to avoid detecting echoes from a click or to prevent detecting a large number of clicks if an animal is buzzing near the recorder.

Store Snippets: Select to enable storage of detection snippets.

Snippet pre- and post-trigger durations: The time with respect to the detection at which the snippet will be taken. The snippet starts *pre-trigger* seconds before the detection and ends *post-trigger* seconds after the detection. These are both limited to 1.5 ms maximum which is more than long enough to cover odontocete clicks. The number of samples saved per snippet is determined by the sum of the pre- and post-trigger times. With the maximum settings, 1728 samples will be saved per snippet.

4.1.4 Output File formats

The ST click detector produces two additional output files per recording with suffixes 'bcl' and 'dwv'. These are in addition to the .wav and .xml files generated normally. The Pamguard interface automatically interprets these files when displaying detection and continuous recording results. For users interested in accessing the data using other interfaces, the details of the file formats are given below:

- **xml**   This is the metadata file produced by SoundTrap to document each recording. The ST detector adds metadata about the detector and the user settings to this file.

- **wav**   This is a Microsoft WAV format file containing the decimated continuous sound recording produced in parallel with the detector. The sampling rate is selected by the user but would typically be 48kHz or 96kHz to maximize recording time. By default, sound data is compressed in the SoundTrap using the lossless X3 compressor but this is transparent to the user: the .wav file contains the reconstituted uncompressed data.

- **dwv**   This is a Microsoft WAV format file containing the wideband sound snippets for each detection. The sampling rate is 576 kHz and the snippets are arranged contiguously with a constant number of samples per snippet. The size of each snippet is set the by the pre- and post-trigger user parameters. The snippet size in samples will be close to round((pre+post)*576e3) but the precise sample count can be found in the .xml file (see the Matlab tools for an example of how to extract this information automatically). By default, snippet sound data is compressed using the lossless X3 compressor but this is transparent to the user: the .dwv file contains the reconstituted uncompressed data. Up to 100000 snippets will be saved per recording (i.e., per output file). If more detections are made over this interval, they will be reported in the BCL file (see below) but no snippet will be saved. This puts an upper limit on the memory usage rate making it easier to calculate for how long the SoundTrap will be able to record.

- **bcl**   This is a comma-separated-variable (CSV) text file containing information about detections. Each line has 7 columns with the following format:

  Seconds (in Unix seconds), Microseconds, Report type, Info1,Info2,Info3,Info4,

  To obtain high enough resolution, timing information is spread over two fields (Seconds and Microseconds). The time of each entry is then Seconds+Microseconds/1e6. The four Info fields are determined by the report type of which there are two. Detections have a report type of 'D'. The next two fields (Info1 and Info2) indicate whether a snippet was saved (1 or

0) and the noise level at the time of the detection. Fields Info3 and Info4 are not used in detection reports. The second report type is an effort report which has a type of 'E'. The effort report indicates the times over which the detector was operating. There will usually be an on-effort report at the start of each recording (i.e., with a detector state of 1) and an off-effort report at the end of each recording. The on-effort report has no other data and so appears as: *seconds,microseconds,E,1,,,*

The off-effort report appears as: *seconds,microseconds,E,0,noise level,ndets,nsaved,*

where ndets is the total number of detections made since going on effort and nsaved is the number of these for which snippets were saved. In both report types, the noise level is given in Centibels, i.e., 100 log10(p) where p is the noise power referenced to the recorder calibration. The absolute threshold used for each detection is then p+10^(RDT/10). If no detections were made throughout a recording, the BCL file will contain two lines:

start_time,microseconds,E,1,,,

end_time,microseconds,E,0,noise level,0,0

If there are detections, they will be bracketed between these lines and the appropriate detections counts will be changed in the off-effort report. The BCL file can be read and displayed by Excel, Libre Office, Open Office etc. See also the Matlab tools for a function to read this file format.

4.1.5 Click Detector Caveats and Cautions

While every care has been taken in producing the SoundTrap Click Detector, this is free software offered 'as is', in the hope that it will be useful: there is no warranty, implied or otherwise, nor implication of fitness for any particular purpose. Please use responsibly! Test that the code functions correctly on your SoundTrap before deploying it, e.g., by setting the RDT to 12 dB and then tapping lightly on the hydrophone with a finger nail. Even if the code is functioning, it may not detect clicks because of poor signal-to-noise ratio, because of inappropriate user settings, or because of a poor mooring design (the same problems that would give you a bad continuous recording).